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Edited by:

Nagib Callaos
Hsing-Wei Chu
José Ferrer
William Lesso
Michael J. Savoie
Mohammad Siddique

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Yoon, Changwoo	Electronics and Telecommunications Research Institute	South Korea
Yoshida, Eri	Toyohashi University of Technology	Japan
Yoshida, Takahiro	Tokyo University of Science	Japan
You, Younggap	Chungbuk National University	South Korea
Yu, Xin	University of Bath	UK
Zadeh, Jeff	Virginia State University	USA
Zarama, Roberto	Universidad de los Andes	Colombia
Zaretsky, Esther	Givat Washington College of Education	Israel
Zelinka, Tomas	Czech Technical University in Prague	Czech Republic
Zeller, Andrew J.	Norisbank	Germany
Zhang, Jinfang	University of Waterloo	Canada
Zhang, Linda L.	University of Groningen	Netherlands
Zhang, Qingyu	Arkansas State University	USA
Zhang, Xiaozheng Jane	California Polytechnic State University	USA
Zhonghua, Fang	Shanghai Institute of Technical Physics	USA
Zhou, Dan	University of California San Diego	USA
Zhu, Hui	Soochow University	China
Zobaa, Ahmed	Cairo University	Egypt

ADDITIONAL REVIEWERS

Abbas-Turki, Abdeljalil	University of Technology of Belfort-Montbéliard	France
Abdel Hafez, Hoda	Suez Canal University	Egypt
Abdul, Hamed	University of Management and Technology	Pakistan
Aboalsamh, Hatim	King Saud University	Saudi Arabia
Abu Bakar, Ahmad B.	International Islamic University of Malaysia	Malaysia
Adela, Ionescu	University of Craiova	Romania
Agulhari, Cristiano M.	State University of Campinas	Brazil
Akbar Hussain, D. M.	Aalborg University Esbjerg	Denmark
Aleksic-Maslac, Karmela	Zagreb School of Economics and Management	Croatia
Alexik, Mikulas	University of Zilina	Slovakia
Almulla, Mohammed	Kuwait University	South Korea
Alzaid, Hani	Queensland University of Technology	Australia
Andreae, John H.	University of Canterbury	New Zealand
Anido, Cecilia	Far Eastern University	Philippines
Apolloni, Bruno	University of Milan	Italy
Araújo, Armando	University of Porto	Portugal
Arora, Rajan	Cadence Design Systems	India
Arunyawat, Uraiwan	Kasetsart University	Thailand
Asatryan, David	Institute for Informatics and Automation Problems of NAS	Armenia
Atmaca, Tulin	Telecom SudParis	France
Avny, Amos	Omnidev International Consultants	Israel
Bacha, Faouzi	University of Tunis	Tunisia
Bagnoli, Franco	University of Florence	Italy
Balas, Valentina	Aurel Vlaicu University of Arad	Romania
Bamidis, Panos	Aristotle University of Thessaloniki	Greece
Bardine, Alessandro	University of Pisa	Italy
Bargiotas, Dimitrios	Technological Education Institution of Chalkida	Greece
Bartolini, Sandro	University of Siena	Italy
Batos, Vedran	University of Dubrovnik	Croatia
Behzadan, Amir	University of Central Florida	USA
Bessmertny, Igor	University of Information Technologies	Russian Federation
Bettaz, Mohamed	Philadelphia University	Jordan
Bisceglia, Bruno	University of Salerno	Italy
Boonjing, Veera	King Mongkut's Institute of Technology Ladkrabang	Thailand
Booth, Marcia	West Virginia State University	USA
Borges, Carlos C. H.	National Laboratory for Scientific Computation	Brazil
Borworn, Papasratorn	King Mongkut's University of Technology	Thailand
Boudaba, Madjid	Electronic Solutions GmbH	Germany
Buglione, Luigi	Engineering IT	Italy
Burita, Ladislav	Military Academy in Brno	Czech Republic

Burton, Peter G.	Australian Catholic University	Australia
Camilleri, Mario	University of Malta	Malta
Canbolat, Huseyin	Mersin University	Turkey
Carnes, Patrick	Kirtland Air Force Base	USA
Castellini, Horacio	National University of Rosario	Argentina
Cechova, Ivana	University of Defence	Czech Republic
Chang, Ching Pou	Hsiuping Institute of Technology	Taiwan
Chang, Hsung Pin	National Chung Hsing University	Taiwan
Chang, Weng-long	National Kaohsiung University of Applied Sciences	Taiwan
Chang, Yu-Ju	National Chi Nan University	Taiwan
Chen, Chin-Chou	Chunghwa Telecom	Taiwan
Chen, Jingchao	DongHua University	China
Chen, Kuan-Hung	Feng-Chia University	Taiwan
Chen, Liang-Bi	National Sun Yat-Sen University	Taiwan
Chengalvarayan, R.	AT&T Labs Research	USA
Chiu, Shao-I	Taipei College of Maritime Technology	Taiwan
Clément, Alain	Université d`Angers	France
Corcuera, Pedro	University of Cantabria	Spain
Corsano, Gabriela	Instituto de Desarrollo y Diseño	Argentina
Costa, João	Federal University of Pará	Brazil
Crampes, Michel	Ecole des Mines d`Ales Frace	France
Cristóbal-Salas, Alfredo	University of Veracruz	Mexico
Cuvillo, Carlos del	Technical University of Madrid	Spain
D`Silva, Icy	University of Guelph	Canada
Dahlan, Jaslin	Mara University of Technology	Malaysia
Daley, Wayne	Georgia Tech Research Institute	USA
Datcu, Dragos	Delft University of Technology	Netherlands
De Diego, José Ramón	Universidad de Oviedo	Spain
De la Rosa, Guadalupe	Universidad de Guanajuato	Mexico
Di Rico, Gianluca	Osservatorio Astronomico di Teramo	Italy
Dimililer, Kamil	Near East University	Cyprus
Dizdaroglu, Bekir	Karadeniz Technical University	Turkey
Dobritoiu, Maria	University of Petrosani	Romania
Dvornik, Josko	University of Split	Croatia
Dzhusupova, Zamira	United Nations University	Macau
Eaglestone, Barry	University of Sheffield	UK
Ediberidze, Alexandeer	Technical University of Georgia	Georgia
El Bakkali, Hanan	ENSIAS	Morocco
El Manouni, Said	Al-Imam University	Saudi Arabia
Elgamal, Mohamed	University of Victoria	Canada
El-Nadi, Khairia	Alexandria University	Egypt
Erol, Cemil B.	TUBITAK	Turkey
Farooqui, Aamir A.	King Fahd University of Petroleum and Minerals	USA
Faulín, Javier	Public University of Navarre	Spain
Félez, Jesús	Technical University of Madrid	Spain
Fillion, Gerard	University of Moncton	Canada
Fine, Terri	University of Central Florida	USA
Fiorini, Rodolfo	Polytechnic of Milan	Italy
Florea, Adrian	University of Sibiu	Romania
Florescu, Gabriela	National Institute for Research and Development in Informatics	Romania
Floyd, Raymond	Innovative Insights, Inc.	USA

Fox, Richard	Northern Kentucky University	USA
Fukase, Masa-Aki	Hirosaki University	Japan
Fúster-Sabater, Amparo	Consejo Superior de Investigaciones Científicas	Spain
García Marco, Francisco	University of Zaragoza	Spain
Genser, Robert	Institute for Handling Devices and Robotics	Austria
Giampapa, Joseph	Carnegie Mellon University	USA
Gini, Giuseppina	Polytechnic of Milan	Italy
Golayoglu F., Afet	Baskent University	Turkey
Gonçalves, Ricardo	New University of Lisbon	Portugal
Grygierzec, Wieslaw	University of Agriculture in Krakow	Poland
Guang, Liang	University of Turku	Finland
Haack, Bertil	Technical University of Applied Sciences Wildau	Germany
Haddad, Hisham	Kennesaw State University	USA
Hameed, Shihab A.	International Islamic University Malaysia	Malaysia
Harib, Khalifa	United Arab Emirates University	UAE
Hartley, Roger	University of Leeds	UK
Hu, Hong	Hampton University	USA
Huang, Yo-Ping	National Taipei University of Technology	Taiwan
Hussain, Aini	National University of Malaysia	Malaysia
Ianigro, Massimo	Italian National Research Council	Italy
Ibrahim, Azzam	Hamad Medical Corporation	USA
Ilkova, Tatiana	Institute of Biophysics and Biomedical Engineering	Bulgaria
Inci, A. Can	Bryant University	USA
Ingber, Lester	Lester Ingber Research	USA
Intakosum, Sarun	King Mongkut`s Institute of Technology Ladkrabang	Thailand
Iovan, Stefan	Romanian Railway IT Company	Romania
Ishikawa, Yasushige	Kyoto University of Foreign Studies	Japan
Ivlev, Oleg	University of Bremen	Germany
Janota, Ales	University of Zilina	Slovakia
Jaoua, Ali	University of Qatar	Qatar
Job, Remo	University of Trento	Italy
Jwo, Dah-Jing	National Taiwan Ocean University	Taiwan
Kalpic, Damir	University of Zagreb	Croatia
Karigar, Chandrakant	Bangalore University	India
Kawarazaki, Noriyuki	Kanagawa Institute of Technology	Japan
Kim, Do-Hoon	Kyung Hee University	South Korea
Kim, Hyung Nam	Virginia Polytechnic Institute and State University	USA
Kim, Hyunju	Jackson State University	USA
Kim, Mooyoung	Sejong University	South Korea
Kiriazov, Petko	Bulgarian Academy of Sciences	Bulgaria
Klamka, Jerzy	Silesian University of Technology	Poland
Kong, Hyung-Yun	University of Ulsan	South Korea
Krishnam, Manjunath	Intellon Corporation	USA
Kroumov, Valeri	Okayama University of Science	Japan
Ksenofontov, Alexandre	Moscow Engineering Physics Institute	Russian Federation
Kurtulus, Kemal	Istanbul University	Turkey
Kurubacak, Gulsun	Anadolu University	Turkey
Lai, Cristian	Center for Advanced Studies, Research and	Italy
Lappas, Georgios	Technological Educational Institution of Western Macedonia	Greece
Lara, Teodoro	University of the Andes	Venezuela
Las-Heras, Fernando	University of Oviedo	Spain

Law, Rob	Hong Kong Polytechnic University	Hong Kong
Ledesma Orozco, Sergio E.	Guanajuato University	Mexico
Lee, DoHoon	Pusan National University	South Korea
Lee, Jong Hyup	Inje University	South Korea
Lee, Jong Kun	Changwon National University	South Korea
Lee, Richard C. H.	University of Hong Kong	Hong Kong
Lehman, Mario	Sofilab S.A. de C.V	Mexico
Leporati, Francesco	Pavia University	Italy
Li, Di	South-China University of Technology	China
Li, Weigang	University of Brasilia	Brazil
Li, Zheng	Alcatel-Lucent	USA
Liang, Lou Y.	Leader University	Taiwan
Liao, Chu-Hsien	Food Industry Research & Development Institute	Taiwan
Lin, Hong	University of Houston Downtown	USA
Liu, Hong	Embry-Riddle Aeronautical University	USA
Liu, HsinChih Frank	Shih-Chien University	Taiwan
Liu, Yonghuai	University of Wales Aberystwyth	UK
Lo, Yu-Kang	National Taiwan University of Science and Technology	Taiwan
Lopes da Silva, Paulo A,	Military Engineering Institute	Brazil
Luna Rodríguez, Juan J.	Cordoba University	Spain
Machado, José	Institute of Engineering of Porto	Portugal
Mainguenaud, Michel	Institut National des Sciences Appliquées	France
Malan, Danie	University of Pretoria	South Africa
Mansour, Essam	International University in Germany	Germany
Mansour, Samah	Grand Valley State University	USA
Martín, José L.	University of the Basque Country	Spain
Martínez-Carreras, M. A.	University of Murcia	Spain
Mayer, Bernd	Emergentec Biodevelopment GmbH	Austria
Mehata, K. M.	Anna University	India
Memon, Qurban	Hamdard University	Pakistan
Meyer, Heiko	Gefasoft AG	Germany
Milani, Mattia	Intercom R. R. L.	Italy
Moharrum, Mohammed	Old Dominion University	USA
Mohsen, Ghribi	University of Moncton	Canada
Montisci, Augusto	University of Cagliari	Italy
Moody, Scott	The Boeing Company	USA
Moreno, María N.	University of Salamanca	Spain
Morgan, Theresa	Wudang Research Association	USA
Mozar, Stefan	Electrical Testing Services Pty Ltd.	Australia
Mtika, Chatonda	Algis Autograding, Inc.	Canada
Muni, Bishnu Prasad	Bhel Corporate R&D	India
Musio, Carlo	Institute of Cybernetics Eduardo Caianiello	Italy
Nagar, Atulya Kumar	Liverpool Hope University	UK
Nagy, Endre L.	Society of Instrument and Control Engineers	Japan
Nahm, In Hyun	Sun Moon University	South Korea
Narasimhan, Lakshmi	University of Newcastle	USA
Nemec, Juraj	Matej Bel University	Slovakia
Ng, Kia	University of Leeds	UK
Nieuwenhuis, Lambert	University of Twente	Netherlands
Occelli, Sylvie	Institute for Economic & Social Research of Piedmont	Italy
Odetayo, Michael	Coventry University	UK

Ogorodnikov, Dmitri	Mount Sinai School of Medicine	USA
Okatan, Ali	Halic University	Turkey
Ortiz, Andrés	University of Malaga	Spain
Osborne, King	University of Central Florida	USA
Otamendi, Javier	Rey Juan Carlos University	Spain
Pandey, Santosh K.	Institute of Chartered Accountants of India	India
Pantelelis, Nikos G.	National Technical University of Athens	Greece
Park, Se Hyun	Chung-Ang University	South Korea
Parrilla Roure, Luís	University of Granada	Spain
Passos, Nelson Luiz	Midwestern State University	USA
Patel, Susmit H.	MITRE Corporation	USA
Pavone, Mario	University of Catania	Italy
Pisarchik, Alexander	Center for Research in Optics	Mexico
Plakitsi, Katerina	University of Ioannina	Greece
Poh, Elsa	Eastern Michigan University	USA
Pokrywka, Rafal	IBM SWG Laboratory	Poland
Prakash, Naveen	Jaypee University of Information Technology	India
Priest, John	University of Texas Arlington	USA
Pruski, Alain	Paul Verlaine University – Metz	France
Rahnama, Ali	Amirkabir University of Technology	Iran
Resta, Marina	University of Genova	Italy
Rizki, Mateen	Wright State University	USA
Romanov, Sergey	Russian Academy of Sciences	Russian Federation
Rot, Artur	Wroclaw University of Economics	Poland
Rotondi, Guido	Italian National Statistical Institute	Italy
Rusconi, Andrea	Selex Galileo	Italy
Saitta, Francesco	University of Palermo	Italy
Saleemi, Muhammad M.	Åbo Akademi University	Finland
Sarukhanyan, Hakob G.	Institute for Informatics and Automation Problems of NAS	Armenia
Schreurs, Jeanne	Hasselt University	Belgium
Segovia, Hugo	Central University of Venezuela	Venezuela
Selcuk, Artut	Sabanci University	Turkey
Shareef, Ali	University of Maine	USA
Shing, Chen-Chi	Radford University	USA
Silva, Geraldo	Estadual Paulista University	Brazil
Simeonov, Stanislav	Burgas Free University	Bulgaria
Simurina, Jurica	University of Zagreb	Croatia
Singh, Vijander	Netaji Subhas Institute of Technology	India
Smith Nash, Susan	University of Oklahoma	USA
Snow, Richard	Embry-Riddle Aeronautical University	USA
Sokolov, Sergey	Keldysh Institute for Applied Mathematics	Russian Federation
Somkantha, Krit	Rajabhat University Udornthani Thailand	Thailand
Sousa, António	Institute of Biomedical Engineering	Portugal
Stanchev, Peter	Kettering University	USA
Stasytytì, Viktorija	Vilnius Gediminas Technical University	Lithuania
Štork, Milan	University of West Bohemia	Czech Republic
Sutherland, Trudy	Vaal University of Technology	South Africa
Szabo, Raisa	Nova Southeastern University	USA
Talla, Malleswara	Concordia University	Canada
Talukdar, Fazal Ahmed	National Institute of Technology Silchar	India
Tanaka, Hirokazu	Toshiba Corporation	Japan

Tenreiro Machado, J. A.	Institute of Engineering of Porto	Portugal
Thissen, M. Rita	RTI International	USA
Thurasamy, Ramayah	Science University of Malaysia	Malaysia
Tickle, Andrew	Coventry University	UK
Tico, Marius	Nokia Research Center	USA
Trobec, Roman	Jozef Stefan Institute	Slovenia
Tsai, Ping-Sing	The University of Texas - Pan American	USA
Uddin, Vali	Pakistan Naval Engineering College	Pakistan
Vaganova, Natalia A.	Russian Academy of Sciences	Russian Federation
Varriale, Luisa	Parthenope University of Naples	Italy
Vasilache, Simona	University of Tsukuba	Japan
Vázquez, Ernesto	Autonomous University of Nuevo Leon	Mexico
Vdović, Roberto	University of Zagreb	Croatia
Verber, Domen	University of Maribor	Solomon Islands
Vint, Larry	Griffith University	Australia
Volf, Jaromir	Czech Technical University in Prague	Czech Republic
Wada, Shigeo	Tokyo Denki University	Japan
Walters, Sharon	Southern Illinois University	USA
Wang, Chian	National Changhua University of Education	Taiwan
Wang, Fuchung	National Chengchi University	Taiwan
Wang, Xiao Hui	University of Pittsburgh	USA
Wang, Xihuai	Shanghai Maritime University	China
Wang, Yi-Fan	National Taipei College of Business	Taiwan
Wen, Feng	Southwest Jiaotong University	China
Wesley, Joan	Jackson State University	USA
Wicker, Dorothy	Walden University	USA
Wilson, Hentie	University of South Africa	South Africa
Wiriyasuttiwong, W.	Srinakharinwirot University	Thailand
Xie, Xianghui	Chinese Academy of Sciences	China
Yahiaoui, Azzedine	Eindhoven University of Technology	Netherlands
Yang, Jingyun	Harvard Medical School	USA
Yildirim, Yakup	Bilkent University	Turkey
Yin, Jianwen	Dell Computer Corporation	USA
Yossakda, Nipa	Northwestern Polytechnic University	USA
Yourguelenas, Youri V.	General Physics Institute Ras	Russian Federation
Zaman, Saiful	Sultan Qaboos University	Oman
Zhang, Xiao-Dong	Xi'an Jiaotong University	China
Zhang, Yanlong	Manchester Metropolitan University	UK
Zhong, Cheng	Guangxi University	China
Zolotova, Iveta	Technical University Kosice	Slovakia
Zorzo, Sérgio Donizetti	Federal University of São Carlos	Brazil
Zuzeviciute, Vaiva	Vytautas Magnus University	Lithuania

ADDITIONAL REVIEWERS FOR THE NON-BLIND REVIEWING

Abdulah Zadeh, Abdulah	Shahid Beheshti University	Iran
Alexik, Mikulas	University of Zilina	Slovakia
Alsmadi, Izzat	Yarmouk University	Jordan
Álvarez González, Ricardo	Benemérita Universidad Autónoma de Puebla	Mexico
Al-Yasiri, Adil	University of Salford	UK
Anderson, Janice	University of North Carolina at Chapel Hill	USA
Anita, Mary	Anna University	India
Antidze, Jemal	I.Vekua Scientific Institute of applied mathematics	Georgia
Arakaki, Reinaldo Gen I.	Faculdade de Tecnologia de São José dos Campos	Brazil
Ashoori, Maryam	University of Ottawa	Canada
Avgerou, Chrisanthi	London School of Economics and Political Science	UK
Barb, Adrian	Penn State University	USA
Basu, Aryabrata	University of Georgia	USA
Becker, Matthias	University of Flensburg	Germany
Berghaus, Martin	TU Dortmund	Germany
Berleant, Daniel	University of Arkansas at Little Rock	USA
Bethke, Albert	RTI International	USA
Bi, Zhuming	Indiana University	USA
Bönke, Dietmar	Reutlingen University	Germany
Bubnov, Alexey	Academy of Sciences of the Czech Republic	Czech Republic
Cardenas A., Diana M.	Universidad Nacional de Colombia	Colombia
Chae, Yeon Sik	MINT	South Korea
Chandra, Dr Pravin	GGS IPU Delhi	India
Chang, Chih-hung	Hsiuping Institute of Technology	Taiwan
Chang, Weng-long	National Kaohsiung University of Applied Sciences	Taiwan
Chemak, Chokri	University for Information Science and Technology	France
Chen, Chun-hsien	Nanyang Technological University	Singapore
Chen, Ke	School of Computer Science- The University of Manchester	UK
Chen, Mo	State University of New York at Binghamton	USA
Chen, Thomas	Swansea University	USA
Choi, Ho Yong	Chungbuk National University	South Korea
Choi, Tae-yong	Korea Institute of Machinery and Materials	South Korea
Chu, Chih-Ping	National Cheng Kung University	Taiwan
Chu, Xiumin	Intelligent Transport System Research Center	China
Contreras, Leonardo	Universidad Simón Bolívar	Venezuela
Dacey, Simon	Unitec New Zealand	New Zealand
Daneshmand M., Amin	Malayer Azad University	Iran
De, Dr. Sadhan K.	Indian Institute of Technology Kharagpur	India
De Groot, Peter	University of Southampton	UK
Deshmukh, S.G.	ABV Indian Institute of Information Technology and	India

	Management Gwalior	
Durai Raj, K. Antony A.	Infosys Technologies Limited	India
Dvorak, Zdenek	Univerzity of Zilina	Slovakia
Dvornik, Josko	University of Split	Croatia
Ekstrom, Joseph	Brigham Young University	USA
El Nasan, Adnan	American University in Dubai	UAE
El Oualkadi, Ahmed	Abdelmalek Essaadi University	Morocco
Elmahboub, Widad	Hampton University	USA
Erdogan, Eylem	Kadir Has University	Turkey
Essam A., Ahmed	Sohag University	Egypt
Estrela, Vania	State University of Rio de Janeiro	Brazil
Ezekiel, Soundararjan	Indiana University of Pennsylvania	USA
Faruquzzaman B., A.	Bangladesh University of Engineering and Technology	Bangladesh
Ferreira, Andrea	Federal University of Ceará	Brazil
Figueiredo, Josiel	UFMT	Brazil
Forcolin, Margherita	Insiel S.P.A.	Italy
Franz, Heike	Electronic Data Systems Corporation	Germany
Garrett, Aaron	Jacksonville State University	USA
Gerber, Mariana	Nelson Mandela Metropolitan University	South Africa
Gini, Giuseppina	Polytechnic of Milan	Italy
Goron, Juan	California School of Mines	USA
Gupta, M.P	Indian Institute of Technology Delhi	India
Hagemeier-Klose, Maria	Technical University of Munich	Germany
Ham, Chan	Southern Polytechnic State University	USA
Hamie, Ali	University of Brighton	UK
Haro Aguilar, Gabriel	Colegio de Postgraduados en Ciencias Agrícolas	Mexico
Hrubes, Pavel	Czech Technical University Praha	Czech Republic
Hu, Dali	Jiangxi University of Finance and Economics	China
Hu, Vincent	National Institute of Standards and Technology	USA
Huang, Shih-kun	National Chiao Tung University	Taiwan
Huang, Yi-hung	National Taichung University	Taiwan
Hussein Ali, Samaher	Babylon University	Iraq
Hwang, Kofo	Overseas Chinese University	Taiwan
Ibrahim, Azzam	Hamad Medical Corporation	USA
Ilkova, Tatiana	Bulgarian Academy of Sciences	Bulgaria
Imada, Akira	Brest State Technical University	Belarus
Janota, Ales	University of Zilina	Slovakia
Jiang, Yuantao	Shanghai Maritime University	China
Johannessnon, Paul	SYSLAB	Sweden
Jouis, Christophe	University Paris 3	France
Juan, Ángel A.	Open University of Catalonia	Spain
Judd, Dave	MDE/OEAA	USA
Jung, Kyung Kwon	Dongguk University	South Korea
Karatoy, Hilal	Technische Universiteit Eindhoven	Netherlands
Katar Srinivas	Atheros Communications- Ocala- Florida	USA
Kazi, Hameedullah	Isra University	Pakistan
Keesler, Venessa	MDE/OEAA	USA
Kelemen, Miroslav	Armed Forces Academy	Czech Republic
Kim, Hyungseok	Chonbuk National University	South Korea
Kritzinger, Elmarie	University of South Africa	South Africa
Kumamaru, Sigehiro	Hyogo University	Japan

Kumar, Mukesh	Delhi Public School - R.K Puram	India
Kurubacak, Gulsun	Anadolu University	Turkey
Kwon, Heyun-young	Kwangwon University	South Korea
Lee, Cheng-chi	Library and Information Science- Fu Jen Catholic University	Taiwan
Levesque, Mario	Memorial University in Newfoundland	Canada
Levian, Dina	D. Yellin College of Education	Israel
Li, Guoqiang	University of Missouri-St. Louis	USA
Liang, Jiaqi	Georgia Institute of Technology	USA
Libati, Hasting	Copperbelt University	Zambia
Lin, Yu-Ju	University of Florida	USA
Lisboa, Mauricio	CEPEL	Brazil
Liu, C. C.	Ching Yun University	Taiwan
Liu, Chao-liang	Asia University	Taiwan
Lodderman, Frederick	California School of Mines	USA
López Trujillo, Marcelo	Universidad de Caldas	Colombia
Luh, Guan Chun	Tatung University	Taiwan
Luhanga, Pearson	University of Botswana	Botswana
Lunt, Barry	Brigham Young University	USA
Lv, Nengchao	Wuhan University of Technology	China
Malzahn, Don	Wichita State University	USA
Mansoor, Wathiq	American University in Dubai	UAE
Mastacan, Lucian	Gheorghe Asachi Technical University	Romania
Matellan, Vicente	Universidad de Leon	Spain
Meladze, Hamlet	St. Andrew Georgian University	Georgia
Méndez Páez, Rafael	Pontificia Universidad Javeriana	Colombia
Mihci, Gurkan	Izmir Economy University	Turkey
Miro, Kraetzl	DSTO	Australia
Moeller, Knut	Furtwangen university	Germany
Morgan, Theresa	Wudang Research Association	USA
Morshed, Ahmed Hesham	Ain Shams University	Egypt
Mostafazadeh, Mehrdad	IIEES	Iran
Muis, Abdul	University of Indonesia	Indonesia
Muller, Logan	AIT	Thailand
Murch, Ron	University of Calgary	Canada
Murugesan, Karuppasamy	Atilin University	India
Myrick, Stephanie	Naval Research Laboratory	USA
Okatan, Ali	Halic University	Turkey
Oliveira, Hueder Paulo M.	Universidade Camilo Castelo Branco	Brazil
Olson, Patrick	National University	USA
Oreku, George	Tanzania Industrial Research	Tanzania
Otahal, Stanislav	Charles University	Czech Republic
Pandey, Abhishek	IIIT Allahabad	India
Park, Cheol Hoon	Korea Institute of Machinery and Materials	South Korea
Pascu, Anca	Universite de Brest	France
Passos, Nelson Luiz	Midwestern State University	USA
Paterson, Matthew	University of Ottawa	Canada
Peng, Ya-Fu	Ching Yun University	Taiwan
Perunicic, Mihailo	Faculty of Technology	Yugoslavia
Petrella Toffolo, Carlos	Universidad Católica	Uruguay
Picariello, Antonio	Universita` di Napoli Federico II	Italy
Pietsch, Joachim	IADT	Ireland

Plotnick, Linda	Jacksonville State University	USA
Pugliese, Andrea	University of Calabria	Italy
Puigt, Matthieu	Institute of Computer Science	Greece
Puthooran, Emjee	IIT Roorkee	India
Quirolgico, Stephen	NIST	USA
Rao, K Sreenivasa	IIT Kharagpur	India
Ren, Jianfeng	Qualcomm Inc.	USA
Rigueira, Glaucio	CEPEL	Brazil
Rike, Robert	Environmental Systems Research Institute - Inc.	USA
Rodionov, Alexey	Institute of Computational Mathematics and Mathematical Geophysics	Russian Federation
Rodríguez de la O, Jose L.	Universidad Autonoma Chapingo	Mexico
Roe, Marvin	Naval Research Laboratory	USA
Ruiz-Vanoye, Jorge A.	National Center for Research and Technological Development	Mexico
Rusconi, Andrea	Selex Galileo	Italy
Schaeffer, Donna M.	Marymount University	USA
Sebastian, van Delden	University South Carolina Upstate	USA
Shafir, Abraham I.	Giv`at Washington Academic College of Education	Israel
Shaya, Fadia	University of Maryland School of Pharmacy	USA
Shen, Junan	Georgia Southern University	USA
Shi, Lei	University of Maryland, Baltimore County	USA
Shufeng, Wang	Shandong University of Technology	China
Singhal, Anoop	NIST	USA
Smith, David	Indiana University of Pennsylvania	USA
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Fox, Kelly	Texas Tech University	USA
Freund, Rodolf	Vienna University of Technology	Austria
Fu, Shih-Lung	National Taiwan University	Taiwan
Fu, Xiuju	Institute of High Performance Computing	Singapore
Fu, Yonggang	Shanghai Jiao Tong University	China
Fuhrer, Patrik	University of Fribourg	Switzerland
Fujikawa, Takemi	University of Western Sydney	Australia
Fujita, Naoyuki	Japan Aerospace Exploration Agency	Japan
Fumizawa, Motoo	Shonan Institute of Technology	Japan
Gagnon, Francois	École de Technologie Supérieure	Canada
Ganapathi, Nanthini	Research Triangle Institute	USA
Ganapathy, Velappa	Monash University	Malaysia
Ganchev, Ivan	University of Limerick	Ireland
García-Atanacio, César	Instituto Nacional de Investigaciones Nucleares	Mexico

Gardezi, A. K.	Colegio de Postgraduados	Mexico
Garibaldi, Jonathan M.	University of Nottingham	UK
Georgescu, Vasile	University of Craiova	Romania
Gesekus, Tim	DFS Deutsche Flugsicherung Gmbh	Germany
Glotzbach, Ronald J.	Purdue University	USA
Godavarty, Anuradha	Florida International University	USA
González, Jean	Florida International University	USA
Gordon, Richard	University of KwaZulu Natal	South Africa
Goriachkin, Oleg	Volga State Academy of Telecommunication and Informatics	Russian Federation
Gosselin, Clément	Universite Laval	Canada
Goulding, Tom	Daniel Webster College	USA
Gregory, Mark A.	RMIT University	Australia
Guadarrama, Javier de J.	Instituto Tecnológico de Toluca	Mexico
Guevara L., Miguel A.	University of Porto	Portugal
Guiasu, Radu Cornel	York University	Canada
Guiasu, Silviu	York University	Canada
Gulez, Kayhan	Yýldýz Teknik Üniversitesi	Turkey
Gustavsson, Rune	Blekinge Institute of Technology	Sweden
Gyires, Tibor	Illinois State University	USA
Haba, C. G.	Technical University of Iasi	Romania
Hallot, Frédéric	Royal Military Academy	Belgium
Ham, Chan	Southern Polytechnic State University	USA
Hamanaka, Masatoshi	University of Tsukuba	Japan
Hammond, Bruce R.	Saint Leo University	USA
Hangai, Seiichiro	Tokyo University of Science	Japan
Hao, Tianyong	City University of Hong Kong	China
Hardy, Frank	University of South Carolina Upstate	USA
Hardy, Leon C.	Embry-Riddle Aeronautical University	USA
Hashimoto, Shigehiro	Osaka Institute of Technology	Japan
Heiserich, Gerd	Institute of Transport and Automation Technology	Germany
Hemmelman, Brian	The South Dakota School of Mines and Technology	USA
Hendel, Russell Jay	Towson University	USA
Henninger, Michael	PH Weingarten	Germany
Herget, Josef	University of Applied Sciences	Switzerland
Herndon, D. N.	University of Texas Medical Branch at Galveston	USA
Herr, Stephan	DFS Deutsche Flugsicherung GmbH	Germany
Hetzer, Dirk	Media Broadcast	Germany
Higashiyama, Yoichi	Ehime University	Japan
Hochin, Teruhisa	Osaka Prefecture University	Japan
Hodge, Diane M.	Radford University	USA
Hofmeister, Helge	BASF IT Services	Belgium
Hong, Yun-Ki	Chungbuk National University	South Korea
Horne, Jeremy	Maricopa Community College	USA
Hsu, Shu-Mei	Tatung University	Taiwan
Huang, Pin Chia	I-Shou University Kaohsiung	Taiwan
Huang, Ruhua	Wuhan University	China
Huang, Sheng He	University of Southern California	USA
Hvass, Michael	IBM Denmark	Denmark
Iembo, Rosanna	University of Calabria	Italy
Imai, Michita	Keio Uiversity	Japan

Imamura, Nobuaki	Kobe City College of Technology	Japan
Ishikawa, Hiroshi	NUIS	Japan
Ito, Akinori	Tohoku University	Japan
Jäntschi, Lorentz	Academic Direct Organization	Romania
Jiménez Rodríguez, Lourdes	University of Alcala	Spain
Johnson, Mark	Benet Laboratories	USA
Jones, Paul	University of Cincinnati	USA
Joordens, Steve	University of Toronto Scarborough	Canada
Jung, Kyung Im	Samsung Electronics, R. O. Korea	South Korea
Jung, Kyung Kwon	Dongguk University	South Korea
Jung, Seul	Chungnam National University	South Korea
Kadoch, Michel	University of Québec	Canada
Kamejima, Kohji	Osaka Institute of Technology	Japan
Kaneko, Takashi	Niigata University	Japan
Kao, Chih-Yang	Ming-Chuan University	Taiwan
Karamat, Parwaiz	The Open Polytechnic of New Zealand	New Zealand
Kasapoglu, Ercin	Hacettepe Üniversitesi	Turkey
Kaszubiak, J.	University Magdeburg	Germany
Kawaguchi, Masashi	Suzuka National College of Technology	Japan
Kehtarnavaz, Nasser	University of Texas at Dallas	USA
Khaled, Pervez	University of Illinois at Chicago	USA
Khan, Faisal	KUSTAR	U.A.E
Khatri, Anil	Bowie State University	USA
Kim, Jeongdae	Information and Communications University	South Korea
Kim, Kyungwoo	University of Florida	USA
Kim, Seok-Man	Chungbuk National University	South Korea
Kim, Yeo Jin	Samsung Electronics, R. O. Korea	South Korea
Kim, Yeon-Ho	Chungbuk National University	South Korea
Kim, Yong Hak	Korea Electric Power Research Institute	South Korea
Kincaid, Rex K.	The College of William and Mary	USA
Kira, Dennis S.	Concordia University	Canada
Kizirian, Robin	Drexel University	USA
Klapp, Jaime	Instituto Nacional de Investigaciones Nucleares	Mexico
Kobal, Damjan	University of Ljubljana	Slovenia
Koczkodaj, Waldemar W.	Laurentian University	Canada
Komatsu, Takanori	Shinshu University	Japan
Kouki, A.	École de Technologie Supérieure	Canada
Kozma-Bognár, Veronika	University of Pannonia	Hungary
Krakowska, Monika	Jagiellonian University	Poland
Kreisler, Alain	Université Pierre et Marie Curie - Paris Sorbonne	France
Kromrey, Jeffrey D.	University of South Florida	USA
Kronreif, Gernot	Austrian Research Centers	Austria
Krothapalli, Sreenivasa Rao	Indian Institute of Technology Kharagpur	India
Kuftin, Felix A.	(KTTI)	Russian Federation
Kung, C. M.	Shih Chien University Kaohsiung Campus	Taiwan
Kuragano, Tetsuzo	The American Society of Mechanical Engineers	Japan
Kutter, Anna K.	PH Weingarten	Germany
Kwon, Yongjin (James)	Ajou University	South Korea
Lahlouhi, Ammar	University of Biskra	Algeria
Lai, James C. K.	Idaho State University College of Pharmacy	USA
Latawiec, Krzysztof J.	Opole University of Technology	Poland

Latchman, Haniph A.	University of Florida	USA
Lee, Hwajung	Radford University	USA
Lee, Jae-Suk	Gwangju Institute of Science and Technology	South Korea
Lee, Kangsun	MyongJi University	South Korea
Lee, Nam Ho	Korea Electric Power Research Institute	South Korea
Lee, Sang-Jin	Chungbuk National University	South Korea
Lee, Suk Bong	Samsung Electronics, R. O. Korea	South Korea
Lee, Yih-Jiun	Chien Kuo Technology University	Taiwan
Lee, Yusin	National Cheng Kung University	Taiwan
Letellier, T.	Université Victor Segalen	France
Li, Lihong	City University of New York	USA
Lin, Shu-Chiung	Tatung University	Taiwan
Linares, Oscar	Universidad Distrital Francisco José de Caldas	Colombia
Lipikorn, Rajalida	Chulalongkorn University	Thailand
Lipinski, Piotr	Technical University of Lodz	Poland
Litvin, Vladimir	California Institute of Technology	USA
Liu, Jun	University of Ulster	UK
Liu, Kuo-Shean	Tatung University	Taiwan
Liu, Shih-Chi	Tatung University	Taiwan
Livne, Nava L.	University of Utah	USA
Livne, Oren E.	University of Utah	USA
Long, Changjiang	Huazhong University	China
López Román, Leobardo	University of Sonora	Mexico
Lou, Shi Jer	NPUST	Taiwan
Loutfi, Mohamed	University of Sunderland	UK
Love C., Gloria	Dillard University	USA
Lowe, John	University of Bath	UK
Lowry, Pam	Lawrence Technological University	USA
Luh, Guan Chun	Tatung University	Taiwan
Lui, Wen Lik Dennis	Monash University	Malaysia
Lyell, Margaret	Intelligent Automation, Inc.	USA
Ma, Yongqing	Victoria University of Wellington	New Zealand
Machotka, Jan	University of South Australia	Australia
Mahendran, Francis	Motorola Software Group Singapore	Singapore
Mahgoub, Ahmed G.	Alexandria University	Egypt
Manley, Denis	Dublin Institute of Technology	Ireland
Mansikkamäki, Pauliina	Tampere University of Technology	Finland
Marino, Mark	Erie County Community College	USA
Martínez, Pablo	RIKEN	Japan
Martínez, Sergio	Florida International University	USA
Martínez Madrid, Natividad	Universidad Carlos III de Madrid	Spain
Marwala, Tshilidzi	University of Johannesburg	South Africa
Mascari, Jean-François	Istituto per le Applicazioni del Calcolo	Italy
Masoumi, Nasser	University of Tehran	Iran
Mathews, Brian	University of Bedfordshire	UK
Matsumoto, Kazunori	KDDI R&D Laboratories Inc.	Japan
Matsuno, Akira	Teikyo University	Japan
Mayer, Daniel	University of West Bohemia in Pilsen	Czech Republic
Mbobi, Aime Mokhoo	Centennial College	Canada
Medina, Omar	Universidad de Guanajuato	Mexico
Mehrabian, Ali	University of Central Florida	USA

Mellouli, Sehl	Université Laval	Canada
Meyer, Heiko	University of Applied Sciences Munich	Germany
Michaelis, B.	University Magdeburg	Germany
Migliarese, Piero	Universita Della Calabria	Italy
Miller, R.	The MITRE Corporation	USA
Minnaert, Eric	South Dakota School of Mines & Technology	USA
Mirza Sebzali, Yussef	Kuwait Institute for Scientific Research	Kuwait
Mistry, Jaisheel	University of the Witwatersrand	South Africa
Moin, Lubna	Pakistan Naval Engineering College	Pakistan
Moreau, Alban	University of Brest	France
Moreno, Carlos M.	Universidad Central de Venezuela	Venezuela
Moreno S. C., Ana María	Universidad Politécnica de Madrid	Spain
Morii, Hisashi	Shizuoka University	Japan
Mostafaeipour, Ali	Yazd University	Iran
Muknahallipatna, Suresh	University of Wyoming	USA
Muraleedharan, Rajani	Syracuse University	USA
Naddeo, Alessandro	Università di Salermo	Italy
Nadworny, Margaret	Global Software Group, Motorola	USA
Nagai, Yasuo	Tokyo University of Information Sciences	Japan
Nagalakshmi, Vadlamani	Gandhi Institute of Technology and Management	India
Nagaoka, Tomoyuki	Tokyo Metropolitan University	Japan
Nahmens, Isabelina	University of South Florida	USA
Naillon, Martina	Co-Decision Technology	France
Nair, V. S. Sukumaran	Southern Methodist University	USA
Nakashima, Takuya	Shizuoka University	Japan
Nam, Su Chul	Korea Electronic Power Research Institute	South Korea
Nave, Felecia M.	Prairie View A&M University	USA
Nawawi, S. W.	Universiti Teknologi Malaysia	Malaysia
Nazmy, Taymoor M.	Ain Shams University	Egypt
Nedic, Zorica	University of South Australia	Australia
Nelwamondo, Fulufhelo V.	University of the Witwatersrand	South Africa
Neo, Yoichiro	Shizuoka University	Japan
Nguyen, Mai	RTI International	USA
Nguyen, Patricia	RTI International	USA
Ni, Xingliang	University of Science and Technology of China	China
Noh, Bong Nam	Chonnam National University	South Korea
Nonaka, Hidetoshi	Hokkaido University	Japan
Novikov, Oleg	Tomko	Russian Federation
O'Brien, Ann	Loughborough University	UK
Obrebski, Jan B.	Politechnika Warszawska	Poland
Ocelka, Tomas	Institute of Public Health	Czech Republic
Oh, Yun Sang	Samsung Electronics, R. O. Korea	South Korea
Ojala, Pasi	University of Oulu	Finland
Olla, Phillip	Madonna University	USA
Olson, Patrick C.	National University and Aware Consulting Group	USA
Ong, Vincent Koon	University of Bedfordshire	UK
Osadciw, Lisa Ann	Syracuse University	USA
Ostergaard, Soren Duus	IBM Europe	Denmark
Overmeyer, Ludger	Institute of Transport and Automation Technology	Germany
Oya, Hidetoshi	Shonan Institute of Technology	Japan
Ozdemir, Ahmet S.	Marmara University	Turkey

Palesi, Maurizio	University of Catania	Italy
Paré, Dwayne E.	University of Toronto Scarborough	Canada
Park, Kyung-Chang	Chungbuk National University	South Korea
Park, Youngc	Baekseok University	South Korea
Peng, Jian	University of Saskatchewan	Canada
Petkov, Emil	Northumbria University	UK
Pfeifer, Michael	Technical University of Dortmund	Germany
Phillips, C. Dianne	NorthWest Arkansas Community College	USA
Phillips, James	Louisiana Tech University	USA
Pierce, Ryan M.	Arkansas State University	USA
Pitzer, Erik	University of Applied Sciences Hagenberg	Austria
Platt, Glenn	CSIRO	Australia
Polanski, Andrzej	Silesian University of Technology	Poland
Poon, Gilbert	University of Waterloo	Canada
Popentiu, Florin	University of Oradea	Romania
Postolache, Octavian	Instituto de Telecomunicações	Portugal
Poulin, Régis	Universite Laval	Canada
Pulcher, Karen L.	University of Central Missouri	USA
Pun, Daniel	Central Queensland University	Australia
Putnam, Janice	University of Central Missouri	USA
Quan, Xiaojun	University of Science and Technology of China	China
Quintyne, Vasco	Universoty of the West Indies	Barbados
Rachev, Boris	Technical University of Varna	USA
Rahman, Anuar Abdul	Pusat Tenaga Malaysia	Malaysia
Rahman, Mohammad	University of Texas at Dallas	USA
Ramachandran, S.	Indian Institute of Technology Madras	India
Ramirez C., Guillermo H.	Soka University	Japan
Ratkovic Kovacevic, Nada	University of Belgrade	Serbia
Ren, Jianfeng	Qualcomm Inc,QCT Multimedia R and D and Standards	USA
Revetria, Roberto	Università degli Studi di Genova	Italy
Riaz Moghal, Mohammad	University College of Engineering and Technology	Pakistan
Rodríguez, María Dolores	Universidad de Alcalá	Spain
Ropella, Glen E. P.	Tempus Dictum Inc.	USA
Rossignol, R.	Université Victor Segalen	France
Rossmann, Jürgen	RWTH Aachen University	Germany
Ruan, Tongjun	New Mexico Tech	USA
Rutkauskas, Aleksandras V.	Vilnius Gediminas Technical University	Lithuania
Saadane, Rachid	Institut Eurecom	France
Sahara, Tomohiro	Osaka Institute of Technology	Japan
Salazar, Dora	Texas Tech University	USA
Saleh, Magda M.	Alexandria University	Egypt
Sanna, Andrea	Politecnico di Torino	Italy
Šaruckij, Mark	Cracow University of Economics	Poland
Sateesh Reddy, J.	Indian Institute of Technology Madras	India
Sato, Tomoaki	Hirosaki University	Japan
Sax, Eric	Mercedes-Benz Technology Gmbh	Germany
Schaeffer, Donna M.	Marymount University	USA
Schlette, Christian	RWTH Aachen University	Germany
Schluse, M.	RWTH Aachen University	Germany
Schrader, P. G.	University of Nevada	USA
Schulz, Lennart	Institute of Transport and Automation Technology	Germany

Schumacher, Jens	University of Applied Sciences Vorarlberg	Austria
Seepold, Ralf	Universidad Carlos III de Madrid	Spain
Segall, Richard S.	Arkansas State University	USA
Seitzer, Jennifer	The University of Dayton	USA
Sert, Yasemin	University of South Florida	USA
Shaw, Jill	The Open University	UK
Shayeghi, Hossien	Iran University of Science	Iran
Shim, Eung Bo	Korea Electric Power Research Institute	South Korea
Shin, Jeong Hoon	Korea Electronic Power Research Institute	South Korea
Shin, Jungpil	University of Aizu	Japan
Shiraishi, Yoshiaki	Nagoya Institute of Technology	Japan
Shklyar, Benzion	Holon Academic Institute	Israel
Sim, Sang Gyoo	Samsung Electronics, R. O. Korea	South Korea
Sinkunas, Stasys	Kaunas University of Technology	Lithuania
Sleit, Azzam Talal	University of Jordan	Jordan
Soeiro, Alfredo	University Porto	Portugal
Song, Hong Jun	University of Sydney	Australia
Soundararajan, Ezekiel	Indiana University of Pennsylvania	USA
Srisawangrat, Songsiri	University of Regina	Canada
Starosolski, Zbigniew	Silesian University of Technology	Poland
Stasytyte, Viktorija	Vilnius Gediminas Technical University	Lithuania
Stößlein, Martin	Universität Erlangen-Nürnberg	Germany
Stubberud, Stephen	The Boeing Company	USA
Su, J. L.	Shanghai University	China
Su, Wei	National University of Defense Technology	USA
Sun, Baolin	Wuhan University	China
Suzuki, Motoyuki	Tohoku University	Japan
Swart, William	East Carolina University	USA
Szygenda, Stephen A.	Southern Methodist University	USA
Takemi, Fujikawa	University of Western Sydney	Australia
Tam, Wing K.	Swinburne University of Technology	Australia
Tappert, Charles C.	Pace University	USA
Taylor, Stephen	Sussex University	UK
Tchier, Fairouz	King Saud University	USA
Teng, Chia-Chi	Brigham Young University	USA
Teshigawara, Yoshimi	Soka University	Japan
Thakur, Amrit' Anshu	Mississippi State University	USA
Theologou, Michael	National Technical University of Athens	Greece
Thornton, Mitchell A.	Southern Methodist University	USA
Till, Robert	John Jay College	USA
Trahan, Shane	RTI International	USA
Traum, Maria	Johannes Kepler University	Austria
Trimble, Robert	Indiana University of Pennsylvania	USA
Trzaska, Mariusz	Polish Japanese Institute of Information Technology	Poland
Tsai, Li-Hung	Tatung University	Taiwan
Tsaur, Woei-Jiunn	Da-Yeh University	Taiwan
Tseng, Ko Ying	Tatung University	Taiwan
Tseng, Tzu-Liang (Bill)	The University of Texas at El Paso	USA
Tsiligaridis, John	The State University of New York at Buffalo	USA
Tsubaki, Michiko	The University of Electro-Communications	Japan
Turnitsa, Charles D.	Old Dominion University	USA

Valakevicius, Eimutis	Kaunas University of Technology	Lithuania
Van Delden, Sebastian	University of South Carolina Upstate	USA
Vargoz, Erik P.	The College of William and Mary	USA
Vasinek, Vladimir	Technical University of Ostrava	Czech Republic
Venkataraman, Satyamurti	AIAMED	India
Verlinde, Patrick	Royal Military Academy	Belgium
Viloria, Orlando H.	Universidad Simón Bolívar	Venezuela
Vitral, Renan	BITSYS	USA
Volkov-Husovic, T.	University of Belgrade	Yugoslavia
Voss, Andreas	Dortmund University of Technology	Germany
Wagner, Stefan	Upper Austrian University of Applied Sciences	Austria
Walter J., Ammann	Swiss Federal Institute for Snow and Avalanche Research Davos	Switzerland
Wang, Lei	University of Houston	USA
Warwick, Jon	London South Bank University	UK
Wei, Xinzhou	New York City College of Technology	USA
Wells, Harvey	King's College London	UK
Whitbrook, Amanda M.	University of Nottingham	UK
Wirtz, Guido	Otto-Friedrich-Universität Bamberg	Germany
Woodhead, Steve	University of Greenwich	UK
Woodthorpe, John	The Open University	UK
Wu, Chun Yin	Tatung University	Taiwan
Yamada, Seiji	National Institute of Informatic	Japan
Yamaguchi, Akira	Meisei University	Japan
Yan, Kuo Qin	Chaoyang University of Technology	Taiwan
Yan, Mu Tian	Huafan University	Taiwan
Yang, Huiqing	Virginia State University	USA
Yang, Hung Jen	National Kaohsiung Normal University	Taiwan
Yang, Ming	Jacksonville State University	USA
Yang, Sung Un	Syracuse University	USA
Yang, Yueh-Ting	Drexel University	USA
Yasser, Muhammad	BHK	Japan
Yatsymirskyy, Mykhaylo	Technical University of Lodz	Poland
Yazawa, Toru	Tokyo Metropolitan University	Japan
Yilmaz, Levent	Auburn University	USA
Yoon, Changwoo	Electronics and Telecommunications Research Institute	South Korea
Yoshida, Eri	Toyohashi University of Technology	Japan
Yoshida, Takahiro	Tokyo University of Science	Japan
You, Younggap	Chungbuk National University	South Korea
Yu, Xin	University of Bath	UK
Zadeh, Jeff	Virginia State University	USA
Zarama, Roberto	Universidad de los Andes	Colombia
Zaretsky, Esther	Givat Washington College of Education	Israel
Zelinka, Tomas	Czech Technical University in Prague	Czech Republic
Zeller, Andrew J.	Norisbank	Germany
Zhang, Jinfang	University of Waterloo	Canada
Zhang, Linda L.	University of Groningen	Netherlands
Zhang, Qingyu	Arkansas State University	USA
Zhang, Xiaozheng Jane	California Polytechnic State University	USA
Zhonghua, Fang	Shanghai Institute of Technical Physics	USA
Zhou, Dan	University of California San Diego	USA

Zhu, Hui	Soochow University	China
Zobaa, Ahmed	Cairo University	Egypt

ADDITIONAL REVIEWERS

Abdelouahab, Kadem	University of Setif	Algeria
Abe, Akinori	NTT Communication Science Laboratories	Japan
Aboalsamh, Hatim A.	King Saud University	Saudi Arabia
Abramov, Gennady	Voronezh State Technological Academy	Russian Federation
Abusitta, Adel H.	University of Jordan	Jordan
Abuzir, Yousef S. Y.	Al-Quds Open University	Palestine
Acharya, Sushil	Robert Morris University	USA
Adascalitei, Adrian A.	Gheorghe Asachi Technical University	Romania
Agakov, Felix	University of Edinburgh	UK
Aguilar Castro, José L.	University of the Andes	Venezuela
Aguilar Torres, Fernando J.	Almeria University	Spain
Ahmad, Mohiuddin	Khulna University of Engineering and Technology	Bangladesh
Aljahdali, Sultan	Taif University	Saudi Arabia
Al-Obaidy, Mohaned	Gulf College Oman	Oman
Als, Adrian	University of the West Indies	Barbados
Alwis, W. A. M.	Republic Polytechnic Singapore	Singapore
Anish, Anthony	University of Alabama at Birmingham	USA
Apostol, Marian	National Institute for Physics and Nuclear Engineering	Romania
Aruga, Masahiro	Tokai University	Japan
Averweg, Udo Richard	University of KwaZulu-Natal	South Africa
Balas, Valentina Emilia	Aurel Vlaicu University of Arad	Romania
Banger, Daljit Roy	Simple Enterprise Architecture Toolset	UK
Bartolini, Sandro	University of Siena	Italy
Bashir, Shariq	Vienna University of Technology	Austria
Benhard, Sitohang	Bandung Institute of Technology	Indonesia
Bjelkemyr, Marcus	Royal Institute of Technology	Sweden
Bocu, Razvan	University College Cork	Ireland
Braiman, Avital	Brown University	USA
Brandstätter, Markus	Technical University of Munich	Germany
Bratina, Božidar	University of Maribor	Slovenia
Breczko, Teodor	University of Bialystok	Poland
Bubnov, Alexey	Academy of Sciences of the Czech Republic	Czech Republic
Bulegon, Ana Marli	Federal University of Rio Grande do Sul	Brazil
Cai, Dengke	Technical University of Dortmund	Germany
Caleiro, António	University of Évora	Portugal
Cao, Yiwei	Aachen University	Germany
Caron-Pargue, Josiane	University of Poitiers	France
Cervenka, Jan	Cervenka Consulting, Ltd	Czech Republic
Cervone, Guido	George Mason University	USA
Chang, Ching-Pou	Hsiuping Institute of Technology	Taiwan
Cheaitou, Ali	Euromed Management	France
Chen, Duanbing	UESTC	China
Chen, Zengqiang	Nankai University	China
Cimagalli, Valerio	Sapienza University of Rome	Italy
Corbière, Alain	LIUM Laboratory	France

Cucchieri, Attilio	University of Sao Paulo	Brazil
Curós-Vilà, Pilar	University of Girona	Spain
D'Ariano, Andrea	Roma Tre University	Italy
De Lazzari, Claudio	Institute of Clinical Physiology	Italy
De Nicola, Antonio	ENEA	Italy
Del Bianco, Vieri	University College Dublin	Ireland
Della Rocca, Antonio Bruno	ENEA	Italy
Díaz Ochoa, Juan Guillermo	Max Planck Institute for Complex Technical Systems	Germany
Dimililer, Kamil	Institute of Electrical and Electronics Engineers	Cyprus
Doma, Salah	Alexandria University and Sinai University	Egypt
Dvornik, Josko	University of Split	Croatia
Eckl, Carolin	Technical University of Munich	Germany
Eggen, Roger	University of North Florida	USA
El Kashlan, Ahmed	Arab Academy for Science and Technology	Egypt
El Manouni, Said	Al-Imam University	Morocco
Eshragh, Sepideh	University of Delaware	USA
Faruqi, M.	Texas A&M University-Kingsville	USA
Fortino, Giancarlo	University of Calabria	Italy
Fu, Xiuju	Institute of High Performance Computing	Singapore
Furst, Jacob D.	DePaul University	USA
Fúster-Sabater, Amparo	Institute of Applied Physics	Spain
Gamal, Yosr	Cairo University	Egypt
Ganu, Shreerang	Florida International University	USA
Garai, Gautam	Saha Institute of Nuclear Physics	India
García, Abel	INAOE	Mexico
García Rojas, Leonardo	BSI Group México	Mexico
Georgieva T., Tsvetanka	University of Veliko Turnovo St Cyril and St. Methodius	Bulgaria
Golayoglu Fatullayev, Afet	Baskent University	Turkey
Gorgan, Dorian	Technical University of Cluj-Napoca	Romania
Grau, Juan B.	Technical University of Madrid- UPM	Spain
Hachour, Hakim	University of Paris 8	France
Ham, Chan	Southern Polytechnic State University	USA
Hassini, Abdelatif	University of Oran Es-Senia	Algeria
Hespel, Christiane	Institut National des Sciences Appliquées de Rennes	France
Hirz, Mario	Graz University of Technology	Austria
Hokimoto, Tsukasa	Hokkaido University	Japan
Holifield, David	University of Wales Institute Cardiff	UK
Hu, Chuan-Gan	Nankai University	China
Huang, En-Hsin	Alcatel-Lucent Technologies	USA
Huang, Tingwen	Texas A&M University at Qatar	Qatar
Hussein Al-janabi, Samaher	Babylon University	Iraq
Ingber, Lester	Lester Ingber Research	USA
Inzunza González, Everardo	Autonomous University of Baja California	Mexico
Iribarne, Luís	University of Almeria	Spain
Ivanov, Sergiu	University of Craiova	Romania
Jaén, José Alberto	Polytechnic University of Madrid	Spain
Jakkula, Vikramaditya	Washington State University	USA
Janota, Ales	University of Zilina	Slovakia
Jardim-Goncalves, Ricardo	University Nova of Lisboa	Portugal
Jia, Lei	New York University	USA
Kamyshnikov, Vladimir	Tomsk State Architectural University	Russian Federation

Karadimitriou, Kosmas	Louisiana State University	USA
Kawaguchi, Masashi	Suzuka National College of Technology	Japan
Kim, Kyungdeok	Uiduk University	South Korea
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The 8th International Symposium on Risk Management and Cyber-Informatics: RMCI 2011
in the context of
The 15th Multi-conference on Systemics, Cybernetics and Informatics: WMSCI 2011

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Number of Papers Included in these Proceedings per Country

(The country of the first author was the one taken into account for these statistics)

Country	# Papers	%
TOTAL	**193**	**100.00**
United States	37	19.17
Japan	11	5.70
South Korea	11	5.70
Latvia	10	5.18
Germany	9	4.66
China	8	4.15
Taiwan	8	4.15
Czech Republic	7	3.63
India	6	3.11
Mexico	6	3.11
Turkey	6	3.11
Australia	5	2.59
Brazil	5	2.59
Canada	5	2.59
Italy	5	2.59
Spain	5	2.59
United Kingdom	5	2.59
France	4	2.07
Lithuania	4	2.07
Croatia	3	1.55
Denmark	3	1.55
Egypt	3	1.55
Israel	3	1.55
Poland	3	1.55
Finland	2	1.04
Greece	2	1.04
Iran	2	1.04
Malaysia	2	1.04
Slovakia	2	1.04
Austria	1	0.52
Belgium	1	0.52
Colombia	1	0.52
Cyprus	1	0.52
Indonesia	1	0.52
Netherlands	1	0.52
Portugal	1	0.52
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South Africa	1	0.52
Switzerland	1	0.52
Vietnam	1	0.52

Foreword

Our purpose in the 15th World Multi-Conference on Systemics, Cybernetics and Informatics (WMSCI 2011) is to provide, in these increasingly related areas, a multi-disciplinary forum, to foster interdisciplinary communication among the participants, and to support the sharing process of diverse perspectives of the same transdisciplinary concepts and principles.

Systemics, Cybernetics and Informatics (SCI) are being increasingly related to each other in almost every scientific discipline and human activity. Their common transdisciplinarity characterizes and communicates them, generating strong relations among them and with other disciplines. They work together to create a whole new way of thinking and practice. This phenomenon persuaded the Organizing Committee to structure WMSCI 2011 as a multi-conference where participants may focus on one area, or on one discipline, while allowing them the possibility of attending conferences from other areas or disciplines. This systemic approach stimulates cross-fertilization among different disciplines, inspiring scholars, originating new hypothesis, supporting production of innovations and generating analogies; which is, after all, one of the very basic principles of the systems' movement and a fundamental aim in cybernetics.

WMSCI 2011 was organized and sponsored by the International Institute of Informatics and Systemics (IIIS), member of the International Federation for Systems Research (IFSR). IIIS is an organization dedicated to contribute to the development of the Systems Approach, Cybernetics, and Informatics potential, using both: knowledge and experience, thinking and action, for the:

a) identification of synergetic relationships among Systemics, Cybernetics and Informatics, and between them and society;
b) promotion of contacts among the different academic areas, through the transdisciplinarity of the systems approach;
c) identification and implementation of communication channels among the different professions;
d) supply of communication links between the academic and professional worlds, as well as between them and the business world, both public and private, political and cultural;
e) stimulus for the creation of integrative arrangements at different levels of society, as well as at the family and personal levels;
f) promotion of transdisciplinary research, both on theoretical issues and on applications to concrete problems.

These IIIS objectives have directed the organizational efforts of yearly WMSCI/ISAS conferences since 1995.

On behalf of the Organizing Committee, I extend our heartfelt thanks to:

1. the 496 members of the Program Committee from 69 countries;
2. the 821 additional reviewers, from 86 countries, for their **double-blind peer reviews**;
3. the 529 reviewers, from 68 countries, for their efforts in making the **non-blind peer reviews**. (Some reviewers supported both: non-blind and double-blind reviewing for different submissions).

A total of 2461 reviews made by 1350 reviewers (who made at least one review) contributed to the quality achieved in WMSCI 2011. This means an average of 6.29 reviews per submission (391 submissions were received). *Each registered author had access, via the conference web site, to the reviews that recommended the acceptance of their respective submissions.* Each registered author could also get information about: 1) the average of the reviewers evaluations according to 8 criteria, and the average of a global evaluation of his/her submission; and 2) the comments and the constructive feedback made by the reviewers, who recommended the acceptance of his/her submission, so the author would be able to improve the final version of the paper.

In the organizational process of WMSCI 2011, about 391 papers/abstracts were submitted. These pre-conference proceedings include about 193 papers that were accepted for presentation from 40 countries. I extend our thanks to the invited sessions' organizers for collecting, reviewing, and selecting the papers that will be presented in their respective sessions. The submissions were reviewed as carefully as time permitted; it is expected that most of them will appear in a more polished and complete form in scientific journals.

This information about WMSCI 2011 is summarized in the following table, along with the other collocated conferences:

Conference	# of submissions received	# of reviewers that made at least one review	# of reviews made	Average of reviews per reviewer	Average of reviews per submission	# of papers included in the proceedings	% of submissions included in the proceedings
WMSCI 2011	**391**	**1350**	**2461**	**1.82**	**6.29**	**193**	**49.36%**
IMETI 2011	**212**	**679**	**1431**	**2.11**	**6.75**	**88**	**41.51%**
IMSCI 2011	**276**	**856**	**2104**	**2.46**	**7.62**	**124**	**44.93%**
CISCI 2011	**388**	**973**	**2359**	**2.42**	**6.08**	**173**	**44.59%**
TOTAL	**1267**	**3858**	**8355**	**2.17**	**6.59**	**578**	**45.62%**

We also extend our gratitude to the focus symposia organizers, as well as to the co-editors of these proceedings, for the hard work, energy and eagerness they displayed preparing their respective sessions. We express our intense gratitude to Professor William Lesso for his wise and opportune tutoring, for his eternal energy, integrity, and continuous support and advice, as the Program Committee Chair of past conferences, and as Honorary President of WMSCI 2011, as well as for being a very caring old friend and intellectual father to many of us. We also extend our gratitude to Professor Belkis Sanchez, who brilliantly managed the organizing process.

Our gratitude to Professors Bela H. Banathy, Stafford Beer, George Klir, Karl Pribram, Paul A. Jensen, and Gheorghe Benga who dignified our past WMSCI conferences by being their Honorary Presidents. Special thanks to Dr. C. Dale Zinn and Professor Jorge Baralt for co-chairing WMSCI 2011 Program Committee and to professors Andrés Tremante and Belkis Sánchez for co-chairing the Organizing Committee. We also extend our gratitude to Drs., Louis H. Kauffman, Leonid Perlovsky**,** Stuart A. Umpleby, Thomas Marlowe**,** Ranulph Glanville, Karl H. Müller, Shigehiro Hashimoto, T. Grandon Gill, Alec Yasinsac, Marta White Szabo**,** Jeremy Horne, Mario Norbis, Ham Chan, Felix Soto-Toro, Susu Nousala, and Dipl.-Math Norbert Jastroch**,** for accepting to address the audience of the General Joint Plenary Sessions with keynote conferences.

Many thanks to Drs. Dale Zinn, Jorge Baralt, Hsing-Wei Chu, Andrés Tremante, Friedrich Welsch, Thierry Lefevre, José Vicente Carrasquero, Angel Oropeza, and Freddy Malpica for chairing and supporting the organization of the focus symposia and conferences in the context of, or collocated with, WMSCI 2011. We also wish to thank all the authors for the quality of their papers.

We extend our gratitude as well to Maria Sanchez, Juan Manuel Pineda, Leonisol Callaos, Dalia Sánchez, Keyla Guedez, Nidimar Díaz, Marcela Briceño, Cindi Padilla Louis Barnes, Sean Barnes, Marisela Jiménez, Noraima Castellano, Abrahan Marin, and Freddy Callaos for their knowledgeable effort in supporting the organizational process producing the hard copy and CD versions of the proceedings, developing and maintaining the software supporting the interactions of the authors with the reviewing process and the Organizing Committee, as well as for their support in the help desk and in the promotional process.

Professor Nagib C. Callaos
WMSCI 2011 General Chair

WMSCI 2011
The 15th World Multi-Conference on Systemics, Cybernetics and Informatics
The SUMMER 5th International Conference on Knowledge Generation, Communication and Management: KGCM 2011
The 4th International Symposium on Academic Globalization: AG 2011
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The 2nd International Symposium on Design and Research In Artificial and Natural Sciences: DRANS 2011
The 2nd International Symposium on Science 2 and Expansion of Science: S2ES
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A Perspective on Knowledge Generation in Humans

Donald Bligh (University of Exeter UK)

Abstract

1 I aim to present a new perspective on human understanding. The perspective is this: A method of explanation controls the kind of knowledge you generate. That's because method controls the relevance of evidence for beliefs.

2 Methods of explanation consist of relating new ideas to old ones. That is to a preformed context.

3 But there's an old problem. What was the preformed context's preformed context? And then its preformed context? And so on. How does knowledge start?

4 This paper says it does not start with some fundamental concepts. It starts with basic brain processes that are necessary to have concepts. They are abilities.

5 There are about a dozen of these, and the bulk of the paper, describes them with numerous visual illustrations from many disciplines. Knowledge from spiritual revelations is rejected.

6 The brain processes combine in an infinite number of ways like atoms in molecules.

7 Yet in the build up of knowledge upon knowledge, each brain process characterises a particular type of explanation.

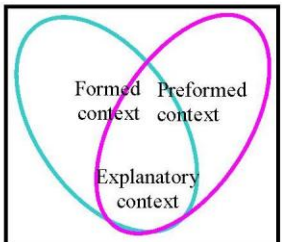
8 The build up creates an underlying structure of knowledge.

9 When challenging explanations in rational argument or discussion, there is a tendency to shift from one explanatory type to another in an ordered way.

Keywords: Philosophy, Knowledge, Learning, Science, Method, Psychology, Explanation

THE IMPORTANCE OF METHOD.

The method of explanation you use controls the kind of knowledge you generate, not the other way round. That's because method controls the relevance of evidence for a proposition. For example if you use religious texts, astrology or scientific methods to explain the solar system you will get very different answers because those methods use different facts and patterns of reasoning. That may be an extreme example, but conflicts generated within, and certainly between, disciplines can often be resolved by recognising subtle differences in their methods. Bohr vs Einstein and freewill vs determinism are examples.

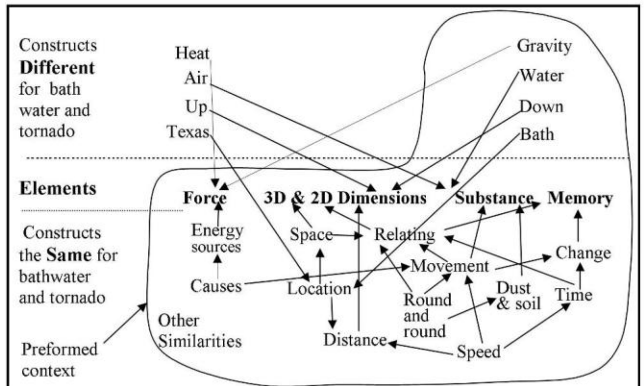


1 The explanatory context is where the preformed and formed contexts are the SAME

So to understand in any depth the knowledge you generate requires analysing how you got it. At one level we can say that, like doing a jig-saw, any explanation involves fitting a new idea to ideas you've already got. Existing ideas form a preformed context. In order to fit, the new idea will have some elements that are the same. That overlap is the explanatory context. But some will be different. What is different and what is the same will form a new context which, in its turn, will be a preformed context for the next new idea.

2 Relate learning to experience

It is as if in any perception and any explanation the brain says *'This is the same as that and it's different from the other'*. These are two brain processes. I call them *'same'* and *'different'* for short. They are not concepts. They are more fundamental. They are abilities the brain needs to have a concept. I call them *'elements'* or abilities that make up a preformed context.



3 Learning fits new ideas to old. That's the art of teaching. The preformed context has a network of related constructs the girl has acquired (unconsciously) already. Arrows suggest lines of dependence. For example the idea of time depends upon experience of change. Dependence converges on basic elements of thought.

What's that? a girl asks, looking at a picture of a tornado.

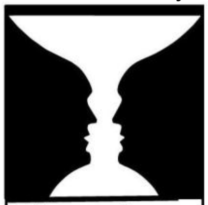
It's a tornado along a Texan motorway. Texas is in America. The air is whirling dust and soil round and round high into the air. That's why it's black. The black dots near the ground are bits of houses destroyed as the air goes round and round.

Why does it go round and round?

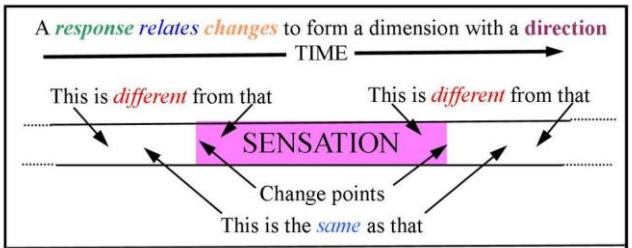
It's like your bath water goes round and round down the plug hole when you've finished your bath, except that the air in the tornado goes up and the water in your bath goes down.

Understanding the answer depends on recognising that the preformed context, the bath water, is the same as, yet different from, the tornado. Tornado is the concept generated relying on a new combination of underlying fundamental abilities, a newly formed context.

But there is an old problem with this. What was the preformed context's preformed context? And what was its preformed context? And so on ad infinitum? Well no. The infinite regress stops when you reach the fundamental methods the brain uses. They are basic brain processes.


4 Figure and ground

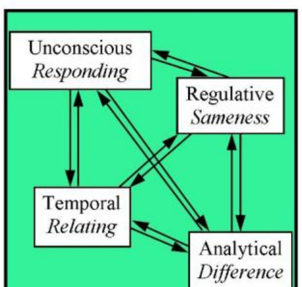
It is important to realise how fundamental *'same'* and *'different'* are. Let's get really fundamental. Perception is to see a figure that is the same in some way and different from its background. Imagine a stimulus, a sensation, a sound. To perceive it, the brain must *'respond'* by *'differentiating'* as the *'same'*, the times when there is no stimulus from when there is; and *'relate'* as the *'same'* those instants when there is. *'Same', 'different', 'responding' and 'relating'* are the most fundamental elements (abilities). All education, all learning and all knowledge depend upon them. If you are a teacher keep all of them in mind when you introduce a new concept.



5 Same, different, responding and relating as basic abilities

What is interesting, if you try to define any one of these four, you will find yourself using the others to do so. They are fully interdependent brain processes. They are fully *'coherent'*. In the figure below, explanatory types depend upon abilities arrows point at as well as their own.

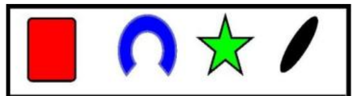
Temporal knowledge. It is arguable that ***'Temporal explanations'*** depend upon *'memories'* as well as *'responses' 'relating' 'same'* and *'different'*. If so, at least the shortest of memories is necessary to conceive of time. On this argument, animals without memories, like most insects, only *'respond'* instinctively to *same'* and *different'* stimuli and consequently are ineffective learners. I think this argument is a little simple, but *'memory'* and the construction of time *'relationships'* seem necessary components of all learning and knowledge in a way that spatial relationships are not, when learning music, for example.



Words in italics depict abilities. Non-italic scripts name types of explanation. Explanatory types depend on abilities arrows point at as well as their own. NB There is total dependence ie. coherence.

6 Basic abilities are coherent

What's the relevance? I must step back a while. I'm getting into some pretty abstract notions and you may be asking why all this matters and where is it leading. I must answer it is about the theme of out conference. How is knowledge generated? It's about how knowledge builds upon itself and then how it is structured. It's about how knowledge fits together and more importantly, how it doesn't. It is about what is fundamentally human – our abilities to explain and understand. Explaining is the particular business of universities in research, in lectures, seminars and essays. I'm leading you to recognise that there are at least a dozen or so explanatory processes. And they each characterise different explanatory types. I call these abilities, these brain processes, ***elements*** of a method of explanation because, like elements in molecules, they can combine in an infinite number of ways in preformed contexts in different explanatory types. As I said at the beginning, I should like to show you that some apparently conflicting theories, freewill and determinism for example, don't conflict because they are based in quite different contexts.


7 Which shape is most like Thursday? And which is most like a circle?

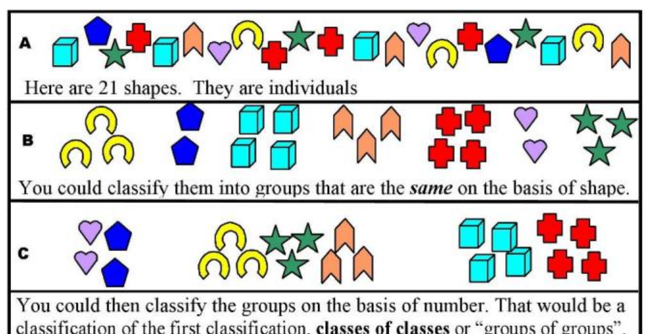
The question an explanation seeks to answer sets the most important element or ability in the preformed context. The question sets the method of getting knowledge. I also want to show that sometimes we can't get a satisfactory explanation because we've asked the wrong question. Which of these shapes is most like Thursday is an obvious example. But some wrong questions are much more subtle. As I shall say later, the whole of our criminal law is based upon a medieval philosophical mistake. It assumes that awareness can cause or restrain our brain's behaviour. But awareness is a consequence, not a cause, of the brain's activity. Awareness is retrospective, not executive. In any case awareness is a mental phenomenon and only physical phenomena can cause physical events like the brain's activity.

STRUCTURE OF EXPLANATORY TYPES

So now the task is to identify those processes, elements, abilities and the type of explanation they support.

Regulative knowledge. Sameness is by far the most important explanatory element. It is fundamental to any explanation based upon a rule or generalisation. Why? Because rules and generalisations are saying *'Treat these examples in the same way'* I call them ***'Regulative explanations'.*** They include mathematics, logic, all laws whether legal, moral, causal and functional explanations.

Mathematics uses sameness over and over again. "Equals" is about sameness. You can't add or subtract apples and oranges. The items have to be the same in some way. More than that, Bertrand Russell**[1]** showed 100 years ago that numbers are classes of classes. They are samenesses of samenesses.



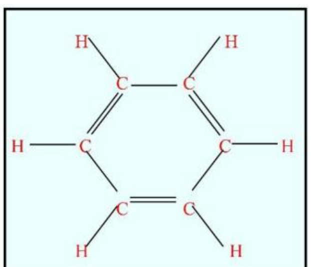
8 Mathematics is ultimately empirical. It use compounds of same.

A large number of regulative explanations are ***functional explanations.*** Functions are what something regularly does. The liver purifies the blood. The natives' dance wards off evil spirits, though you may think its function is to generate community cohesion. Functional explanations are used in architecture, physics, psychology, personnel management, engineering, town planning, …you name it, but most of all in biology. Darwin**[2]** showed how birds on the Galapagos Islands evolved differently when their beaks functioned differently.

Analytical knowledge. ***Analytical explanations*** are based upon the element, *'different'*. What analysis does is to distinguish one thing from another. Nearly every explanation and every perception begins with analysis. Let's imagine a mineralogist who has just split open a rock with his geological hammer. How does he recognize what he sees?

9 To perceive, analysis alternates with sameness

1. **Different:** He sees colored patches (later recognized as crystals) as a figure different from its amorphous background
2. **Same:** by grouping them together as being in the same part of his visual field.
3. **Different:** He distinguishes one part of the visual field as different from the rest
4. **Same:** as having flat sides, a shiny surface and/or a distinctive color.
5. **Different:** Making an assumption that what he sees is a material *substance*, combined with a preformed context, namely his previous knowledge of minerals
6. **Same:** he classifies what he sees as one of a particular group of minerals.
7. **Different:** Using a preformed context, namely his previous knowledge of mineral hardnesses
8. **Same:** he narrows the classification to which this mineral belongs.
9. **Different:** Using again his preformed context, namely previous knowledge of crystal symmetry
10. **Same:** he learns that what he is looking at is a crystal of feldspar.

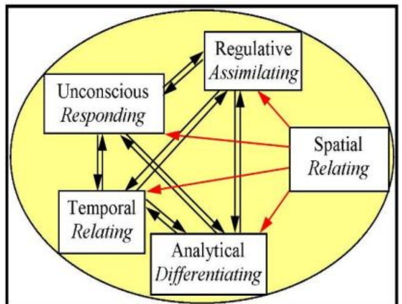


10 Chemistry explained spatially

Spatial knowledge. Relating two and three dimensions characterises ***'Spatial explanations'***. Anatomy, geography, fine arts such as sculpture and the physical sciences, such as chemical formulae are amongst disciplines obviously dependent upon spatial explanations. Brain processes in the optic nerve and occipital cortex responsible for spatial abilities have been studied fairly well in the past 50 years.

It will already be apparent that, more than many people, I think visually. I have tried to represent abstractions like 'sameness', 'different' and 'time' spatially. Indeed I regret that our educational methods and assessments tend to eliminate spatial thinkers in preference to people who are more adept with words. Even with modern printing techniques, academic journals are reluctant to print diagrams and pictures.

The directions of dependencies indicate a relationship of brain processes. They suggest how knowledge is built up, how it is generated and how one explanatory type builds upon others. It suggests a structure of explanatory methods, and thereby suggests an underlying structure of knowledge. See Figure 18. As I have tried to suggest by the analogy with a chemical

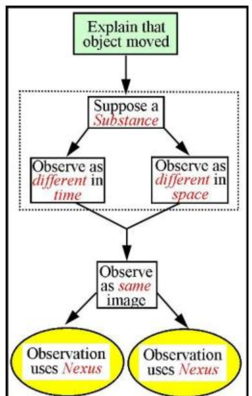


Explanatory types (not in italics) depend on abilities (italics) their arrows point at. Abilities combine to make to a method of explanation.

11 Nexus Dependence of spatial explanations.

molecule and the girl's preformed context, in practice the same processes are used many times in any one preformed context, rather like the same chains of elements repeat in DNA.

Knowledge of movement. Spatial explanations do not necessarily assume the existence of a physical object or substance. Logically they don't. Consider two dimensional representations for example Euclid's geometry. Yet most do. However there is one explanatory type that must make that assumption. That is an explanation that something has moved. That's a ***kinematic explanation***. Consider the following examples. I recognize a nurse from the hospital at a dance. At the dance she's not in uniform and the background context is very different, but there is enough that is the same, her face for example, to conclude that she is the same person. (Notice once again how same and different are intrinsic to the thought.) At an unconscious level I must explain the similarity contained in these images. My answer is that there exists a thing as an object, a physical substance, and it has moved. Analyze this answer: There are at least two observations different in time and space to which I add a new element, substance. See Figure 12.



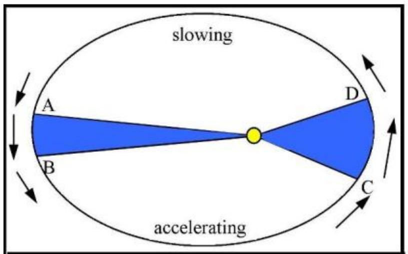
The process whence the arrow comes depends upon the process it points to.

12 Minimal structure of a kinematic explanation

That is how new explanatory types build upon old ones. In this case responses using elements of same, different, time and space are used several times with the addition of a new element or assumption, the existence of substances. Consider examples. The stones of Stonehenge in England built by the Ancient Britons are unlike any local stone. The nearest place with the same rock type is in South Wales. We conclude the Ancient Britons moved them miles away uphill. How they did so with their level of technology is a mystery. But it seems the only explanation.

Kepler**[2]** brought together many observations of the planets at different times and places and concluded that they move, accelerating and slowing, in elliptical orbits sweeping out equal areas in equal periods of time. It was more of a kinematic description than an explanation and he certainly didn't know

13 Stonehenge is not local stone. The kinematic assumption: stones were moved here by ancient Britons. But how? A causal explanation needs a force they surely didn't have.

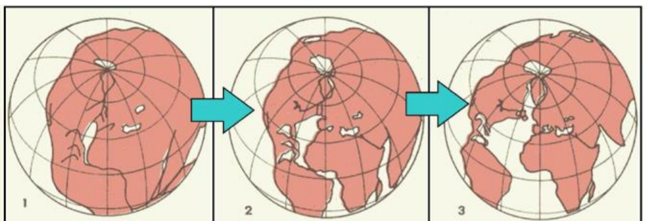


Law I: Each planet revolves around the Sun in an elliptical path, with the Sun occupying one of the foci of the ellipse.
Law II: The straight line joining the Sun and a planet sweeps out equal areas in equal intervals of time.

14 Kepler described movement, not why.

what forces were accelerating and slowing the movements.

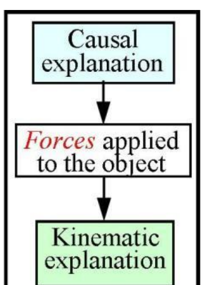
Knowledge of causes. On the basis of many observations of flora, fauna and geological types, Alfred Wegener proposed a theory of Continental Drift in 1912**[3]**. The theory was not accepted at the time because there was no known force that could have moved them. A kinematic explanation was not good enough. People wanted a causal explanation. As I'm sure you know, by 1953 enough was known of atomic energy to suggest a sufficiently powerful force. ***Causal explanations*** require another explanatory element, namely a force. Some kind of energy seems to be necessary in addition to all the elements supporting explanations of movement.



15 In 1911 Wegener could not explain the forces that moved continents

What is important here is to recognize that ***causal explanations*** depend upon the assumption that there is a physical substance. In our cultural heritage there has been a contrary assumption, namely that non-physical entities such as mind and spirits, can cause physical consequences. Religious organizations have never truly faced this particular conflict with science. See Figure 22.

The belief that prayer can induce spiritual or other metaphysical entities to intervene in the material world, contrary to science, seems optimistic.



16 Causal explanations depend on forces and kinematics

Functional explanations. This raises the question of causal laws. Some scientists talk as if all scientific explanations are causal. I hope I have said enough to contradict that. Paradoxically, causal laws as generalizations, are strictly ***regulative explanations.*** As such, they are important ***functional*** explanations though dependent upon causal ones. So looking at the structure of physical explanations, I have specified that dependence in Figures 18 and 24.

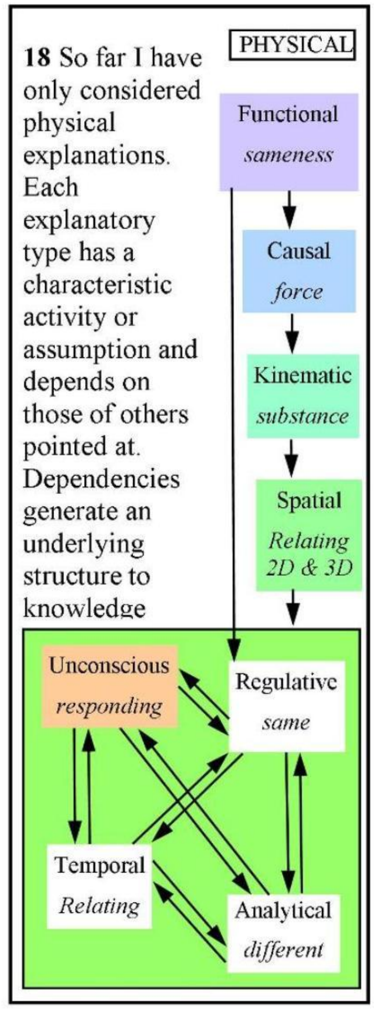
We have now developed a structure of physical explanations. In Figure 18, labels for specific brain processes, abilities or "elements" are in italics. Explanatory types are not. Explanatory types are dependent upon their own element and those they point to. All explanations depend upon *responses* that *relate* observations as being the *same* or *different*. Causal explanations depend upon there being time and space, a force and substance.

17 Cause and effect is learned early

It is worth pointing out that although humans may have an inbuilt disposition to interpret events in terms of cause and effect, that ability is learned in the sense that some relevant experience is necessary to develop it. Unlike the other abilities, the disposition is not there at birth. It appears in the first year or two of life as a part of maturation.

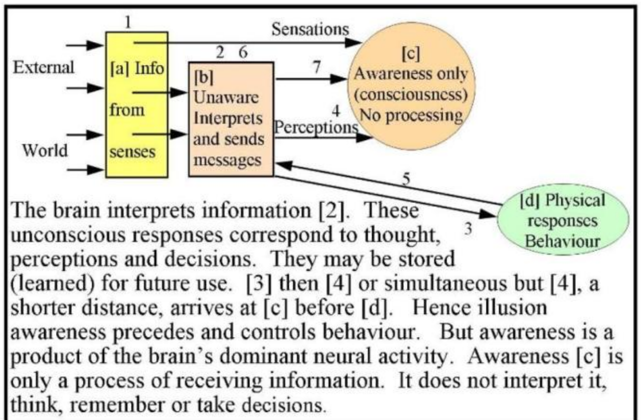
I don't know how to define objectivity. It may have something to do with public verification, but I regard these explanations as relatively objective compared with those that are about myself. It seems to be the content of the knowledge generated that makes the difference.

Unconscious knowledge. One thing I can say is that, whether about myself or the world outside, the vast majority of explanations are ***unconscious responses***. We go about our lives responding to the host of stimuli we receive by relating them, sequencing them in time, rearranging, organizing and interpreting them without any awareness of doing so. That process uses no language and no communication with others whilst interpretation is going on. We generate knowledge unconsciously whilst aware of other activities. True, we can retrieve to mind some of those brain processes after the event. We may then hunt around to find words to describe our previously unconscious thoughts. After the automobile accident we explain to the officer what happened when, at the time, we were chatting to our passenger wholly unaware of how we were interpreting the road ahead.



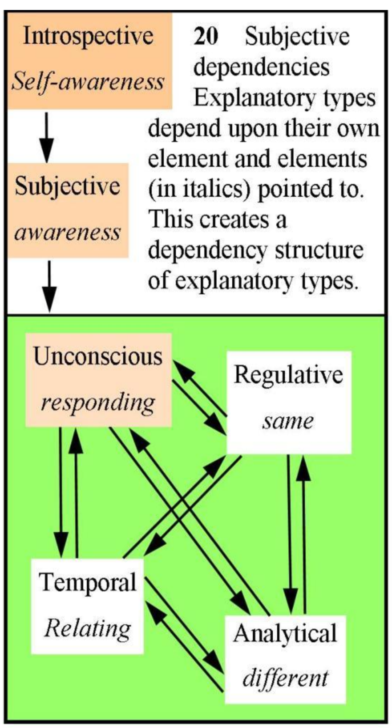
18 So far I have only considered physical explanations. Each explanatory type has a characteristic activity or assumption and depends on those of others pointed at. Dependencies generate an underlying structure to knowledge

Awareness. And here is an important point. All awareness is after the event. All awareness is retrospective though we have an illusion that we can be aware of what we are doing. Yet to say we were aware of something at the time is a very common explanation. We think we were aware of what we were doing before and while we were doing it. Teachers tell us to pay attention and think what you are doing!



19 Illusion that awareness controls action

How should we explain this illusion about our explanations using awareness? Though my brevity risks being glib, there are two points. The first is that awareness is about receiving information, not giving it. The second is all about timing. Awareness seems to involve the thalamus in the brain spraying the cerebral cortex with information about the unconscious explanations. That is a much quicker process than sending instructions to muscles on how to behave and then getting feedback about that process. (Compare route 4 with 3 5 6 7 in Figure 19). So we get the impression that we know we are going to act before we actually do. We seem to be privvy to the process of decision-making, when in fact the decision was taken and instructions sent to the muscles before we were aware of it. Our learning about ourselves is in error.



20 Subjective dependencies Explanatory types depend upon their own element and elements (in italics) pointed to. This creates a dependency structure of explanatory types.

For many people, to accept this error is very painful. Our brains determine our behaviour before we are aware of it. It is about the supposed conflict between scientific determinism and freewill. Yet they are not in conflict because they are about different things. Determinism is about the chain of causes and effects from the External World, to [a] information given to the senses, to brain processing [b], to behaviour [d]. The explanatory method is causal and physical. Freewill in Figure 19 consists of [b] and [c]. The method is awareness and mental. And here I return to the crucial first words of this paper: "The method of explanation you use controls the kind of knowledge you generate". Their preformed contexts are quite different. They don't conflict because they are not on the same battlefield. They are talking about quite different things. The error is the same as "Which shape is most like Thursday?" The confusion disappears once you recognise that.

This is a crucial point. You get confusion if you are unclear about the method, the preformed context, and the explanatory type you are assumng. They must fit the question being asked. Frewill and determinism are answers to different kinds of question. One is physical; the other mental.

Introspection. Questions about awareness as a method of learning are further confused by questions like "How do you know you are in pain?" and "How do you know the robber had a limp?" The answer to the first is "I just do. I'm not weighing up evidence and making a judgement about it. I'm in pain is not an interpretation, a decision or a judgement. It's an event". But introspecting my recollections about what I saw when the robber ran away is a judgement weighing evidence. One is about awareness; the other about awareness of awareness.

The latter method is ***introspection.*** It is used a great deal not only to be aware of what we saw, but to be aware of what we thought and felt now or then. For these questions we flit in and out of introspection and back to simple awareness with such facility it is difficult to know what explanatory type we are using. It's awareness gone compound. It is very vulnerable to self-deception. So isn't it an unreliable method for obtaining knowledge about oneself? Yes, but for many questions no other method is available or appropriate for what we want to know. "Bad but there's nothing better" might be the conclusion.

So far, regarding knowledge generated by rather more subjective methods, I have all too briefly considered three methods and they form the beginnings of a structure of dependence one upon another. The majority of responses are unconscious perceptions. (I regard all perceptions as products of explantory brian processes because they are interpretations of neural data.) Explanations based upon conscious awareness of the world depend upon, and use, unconscious responses. Introspection of awareness obviously depends upon prior awareness. See Figure 20.

Non-moral values. Several forms of knowledge entail values. How do we get them? They depend upon our feelings and emotions. Freud tells us that some are inborn and others are learned and that most of them are unconscious responses. The counselor's job is to bring them to awareness and then encourage the client to introspect and deal with conflicting values. Thus values are dependent upon the structure I have just described.

21 The Three Graces

Ultimately explanations using non-moral values are relative judgments of how far we like or dislike something. Their element is a relative *'preference'.* Consider our ***aesthetic values*** towards Canova's statue of The Three Graces. It is widely admired. Why? Is it the form of the statue, its composition, its balance and its smooth curves? Is it the sexual attraction of the subject? Is it because it evokes in humans feelings of mutual love, friendship, caring and protection that are all basic physical needs of human beings? Or is it because the statue appeals to rather more subtle and possibly abstract feelings such as empathy, consolation and loyalty? If so, these values seem to have a physiological basis in what it is to be human. It is unlikely to be so attractive to other animals.

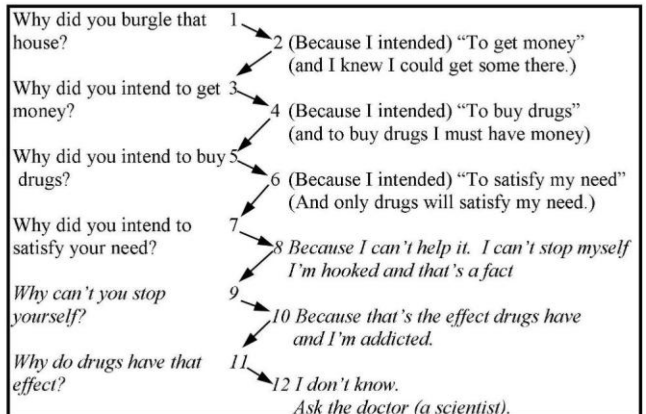
Moral knowledge. I emphasize the dependence of these values upon our physical nature because many religious groups have long believed that our moral values have a spiritual or other metaphysical source. Yet surely our ***moral knowledge*** is dependent upon, or at least has to be consistent with, our non-moral values? The distinctive element of moral knowledge is a feeling of *'obligation'*. Like a 'preference' it is a mental phenomenon, but many people would say an obligation is not relative. You can like two things either equally or one more than the other; but if you have two obligations at the same time, there can be circumstances where you must choose one and not the other. Obligations are all or nothing.

Purposive explanations. Finally Figure 23 shows we also offer purposive explanations based upon intentions.

Spiritual knowledge. There are people who claim to have ***spiritual knowledge.*** Unfortunately for people who do not have this knowledge it is difficult to know what it is. That might be said of all the other kinds of knowledge I have mentioned. However there is a difference. If someone had no knowledge of, say, time, this defect could be attributed to the absence of a physical cause in the brain applying a force to a substance in time and space. If spirits are not physical substances in space it is difficult to see how they can affect anything in space, least of all, a material substance. Certainly that ability is contrary to assumptions of the physical sciences. There is consequently a conflict between spiritual knowledge using spiritual explanations and scientific knowledge using scientific explanations. For this reason spiritual knowledge does not fit the structure of knowledge our brain processes seem to imply. It seems to be left floating on a cloud in the blue. Spiritual explanations are not explanations at all if they don't fit a preformed context. It is open to believers to show that they do. See Figure 24.

A STRUCTURE OF KNOWLEDGE AND EXPLANATORY SHIFTS

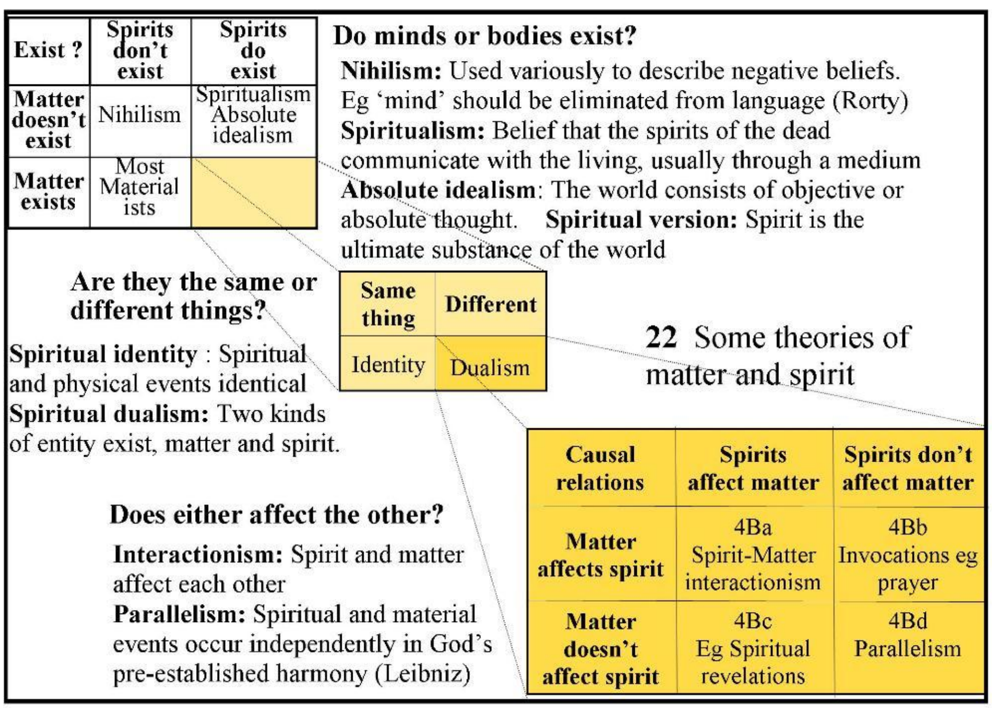
Within the brevity of this paper I have tried to establish a structure of knowledge. Each explanatory type entails dependence upon several, indeed many, abilities. Figure 24 includes only the minimum logical dependences. There are many dependences that are not logically necessary. They are usually entailed in the minor premise. In practice it is obvious, for example, that mental knowledge depends upon physical beliefs (though historically there have been philosophers who deny that). If every dependence and minor premise was shown in Figure 24, it would be a glorious mess. That's because, in the long run, all our explanations, except spiritual ones, do fit together in a coherent mass. The chart, perhaps misleadingly, suggests a coherent foundation for two distinct kinds of knowledge.



23 Explanatory shift from intentions to causes

Explanatory Shifts The chart reveals something interesting about how people justify their beliefs and actions. The young offender repeatedly asked to explain the values behind his intentions, replies with further values for a while; but then suddenly shifts down the chart from values to an introspection about himself, *"I can't help it"*. When asked about that he shift downwards a further step to his awareness of *"the effect drugs have"*. The questioner picks up on the word "effect", rather than challenging his awareness, so the conversation shifts away from mental explanations to physical ones. He has shifted from one side of the chart to the other.

Critically when there is a shift the element of the departed explanatory type drops out of the reasoning. For this reason moral arguments often discuss only facts, not morals.

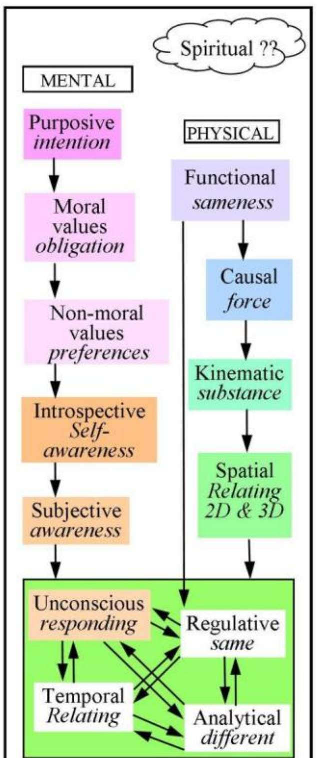


22 Some theories of matter and spirit

CONCLUSIONS

What does this paper achieve? It gives a big picture of how all knowledge is generated in humans; yet it does so at the most fundamental level, not in terms of concepts, but in terms of the brain processes (the elements or abilities) that are necessary to have concepts.

By showing an underlying structure of all knowledge it shows that if you cannot explain something in its own terms, that is to say using the explanatory type assumed by the question to be answered, then shift to the explanatory type immediately below it in Figure 24, not withstanding that this changes the subject away from the terms (the element) in which the question was first posed. Otherwise explanatory shifts risk being evasions for which politicians are notorious. It is true, however, that shifts may reasonably be made to explain a subordinate premise that might be of any explanatory type.



24 An underlying structure of knowledge

Every fact has an explanatory type as its provenance and every question a preformed context. Awareness of the structure provides not only a check on irrelevance, but a guide to what methods are available to answer a question.

The wide view of knowledge is a useful educational corrective to narrow mindedness and over specialization. The book *"Explaining Everything ! in more depth"***[8]** provides a 20 or 24 week course suitable for research students who need to understand their research problem in a variety of contexts.

In line with Kuhn's**[9]** suggestion that knowledge leaps in bounds when there is a paradigm shift, the structure provides new ways of looking at intractable problems.

The classification of problems in terms of their explanatory type can reconcile apparent long-standing intellectual conflicts such as the freewill-determinism debate, literary disagreements and historical and sociological interpretations.

There are, of course, many psychological perspectives on learning (cf. Pavlov, Skinner, Gestalt and Freud[**10]**), whilst logicians, empiricists and rationalists throughout history have presented theirs. Yet so far as I know, the perspective of learning suggested in this paper focusing on methods of understanding is original and compatible with neuroscience. It is pre-conceptual. Once the model is fully understood it can be applied in many fields. For example, by describing what teachers try to instil in terms of brain processes, it is a step nearer to developing a neuroscience of education. More important, as a route to reconciliation, it provides a way of empathising with others' points of view. Other theories don't do this.

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Lisbon strategy on e-Europe as a Knowledge Based Economy and Information Society After Ten Years Since Year 2000

Dusan SOLTES
Faculty of Management, Comenius University,
Bratislava City, 820 05, Slovakia

Abstract: The paper deals with some aspects of the Lisbon strategy of the EU on e-Europe as adopted in year 2000 with the main its objective to make of the EU till the target year 2010 the most advanced knowledge based economy in the world with the Internet as its main backbone of the future e-Europe as a full-fledged Information society. Now ten years after we are trying in this paper to make a brief evaluation what of those strategic goals have been achieved and/or at least partially achieved and what is needed for the future development.
Keywords: e-Europe, Lisbon strategy, ICT-Information and Communication technologies, IST-Information Society Technology, e-Health, e-Government, knowledge based economy, Information society, knowledge base, expert system, community research, ERA – European research area, i2010 strategy, 7FP –Seventh framework program, regions of knowledge

1. INTRODUCTION

According to the original EU Lisbon strategy on e-Europe as adopted in year 2000 for the subsequent decade till year 2010 as one of the main and the most important strategic objectives has been defined the future EU2010 and/or e-Europe as the most advanced knowledge based economy and information society in the world with the full and the most efficient utilization of the latest results and achievements as achieved by the high quality community research especially in connection with the application of the contemporary ICT and IST..

The paper in subsequent parts is dealing with this very comprehensive and challenging objective and that all from various aspects regarding not only some fundamental theoretical and methodical definition of these objectives but as well as also from the aspects of some key political, methodological and other related issues and especially from the aspects of the main implementation results as achieved towards the end of the originally defined final year of 2010. And that all irrespective of the fact that the final original objective on the EU and its e-Europe as the "most advanced knowledge based economy in the world" has been already in year 2004 modified and softened with other strategy i2010 and the "most advanced in the world" has been dropped off on the basis of the relatively critical assessment of the achieved progress in the mid-term W. Kok's report [1] Although according not only this author it all was rather too early and hastily as for some stake holders especially some national governments of the EU member states and especially those from the NMS – New member states it has been misinterpreted as that all the Lisbon strategy has been called off. However, that has not been true and its all various partial objectives except the above main one have been in force and been fully supported by the various financial programs and schemas of the EU under its previous 6FP and especially its current 7FP for years 2007-2013.

2. THE 7FP FOR YEARS 2007-13 AS THE MAIN SOURCE AND VEHICLE FOR GENERATING KNOWLEDGE UNDER THE EU LISBON STRATEGY

As for some theoretical definition of the particular knowledge based economy and an information society it is very hard to find in the particular EU strategic documents on the Lisbon strategy and on e-Europe any more comprehensive definition of these fundamental concepts excepts some more politically motivated declarations like those on a full utilization of the modern ICT, (cheap) Internet as the backbone of the entire Lisbon strategy, the best system of modern e-education, modern and efficient R&D, favourable conditions for modern contemporary e-business environment, the EU as an information society, etc., On the basis of our ongoing research in the particular area we have come to the conclusion that out of various types of modern computer based systems the most closest one to the "knowledge based economy" in this respect is the one defined as an expert system being by its substance and content based not on utilization of classical data and processed information only but on the full and efficient utilization of knowledge. Such a knowledge also represents the main component and the substance of the particular knowledge base as the key part and content of the entire knowledge based system and/or more specifically in our case of the knowledge based economy.

If on the basis of this our hypothesis we are dealing in more details with the analytical comparison of an expert system [2] as such with the e-Europe as a knowledge based economy and information society but also on some problems and still open questions related to generation of an universally accepted "knowledge" first we have to deal also with an important and still rather open issue i.e. what is it the knowledge as such.. In many cases and areas the interpretation of a (new) knowledge is a rather controversial concept and in some problems areas it is surrounded by various political and other impacts on what is and what is already not an accepted (new) knowledge. For example if we take as an example the knowledge on genetically modified foodstuffs we come to two and very different interpretation in the EU in comparison e.g. with the USA. In the USA the genetically modified foodstuffs are considered as a fully and generally accepted food sources that could in the future be an important source of the sufficient food supplies that could successfully resolve the widening gap between the ever growing world population and reduced agricultural soil. On the contrary, in the EU such a genetically modified food has been considered as unsuitable and as such not produced and not being imported into the EU. Hence in case of the knowledge based economy it is always important to define very carefully the very basic concept of the knowledge that has to become a part of the

particular knowledge base as the content and the heart of the entire knowledge based economy.
the problem of the source of such knowledge. Even if we clean case of the genetically modified food, the remaining problem is the source of the "proper" knowledge. According to the generally accepted theory [2] the main source of the knowledge is in the expert systems an expert. Then immediately we have the question who is an expert and where to find industry
him/her as the source of the new relevant knowledge for the needs of the particular knowledge base. In this case the approach of the EU is quite a pragmatic and a relatively simple one. Since the adoption of the Lisbon strategy on the e-Europe, the EU has launched its 7FP as an open source system that is open to the scientists and researchers not only from the EU but also under the same conditions to their colleagues and partners from the whole the rest of world. With some minor exemptions like e.g. the North Korea, practically the whole world has been invited to generate the new best knowledge in response to the particular calls for submission of projects for funding under the 7FP. In some cases this policy of invited experts from the outside of the EU is not even left on the organizers and/or leaders and coordinators of the particular international consortia but it is directly prescribed in the terms of reference of the particular call for the project proposals. Fore example especially in case of such projects that are dealing with the (economic, trade, political, etc.) relations of the EU with the outside world like e.g. relations of the EU towards the Latin America,, or MERCOSUR, towards China or India, etc. it is directly prescribed that the particular consortium has to include also some minimal number of partner institutions/experts from the given region, country, etc. In general we could state that the particular 7FP has become since year 2007 one of the main vehicles to bring the best knowledge to the EU funded projects and thus also to bring their best knowledge, experience and skills for developing the particular knowledge base.
As for the organization of the entire knowledge sources as mentioned above we could say that this problem area is in principle within the 7FP organized into its following main six problem areas viz.:

- Cooperation
- Ideas
- People
- Capacities
- Euratom
- JRC

As for the development of the EU as its strategic objective regarding e-Europe with its knowledge based economy and an information society the main vehicles in this respect have been the two sub-programs i.e. the ICT – Information a communication technologies as a successor of the previous under the 6FP existing the IST – Information society technology that have a cross-sectional character and as such are covering in principle all above six main problem areas.
The scope and size of this paper does not allow us to go into more details regarding this individual sources and/or sectors of the knowledge generation for the particular Knowledge base of the e-Europe but at least very briefly we present here some basic characteristics of all of them as being available at the official web site //cordis.europa.eu/7FP of the EU/7FP [3]:

Cooperation as the main program for enhancing international cooperation in generating the best knowledge
The sub-program Cooperation supports all types of research activities carried out by different research bodies in trans-national cooperation and aims to gain or consolidate leadership in key scientific and technology areas. The budget has been

Another important problem to be solved in connection with the knowledge generation and the knowledge base development is this issue of any political or other influences like in the above devoted to supporting cooperation between universities, research centers and public authorities throughout the EU and beyond. The Cooperation program is sub-divided into ten distinct themes. This ten identified themes reflect the most important fields of knowledge and technology where research excellence is particularly important to improve Europe's ability to address its social, economic, public health, environmental and industrial challenges of the future.

Ideas as the main program of the EU for reinforcing excellence, dynamism and creativity in the EU frontier and/or basic research for producing new knowledge
The objective of the specific program 'Ideas' is to reinforce excellence, dynamism and creativity in European research and improve the attractiveness of Europe for the best researchers from both European and third countries, as well as for industrial research investment. Investigator-driven 'frontier research', within the framework of activities commonly understood as 'basic research', is a key driver of wealth and social progress, as it opens new opportunities for scientific and technological advance, and is instrumental in producing new knowledge leading to future applications and markets.

People as the main program for attracting researchers and best knowledge from the outside world to work in the European Research Area (ERA)
The 'People' Specific Program acknowledges that one of the main competitive edges in science and technology is the quantity and quality of its human resources. To support the further development and consolidation of the European Research Area, this Specific Program's overall strategic objective is to make Europe more attractive for the best researchers from all over the world in order to enable them in close cooperation with their partners from the EU to bring into the EU research and development the best knowledge as being available all over the globe in the particular research area

Capacities as the subprogram for the optimal use of all the research and innovation capacities within the ERA
The Commission's proposals for the FP7 Capacities program aim to enhance research and innovation capacities throughout Europe and ensure their optimal use. The Capacities program has to operate in seven broad areas: Research
infrastructures, Research for the benefit of SMEs, Regions of knowledge and support for regional research-driven clusters, Research potential of Convergence Regions, Science in society, Support to the coherent development of research policies, International cooperation This specific program also aims to support various EU policies and initiatives, find synergies with regional and cohesion policies, the Structural Funds, education and training program and the Competitiveness and Innovation Program (CIP).

Euratom as the specific research program of the EU for the developing and assembling the best knowledge regarding nuclear energy
The FP7 Euratom aims to address the major issues and challenges in nuclear research and to contribute to the further consolidation of the ERA in the nuclear energy sector. This FP enhances in key research fields at the European level as well as the promotion of the free movement of ideas, knowledge and researchers. In general terms, the Euratom research program aims to develop and assemble knowledge and to improve

scientific and technical competences and know-how in support of safety, security, reliability, sustainability and cost-effectiveness of nuclear energy.

Joint Research Centre (JRC) as the main supporter to the development of the knowledge intensive society

The JRC provides customer-driven scientific and technical support to the conception, development, implementation and monitoring of EU policies. As the research 'arm' of the European Commission, the JRC is a reference centre for science and technology issues that serves the interests of the Member States while at the same time remaining independent of special interests. The Commission's proposals for the 7FP has aimed to reinforce the JRC's customer-driven orientation and its already strong connections with the scientific community.

3. WHAT ARE THE MAIN RESULTS IN THE DEVELOPMENT OF THE EU AS A KNOWLEDGE BASED ECONOMY AND INFORMATION SOCIETY

On the basis of the above organization of the development and preparation of the EU as a future knowledge based economy and information society we could bring after four years of the 7FP at least some examples from several sectors that could serve as examples of the particular development of the future e-Europe as the knowledge based economy and information society. Specifically we have selected such sectors that are to some extent key for the development of the e-Europe and also those where we have been directly or indirectly involved in their research development. For more details on some of them you could visit our specialized web at //erdc.fm.uniba.sk. Hence in addition to the official policy statements about the results as achieved in their development and implementation we could add also some of our own experiences in this respect. The selected sectors are as follows:

- e-government
- e-business including also e-business for the SME as one of the main sectors for the success of the EU in the contemporary globalized world
- e-health
- e-education
- e-inclusion
- e-content

e-Government as the main vehicle of the EU to make public administrations in the member states more efficient and effective and thus to correspond to the future e-Europe

According to the original objectives of the Lisbon strategy the e-Government is one of the main vehicles of the EU how to make the Union more efficient on all levels of the central and local governance. In this respect the e-Government has to bring to the citizens of the EU more efficient and effective government services without red tape, bureaucracy, etc. Its intention has been to enable people to achieve the necessary government services more accessible especially through application of the modern ICT. Such modern e-government services have to be faster, without necessity to wait in the long cues and running from one government and administrative office to the other one and so forth and so on. However, the results after ten years of the implementation of this one of the key objectives of the future e-Europe as a knowledge based economy and information society – in fact in some respect being its main focal central point – are more than mixed ones. Some progress has been achieved especially in some smaller EU member countries but in general the results are far from the above main objectives. In most cases the e-Government services in principle are only so to say information services. It means that at the e-Government portals are various information on various government agencies, agendas, services and/or duties but quite a very little has been achieved for the practical performance of those services. For example almost at every governmental portal there is information how to arrange a new passport, new driving licency, what is needed for marriage, etc. but only very little can be done in this respect directly through that portal and/or the Internet as the supposed backbone of the entire Lisbon strategy. And even if it is possible like e.g. in the tax declarations that physical and legal entities could submit their tax declaration through Internet in the online form, but finally, afterwards, they have to send also the hard copy of the particular tax declaration. One of the most dissatisfactory aspects of the e-Government is the lack of its support to the development of the so-called e-democracy. So far only in very few cases of the EU member states and/or their regions it is possible to apply an e-voting as the best way how to achieve much higher turn out in election than through classical physical presence in the voting rooms. Even more striking in this respect is the same negative fact regarding elections to the European parliament that have to be carried out in all EU member states and in an ideal case by as many citizens as possible as unfortunately there has been a continuing trend that in every next EP elections there is a lower turn out of electorate than in a previous one. But again, nothing in this respect has been achieved and/or prepared on the Union level although technically and organizationally it is one of the most suitable ways how to bring into the reality long existing slogan of the EU i.e. bring the EU closer to its citizens. There cannot be any better way how to achieve this than to bring voting to the only democratically elected institution of the EU closer to the citizens than enabling them to vote for their direct representatives in the EP directly from their houses, residencies, etc. As for the development of the e-Government related knowledge base we could state that in principle it has been existing in two forms. The first one i.e. its centralized part is represented by the particular depository and/or the projects data base of the EU/CORDIS system together with all other projects completed under the 6 and 7FPs. The other i.e. decentralized part has been developing on the national level i.e. under the auspices of the individual national governments of the EU member states. For example in the case of Slovakia it is at: //portal.gov.sk. But as we have already stated above, mostly they are oriented more as information than directly action oriented ones.

e-Business including also e-business for the SME as one of the main sectors for the success of the EU in the contemporary globalized world

From the point of view of the future EU in general and the e-Europe in particular as a modern knowledge based economy this e-Business sector plays a key role as only through e-Business services it is possible to create a modern business environment for any further development of the EU as a knowledge based economy as it has been defined as one of four key goals of the original Lisbon strategy. As we have already mentioned in this respect in previous part of this paper regarding e-tax declarations it still quite far from being optimal for businesses especially those that are the most numerous and at the same time the main economic factors for generating the GDP and new and better jobs, etc. as it is also enshrined in the Lisbon strategy itself i.e. for the SMEs. One of the main problems in this respect is also the different implementation of the one of the key preconditions for any e-business communications i.e. e-signature. E-signature as such has been in the EU introduced already almost twelve years ago through the particular Directive on e-signature (EU Directive no. 1999/93/EC yet of year 1999. However, even now in year 2011 there is not a common policy regarding e-signature. The directive has been implemented in all EU member states but very differently in various aspects. In some countries it is available for free so it is easily accessible also for the smallest SMEs. On the other hand in some other countries like e.g. also in Slovakia it is available only for a relatively high fees between 80 to 100 Euro depending upon its technical provisions like e.g. with the USB, chip card, etc. If we take into account - as we have mentioned in the previous part on the e-Government – a few services being in this respect available for the direct e-utilization than it is no surprise that the utilization and application of the e-signature has still been very low in many EU member states. And of course it has been negatively effecting also cross-border and transnational business communications and operations in general on the entire EU level. This negative situation in the e-signature as the key precondition for any e-business operation has been negatively effecting also progressing in other closely related e-business activities and areas as e.g. e-procurement, e-invoicing, etc. Although also in these areas some progress has been achieved in their practical implementation the practical results are still quite far from being within the original time schedules etc. For example in the case of the e-procurement it has been originally expected that it would be introduced on the all EU covering level by the end of 2009 so starting on the 1 January 2010 all procurement in the EU would be conducted only on the basis of its e-version. However, even now in year 2011 it is still remaining only in the stage of preparation and future implementation on the Union level. One of the still remaining problems is also the pertaining language problem as most of the procurement announcements/tenders are although officially announced also on the EU level but the most of the particular documents are available only in the national languages so the all the EU procurement in the sense of the e-procurement remains still only as a distant future. A similar situation is also regarding e-Invoicing where also the particular research and development has already brought many positive results that could be implemented again on the all the EU level but there still remain to be resolved also many related organizational, technical and also financial issues before the full fledged e-Invoicing could be functioning across the entire EU. Especially it is regarding the SMEs. Hence according to the current situation it is expected that e-Invoicing in the full scale will be implemented only in the year 2020 i.e. about ten years since the end of the original target year of the Lisbon strategy in 2010! As for particular knowledge bases, the situation has been more positive. Through various EU programs and concrete projects a lot of knowledge has been accumulated and has been creating the specialized parts of the knowledge bases for the e-business. As a good example in this respect could serve a specialized knowledge base on e-Invoicing that has had an operational knowledge base at //www.e-invoicing.getway.net/knowledgebase [4].

e-Health as the most advanced knowledge based sector of the e-Europe

In comparison with all other sectors the e-health sector could be considered as the most advanced in the terms of the knowledge base and information society services in general. This positive development has basically two main reasons. One is that the health in general has become to be one of the key sectors of the overall sustainable development in the EU as the population becomes still older and thus also more depending upon the health care. The other one is the fact that thanks also to the above first reason, the overall public health system including pharmaceutical industry has become a very profitable business. There are flowing not only huge funds from the government budgets, health insurance funds but also investments of the private sector especially from the pharmaceutical industry that are creating a various specialized PPP projects that are very efficient in all sub-sectors of the e-Health like in the development of new medicines and drug substances, telemedicine, modern treatment procedures, preventive medicine, etc. Thus it is no surprise that right in the e-health the development of the particular knowledge base and related information services has been one of the most successful and fastest growing. It is so mainly due to the above enormous amounts of funding and thus also efficient research, innovation and what is even more important also their relatively fast practical implementation into the daily practice of the public health practically in all member states of the EU. After all, especially the entire telemedicine and e-health are the best examples of the practical implementation of the particular knowledge bases and information services. These knowledge bases are practically utilized by the medical practitioners all over the entire EU and also beyond as it has always been typical for the medical community and its system of international cooperation, networking, congresses, scientific publication dissemination systems, etc. The e-health has only further fostered and accelerated all these traditional positive trends in the exchange of knowledge and information. For illustration it is possible to state that only under the current EU/7FP altogether 59 projects funded by the EU have been completed and/or being under the progress out of that 22 under the Personal Health Care systems, 20 under the Virtual Physiological Human and 17 under the Patient safety [4]. All of them and many from the previous 6FP represent a central knowledge base on e-Health in the EU only on its central union level! The knowledge based systems in e-health are going even that far that there are already under the development and practical utilization so-called “self-learning” systems that are accumulating and storing a gathered knowledge from the previous cases for the future use. One such module has been experimentally developed also under one of our previous projects EU/6FP/IST/iWebCare being available also at our //erdc.fm.uniba.sk [5]

e-Education as the fundamental of the e-Europe but still being to some extent neglected on the Union as well and even more on the national level

It is quite logical that in the heart of the entire e-Europe strategy on knowledge based economy and information society quite logically has to be education. Unfortunately, as in various other areas the education on both the Union as well as national levels has been seriously neglected in terms of funding as well as the lack of the due attention and practical implementation. Although on the one hand there are several important educational programs and initiatives that have to bring the EU closer to its above strategic objectives, their practical implementation is rather too far from any optimal mode. The backbone of the educational strategy of the EU has been under the Lisbon strategy represented by an efficient system of the long-life education for all citizens of the EU. Within this main objective exists several other educational programs that are supporting different kinds of education in the EU and are funded by the community funds like: higher education under the ERASMUS program, Leonardo da Vinci for vocational training, Comenius for school education, Grundtvig for adult education, Transversal programme, Jean Monnet for European researchers.

The biggest and common problem of all these community educational programs has been a relatively low funding from the EU budget – for example in comparison with the funding into the CAP – Common agricultural policy - it is just a fraction and also an insufficient funding on the national levels. Especially national governments are very negatively oriented towards the funding of education. As a rule usually education is the first sector where some cuts are made in case of necessity to find some "reserves" regarding national budgetary needs. The scope of this paper does not allow us to go into more details about specific problems of the above education programs. So for at least illustration we state that for example in the ERASMUS program that is from the development of the knowledge based economy and information society the most important one, our own experiences from direct participation could be summarized as follows. Its key part i.e. the mobility of teachers and students is very important for achieving the main goals i.e. create a common platform for exchange and sharing of the best education practices among and between higher education institutions on the Union level. However, the practical experience is not the most positive one. There is a lot of formalism like e.g. only when the teachers or students come to the hosting university their assignments are considered and very often in case of students the main criterion is the number of credits they could collect and not any systematic selection of relevant courses. The exchange of teachers or students is to some extent hampered by the languages as not in all universities it is possible to deliver or to attend classes in three most common languages in the EU i.e. English, German, French. Especially students in many cases are coming to study to foreign universities without proper and sufficient knowledge of any of these most common languages of instruction. There does not exist any system of the EU curricula i.e. students are often attending courses for which they have not completed the necessary previous courses. For example they cannot attend MIS course if they have not yet completed courses on Introduction to the AIS, data bases, systems analysis, etc. The success of the e-Europe strategy on knowledge based economy and information society requires especially more systematic approach, more funding and better institutional and organization provisions and coordination of this key sector for the entire this strategy. As for the particular knowledge base there has been existing already a big pool of various e-learning and e-education courses but mostly only on the national levels of individual EU member states. It would be desirable to make of them a system on the Union level that could be offered to all educational institutions in the EU and thus to achieve a more systematic, coherent and better organized system of the modern education. At present it is more just a set of various individually developed courses than anything like an integrated e-Europe supporting educational system of e-learning, etc.

e-Inclusion as one of the main instrument for removing the digital divide in the EU and thus making everybody an integral part of the future e-Europe and its knowledge based economy and information society

As we have already mentioned in the previous part on e-education, the ultimate objective of the Lisbon strategy on e-Europe as a knowledge based economy and information society has been to make all these objectives beneficial for all citizens of the EU through modern system of the life-long education. The second step after achieving the particular educational goal is to achieve that everybody in the EU will be also an integral part of that future e-Europe i.e. that it will be included into such a modern knowledge based economy and information society without any restrictions that otherwise always will be existing e.g. due to various social, age (especially for elderly people), health, physical, mental and various other restrictions or handicaps, etc. In view of this, under the e-Europe strategy has been prepared a special program for e-inclusion that should help to include into the e-Europe all however restricted or handicapped citizens. In addition to above already mentioned types of restrictions or handicaps we have to mention in this connection also citizens living in the remote or rural areas, in underdeveloped regions and/or communities, etc. For all of them the e-Inclusion has to bring all advantages of the knowledge economy and information society and the same benefits as for the main parts of the society living within and/or with the full advantages of the modern life without any of the above disadvantages. In this respect the EU within its FPs has been supporting the whole range of projects oriented towards the research and development in the area of e-inclusion. The particular knowledge base for e-Inclusion exists under the framework of the e-Practice at //www.epractice.eu/einclusion. .

e-Content as the way how to make content and/or knowledge of the e-Europe accessible for everybody through modern ICT

The main goal of this part of the e-Europe strategy has been to enable to everybody to access all various kinds of information, knowledge but also master peaces of the culture, literature, music, creative arts, architecture, etc. All of them have to be directly accessible to everybody interested and all that through the latest ICT as a part of the digital agenda of the EU. In this respect a long term project and process of digitalization has been started and been continuing not only regarding of the classical documents stored in various national and other archives, but also digitalization of the content of libraries, museums, galleries, etc. Since the beginning of the 5FP and then continuing throughout 6 and current 7FP an evident progress has been achieved in this section of the digital agenda and/or content of the EU as the future knowledge based economy and information society. On the EU as well as national level of the EU member states have been developed and functioning numerous portals containing the so-called digital content of the cultural heritage of the EU and/or its member states. On the EU level the most representative portal in this respect is at //ec.europa.eu/culture/portal. One of the evident shortcomings of this digital agenda in general is again the shortage of the financial support through the EU funds. Many activities in this respect like e.g. digitalization of national archives, libraries, etc. has to be carried out through ever insufficient national budgets or like it also has been find out through the voluntary(!) work of willing volunteers! If nothing else it is rather a curious but unfortunately also quite common approach to an integral part of future e-Europe as the knowledge based economy and in this specific case of its key part i.e. e-content of the future information society.

4. CONCLUSIONS AND RECOMMENDATIONS

In conclusion we could underline only as we have mentioned it also in the end of the previous part of this paper that in particular the entire Lisbon strategy on e-Europe as the future knowledge based economy and information society lacks first of all an adequate funding. While for the obsolete and out of dated and as we see right now – during the surge of food prices - totally inefficient CAP every year is getting from the budget of the EU more than fifty per cent of the total budget and in absolute figures over 60 billion Euro, for the entire 7FP as the main research and development arm of the EU for the e-Europe strategy it is for seven (we repeat seven!) years 2007-13 only slightly more than 51 billion Euro. As the research and development is impossible to carry out without adequate funding it is an imperative to increase as soon as possible the particular funding and finally to achieve it on the account of the CAP that as we may see also right now has absolutely lost any of its justifications. The prices of the agricultural products are equally increasing in the EU as anywhere in the world in spite of those enormous subsidies that annually are going to this sector in the EU.

The other almost equally important task for the future is to make the entire R&D in the EU better coordinated with the activities in the EU member states. The existing approach to delimitate all responsibilities for implementation of the R&D results as achieved on the community level of the EU to the member states is absolutely not sustainable in the existing form. The implementation has to be coordinated and organized on the EU level with the system that would force member states to be more active and cooperative in practical implementation and utilization of the particular research results. In case of an insufficient cooperation in this respect it is necessary to apply a system of some penalties like e.g. to reduce access to all various funds from the EU budget including the regional, cohesion, social and other funding schemas. The enormous knowledge base of the EU consisting at the moment of more than 1300 already completed and/or projects being in progress within the 7FP has to be also fully utilized by all member states and by the Union institutions as well. Otherwise also in the future we could only repeat what has been presented already in year 2004 in the W. Kok's Mid-term Evaluation of the Lisbon strategy that "there has been achieved some progress in some areas but not in any more coherent and systematic way of the entire strategy as such".

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From Visual Communicator to System Designer - A Better Business Partner

Gerry Derksen
Department of Design, Winthrop University
Rock Hill, South Carolina, USA

ABSTRACT

The contemporary designer is adept at organizing, categorizing, and synthesizing differing conditions of information. Couple these skills with the ability to create interactive experiences that teach participants, who engage in interaction, how to negotiate systems. Because designers currently work within different contexts, it is natural for designers to control specific spatial experiences. Walking into system-designed spaces the visually tailored world around you encourages the things you enjoy and diminish the things you do not. Creating flexible environments such as these will encapsulate all the skills of a designer and take advantage of user input we have not seen before.

The technological changes in design, our relationship with business and marketing suggests that we have out grown our fine art roots and yet we still need to understand those principles that make systems interesting and engaging, that catch the eye of the viewer to start the conversation about what they want or need. Understanding all of these perspectives makes design one of the most difficult professions but also clouds the definition of designer no longer as expert with skills in a particular domain. Design can connect disciplines, control experiences, and create systems, and yet we still need to communicate that design is more than just making things look good. A positive indication that educators are starting to see that design is strong enough to stand on our own and redefine what the next evolution for design could be for both business and technology.

Keywords: Visual Communication Design, System Designer, Design thinking, Business strategy, Technology and Design

1. INTRODUCTION

Recently, the academy has made a shift to prepare students for a future that is interdisciplinary in nature and began reforming the domains of many programs resulting in a reshaping of industry. This is very apparent in the professional programs of Business Marketing, Technology and Design. The design industry has taken on a larger role in business from what was a sub-trade to the marketing department, to an idea generator for new products and services as well as creative thinkers in strategic planning. As part of the skill set for designers we have adopted the marketing approaches to creativity, considering customer needs and interests; first, to peak interest in the product and second, to have a positive experience when they use the product. [1] Designers have also adopted new technologies not only to expedite their own processes but also to creatively use technology as a promotional, interactive, or experience tool. Design is now less of an art form and more of an amalgamation of creator, persuader, and technologist who deals with complex systems that integrate these three skills. This accounts for the shift in design education and continued evolution in practice, as the needs of both business and technology sectors understand the significant role designers can play. However, it does not address the process designers use to create complex things nor does it address how that process integrates within the current project life span in relation to the other two disciplines.

The concept of system designer has evolved from the complexities of marketing and technical development of creative activities so broad in their implementation an overseer of these activities is necessary. The system designer is the creator of constructs for users to navigate through information, mental and physical spaces, so people can create a positive experience that is meaningful to them in a given context. It should not however, be confused with the title given to developers of network systems or software designers specifically. [16] In this context, system designer may employ methodologies for structuring and analyzing systems similar to computer programmers [6] but generally it refers to the creative aspect of systems that incorporate technologies and management or creative process techniques. According to Shelley Evenson professor and principal in user-experience from Microsoft's FUSE lab, system design (sometimes referred to as *service* design) is beginning to emerge as another branch of Visual Communication Design. [5] Designers progressed from the familiar advertising campaigns that have numerous add-ons, communications vehicles, and opportunities for viewer impressions to include environments and experience. The organization of materials, message, context, and content in a number of artifacts including the physical world, the process and performance [5] requires an enormous amount of coordination, knowledge, creativity and communication processing unique to the system designer.

2. RELATIONSHIPS OF THREE DISCIPLINES

Design as a business strategy

Designer and usability expert Chris Paul, from IBM suggests that design is playing a central role in the research and development long before the creative task of interface design. [4] The design process mapped onto the business strategy encourages associative leaps connected to new ways of viewing the problem from user perspectives. Unlike scientific or strategic thinking, design thinking allows for outside influence to take over but there must be evidence of positive outcomes and confidence in the process to produce. Designers who truly understand the design process still rely on formalized methodologies such as concept mapping, mind mapping, empathy mapping, iterative design, point-of-view analysis, etc. to generate ideas. Often business culture is adverse to "loose ideas" or tentative links to the return on investment by any process within the corporate structure. This is problematic because design thinking is prone to false starts, dead ends and what Bruce Mau calls, "the wrong answer is the right answer in search of a different question". [11] It takes courage on the part of business and clear direction from designers to feel confident in design thinking.

Marketing a design centric advantage

Marketing has for years been focused on understanding who the users are that need a product or service. While this is still but this is only half of the equation.

Designers view the problem holistically; first by asking why other prospects are not considering the product or service, secondly, by questioning how the product and its attributes could be modified, repositioned, or re-contextualized to appeal to new prospects and increase sales. One does not follow the other but analysis of both markets and products or services affects the development of the other. An example of the "Philishave" in the 90's showed that electric shavers in different casings would appeal to a larger audience than just offering one type. [9] This was not just a physical change but usability experts at Philips determined that the emotional response to shavers; men related the products they use to how they defined themselves. The internal parts of the shaver were the same but changing the case to exemplify personality types meant more men considered the Philips shaver. [9] Reviewing, what we think, as well as how we think is a motivation of designers because it often results in original points of view. Originality is what distinguishes designers from each other encouraging practices that result in unique perspectives.

Technology development takes advantage of design thinking

Development stages start with predetermined goals typically set out by the business strategy and interpreted by the development team. Iterations of component parts within primary or aspect models [6] of code naturally focus the attention of the development team on the process of solving technical problems. Usability testing draws the attention to the human factors uncovers tangible problems real users have with technical products and services. Usability experts report

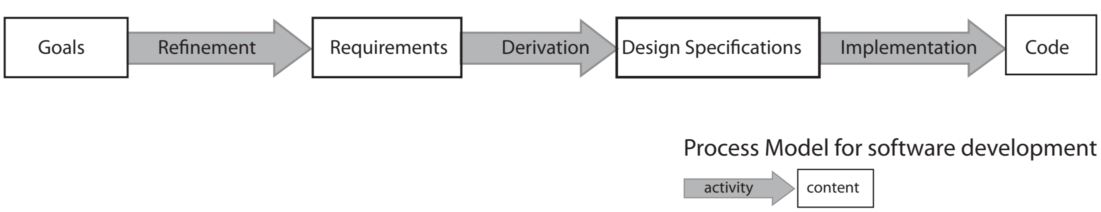
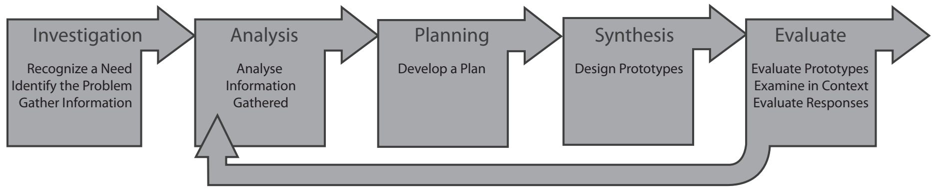


fig. 1.

important information, there are mountains of data collected that are only of value if we can leverage the information into creating a positive experience for the user. As Wansink states, ''…a new product can fail if its development team loses sight of what consumers want''. [19]

Currently, we see that the definition of the user helps to direct a message and attempt to increase the impressions of a company or product on those people defined as potential users. Narrowing of the focus of users in global economies makes sense because you are more likely to take advantage of the world audience scale who are interested in the promotions rather than trying to convert less likely users in local markets, on the issues and incorporate them into the design specifications, where as other testing methods of technical specifications are tested by the developers themselves. These methods only test to meet expectations of functionality, or if they consider the user, the focus driven toward technical solutions rarely consider other human factors. More often designers are tasked with performing usability testing if budget to hire or in-house experts are not available.

Usability is slowly infiltrating the technology process implemented earlier in development lowering the number of negative experiences seen in software and hardware. Usability problems within technology still seem to come fig. 2.



Process Model for Visual Communication Design

from the focus on functionality. It is difficult to separate this from the process because not knowing how to develop a technology is a daunting position to assume. Most computer scientists acquire their knowledge from information that already exists and make incremental improvements or reconstitute current technologies to suit the project evident in the waterfall process model. [fig.1] Charting into the unknown technologies based on what one imagines or what has never been accomplished before does occur but we have seen the decrease in research and development across all sectors. It is however, the place most innovation comes from and a mind set designers are most comfortable. The limits of technology using design thinking may be stretched and have some obvious constraints on project time and money but the unknown areas are often fertile ground for idea generation.

Visual Communication Design Process

There are a number of comparisons that can be made to the process of Visual Communication Design (VCD). Iteration within the process begins after content is gathered and the audience descriptions and needs are well understood. This is prolonged in the cycle however, smaller iterations within the synthesis stage, prototyping often occur. [fig. 2] These seemingly random iterations happen based on the designers ideas and how they believe the components of design will influence the user or effect functionality. Much of these decisions are based on experience and understanding how the user will interpret, consume, and be motivated by the design. Emotional responses to the design also play a large role in the decision making process. David Kelley, founder of IDEO and creator of Stanford's d-school, uses this method and others to connect human behavior to why they behave in this way. [10] If the designer is empathetic to the user and understands their emotional motivations to engage and spend time with the idea as users would there is potential for success. If preliminary tests do not show that users share the designer's emotional assumption, continued iterations or new approaches based on how much or little success the prototype has with the user. [12]

3. PROBLEMS WITH DESIGN

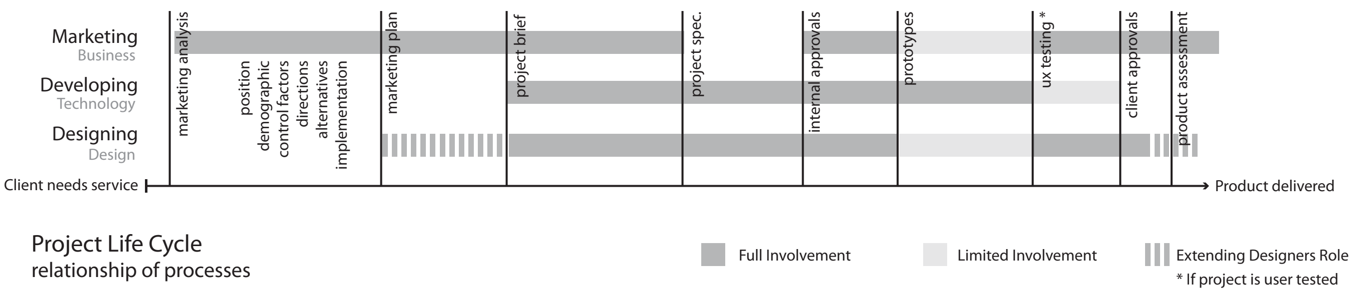
Problems that inhibit high quality system design that everyone experiences in current design projects such as budgets will continue to part of all creative industries but system designers can mitigate problems in scheduling, politics and inefficiencies that often plague projects. Because of changing roles and the emergence of system designer, the discipline is not well established and needs to be vetted, formalized, and proven a benefit before it can establish itself as a true viable professional partner. Added to the process problem are perceptions of the designer as a creative liability. The system designer operates in a managerial role and uses design thinking as a method to organize design problems tying collateral, objects, spaces, media etc. to create an experience that works together.

The reputation of designers that persist, in part because design schools have not emphasized formal methodologies of design thinking even though they may be encouraging students to think like designers is negative. Many marketing texts still describe the "creatives" as unpredictable and temperamental. This is changing but it will need to follow with designers who are fluent in the design thinking processes that positions the designer as a project leader. The system designer is evidence of that change in design education. Interdisciplinary programs that include design, business, and technology are becoming more common or more flexible replacing programs that are more traditional. Kelley also incorporates a design thinking approach to business students as well as design students but he concedes it will only coalesce if consideration for the process is part of the mindset. ([10] see below) Noted previously, multiple processes happening simultaneously that use similar structures and collect similar information are not integrated. The opportunity to make the process more efficient and reduce tensions between the disciplines by expanding the role of the designers and utilizing contemporary design methods seems timely. It may also have more success if business collaborates with designers who currently use these methods rather than adding more to the marketer's responsibilities. The designers practice shapes the mindset for empathy and effectively design to modify that behavior.

Mindsets for Design Thinking

Focus on Human Values
Show don't Tell People Your Ideas
Create Clarity from Complexity
Get Experimental and Experiential
*Be Mindful of Process
Bias Toward Action
Collaborate Across Boundaries

fig. 3.



4. PROCESS INTEGRATION

Perceived as a project cycle in the timeline above the scenario assumes an introduction of a product or service from an outside source. A company who wishes to develop an idea into something and sell it to consumers or other businesses typically approaches a marketing or advertising agency. [fig.3] In-house product development teams may have similar issues associated with this process but are not addressed here. Throughout the scenario the project manager tends to have the most time, research, and as a result control over the direction of the project. Market research and analysis based in scientific methodology and statistical analysis bares additional weight on determining control of the project direction. [20] Once the analysis and marketing plan is complete, the development and design of the project is parsed out to teams acting as sub-trades to carry out the plans of the marketing group. Some coordination with designers happens during discussions of *position* concerning audience appeal followed by coordinating meetings for a timely conclusion. Often this is the only point in all the processes that all disciplines collaborate other than usability testing if it is part of the project budget. Within the marketing process user testing often comes during market analysis to find potential markets often overshadowing the need for testing during the design and development stages. Design and development teams typically interact closely throughout the process resulting in a number of conflicts over deadlines or clear delineations of roles. If there are project delays, they occur during content creation or content management stages, evidence of overall system breakdown. Multiple promotional media platforms and audiences that continuously change, compound the management of these systems. Each discipline in addition has internal process they work through which could be coordinated or could share information to make these processes more efficient.

Taught and regularly implemented processes in industry vary based on company, product/service, agency and client preferences as well as a number of other factors and therefore difficult to compare or proclaim any standardized approach. It is understood that any references to sub-processes within the practice of design, promotion, or development of any project also add variables into the equation and ultimately the final release. These local sub-processes slow the overall process but prove to be the points of refining ideas and integrating qualities into the project, particularly for designers and developers.

The iterative cycles of all three disciplines proceeds at differing times during the overall process of the project and to greater or lesser degrees of regularity forming overlapping cycles rather than a series of gears, where one turn effects the movement of the others. The actors generate solutions based on their particular focus within the project, determining when to initiate new cycles or revisions. The focus of the marketer is on the client, that shifts toward the users during the early stages of the project and later during the release of the project to track user responses. The developer's focus is on the functionality of the product, with reference to the audience in the early stages of their process. Human concerns that effect development are security, error prevention, error recovery, system status, user control, and efficiency. [14] Concerns that are mitigated by technical solutions are meant to off set human behavior, not designed to encourage alternative experiences. It is important to have these solutions incorporated into the design for humans that find they make incorrect assumptions or even for those who purposefully disregard the expected behaviors. More importantly these are efficient solutions for such problems but it does not deal with the question why people behave in ways that do not follow the intended course.

Attentions directed at the client and product functionality, allows the designer to focus specifically on the users and their experience. Leading with the user focus takes advantage of the designer's expertise but will make the process more efficient. For example, as with many processes in business, design, and development, the audience profile is important information to begin to understand potential users. The system designer also uses profiles drawn in the form of personas, or character sketches. Linking the profile to a final product is an estimation of the actual users varying in quality by how they are prepared and how they are understood. Focusing on the data that leads to emotional motivation and tracking the emotional response as they experience design is difficult but a consideration of the system designer. Taking a sample emotional response throughout the experience is time consuming but easily integrated into usability testing later on in the process or earlier in development, approximated during a heuristic evaluation.

5. SYSTEM DESIGN IMMERGING

The evolution of Visual Communication Design in education and practice continues from the fine arts to system designer. Closely associated with Design Science Research (DSR) using similar methodologies the system designer requires more than a traditional design education. The evolution must continue and extend the system designers education to include some aspects of system science and/or information systems analysis, "design science research addresses important unsolved problems in unique or innovative ways or solved problems in more effective or efficient ways." [7] In an attempt to connect Information Systems (IS) research to DSR Hevner writes, "info systems as composed of inherently mutable and adaptable hardware, software and human interfaces provide many unique and challenging design problems that call for new and creative ideas." [7] System designers combine the technical expertise of information systems and shift the focus onto the broader context of user experience, human factors, and contexts that focus on design for human consumption.

Differences from IS education addressing *wicked* problems [2] [3] are precisely defined or nearly defined environments that system designers create and control. Understanding and designing contexts or spaces that content operates within are a widely held responsibility of user centered design theorists and practitioners. [3] The context of design is as important as the content within it. System designers use context to understand the users readiness to consume information and consider the effect of context on the information delivery. [17]

A great deal of discussion in DSR programs have formulated around what constitutes an artifact. Current definitions of artifacts include constructs, models, methods, and instantiations [13] reflecting the computer science aspect of the research. Similar to IS, systems design motivated by the same principles of DSR could conceivable be part of the same research paradigm particularly if "artifact" were also to include visual communication. "The result of design-science research in IS is, by definition, a purposeful IT artifact created to address an important organizational problem". [8] Within the organization, corporate culture and customer relations interact with the artifact or transmitter of information supporting communication but do not ensure it. Visual representations of information leave room for interpretation of the information that has been the domain of design study. The ongoing discussion of artifact among IS professionals is of value to the system designer not only to define domain but also to encourage its interdisciplinary growth. [15]

To varying degrees, critical dependence on human cognition and social abilities is one of the problems system designers tackle but some may take issue with the term "critical". The interaction is critical but their level of involvement in the design in terms of understanding the information or their ability to contribute back into the system only impacts the level of positive experience but does not "break" the experience as the term critical suggests. Where problems are the same as IS developers, system designers solve problems of complex interactions among subcomponent parts inherently flexible to changing design processes and resulting artifacts. [18] The acceptance of IS research as part of DSR illustrates a road map for system designers and in turn demonstrates the value it can bring to the discipline study and research.

6. CONCLUSION

Designers are poised to advance their skills from their early roots to move into system design. The system designer's management of visual communications of all types and the relationship of those communications to each other benefits both technology professionals as well as business and business systems. Situated in process organization with a focus on communication, content and context from the user's perspective is particularly critical to ensuring positive user experiences.

Business is already implementing design thinking in research and development to innovate toward what users want from company products and services. These methods of thinking are part of the design vocabulary and historically have been a part of their education. Information systems analysts have expertise in forming systems that effectively connect information to business and make it possible to communicate to specific audiences. Designers would benefit from IS research and could contribute to the difficulties of user interpretation and those users defined outside the typical demographic definition.

The combination of business design and technology is in need of a manager focused on human factors. Many solutions designed by other disciplines tend toward the solutions within the discipline. Design has no assumptions about a solution or how any particular design can intervene to change behavior only that it can, with the right context, content and willingness to take design-thinking risks. The process integration of the three disciplines will need further study to see how one effects the other and how these processes effect the outcome of the entire system to be designed.

System design has stemmed from the interests of industry, and changes in academic programs. To capitalize on Design Science Research initiatives and follow Information Systems willingness to look at broader definitions of their discipline. Taking advantage of the interest in design thinking and taking steps to broaden the view of design research, system design may be the visual communication designer of the near future.

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Logic Mosaic Generation for Developing and Conservation

Dan OPHIR
Computer Science and Mathematics Department, Ariel University Center of Samaria,
Ariel, 44837, ISRAEL

ABSTRACT

Learning through playing is considered to be both effective and enjoyable. The aim of this learning tool described and defined herein is to develop, preserve and evaluate the mental capabilities of the target user. This learning tool or game can be played either competitively with more than one person playing or as a type of solitaire game for the single user.

This game can be played by a wide spectrum of targeted users. Children from the age of five to adults age 99+ can enjoy playing this game. The reasons to play this game are varied as well. Teachers, mental healthcare and social workers can use this game for teaching, intelligence testing and evaluating. Kids can use it for entertainment, learning and competitions and the elderly can use it as a way of performing "mental gymnastics" thus hopefully warding off or slowing down different types of dementia. Thus, the aim of the tool varies, depending on the target user.

The product of the tool is a game in which the user has to match the edges of a polygon. The complexity of the game can be varied. Higher orders of complexity are suggested: using polyhedrons instead of polygons and using a combination of properties instead of a single property each time. The number of properties is in itself a property.

Keywords: Mosaic, Logic, Abstraction, Common Denominator.

1. INTRODUCTION

In order of proper understanding the proposed issue the following steps' decomposition is being proposed:

1) Development of graphical feature creating the mosaic. The mosaic is a collection of polygons which are attached one to another by some rules specific to the given mosaic (see [1]). The collection of so joined polygons gives a complete object with some graphical or other significance. There is a paving field [4-5] treating the matching-attaching such polygons..

2) Creation a tool, with which it will be able to build knowledge reservoir which includes thesaurus of terms and rules connecting them.

3) Generation of a knowledge reservoir with the above tool (paragraph 2) in various domains (for example: the primitive properties of the objects – color, shape, quantity – see Fig. 1), the style of the language (the alphabet, grammatical rules, vocabulary), foreign languages (it is possible to match the domain to learning the foreign languages (see example Fig. 6), science (chemistry – the periodical table), arithmetic (basic operations – Fig. 2), getting acquaintance with a country (rivers, valleys, mountains).

4) Creating a module treating the coordination, feasibility (the game should be solvable).

2. TWO OPERATING MODES AND THEIR STEPS:

Playing-mode
In this mode the game, it can come as a board or boxed game or as a software package. Either as a board game or on the computer, the game can be played either with a group or individually. The group can either be in one place or connected via an internet network. There are three options of playing:

1) Attaching a tile to a tile that is already lying on the table, according to the existing properties and some logical rules from the set theory (see [1]). This option emphasizes the text written on the tiles. There is a possibility of adding a piece using the shape and the design of the tile. The addition will give meaning to the accomplished shape generated by organizing the whole complex of tiles (Fig. 5 (b)).

2) Using a statistical conclusion (inference) in order to define the common properties for a given match (an opposite operation to (a)).
3) Games based on knowledge (Figs. 2, 3 and 6) allowing the players to further develop knowledge in those areas. The figures order is chosen according the game complexity represented on them.

Creating-mode

As a knowledge base package with user interface features enabling its further development as a repository of information in an appropriately linked form and also a tool for further designing graphically composed forms, emphasizing the aesthetics and the complexities of the design only limited by the imagination of the designer.

3. THE TOOL'S CHARACTERISTIC

1) It should be **adaptive** – the level of the play should be adjusted by the tool after few movements to the level of the participant.
2) **Choice** – the participant can choose various matching shapes besides triangles (Fig, 3 – using hexagons, Fig, 4 other features).
3) **Parameters** – the shape of the final solution (fig. 5).
4) **Solvability** – the attached parts should give the final designed shape, or to enable to one of the players to finish his pieces.

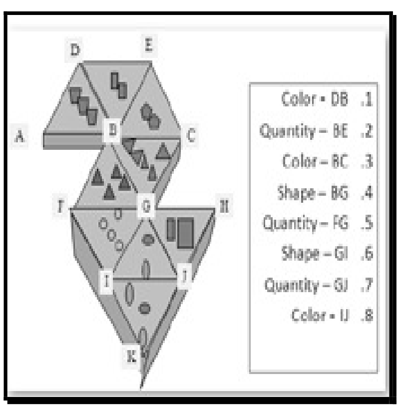


Fig. 1 The logical connections among the triangles with the attached edges. For example DB is common to the triangles: $\Delta ABD \approx \Delta BDE$ the common is the **color** of the object in that two triangles.

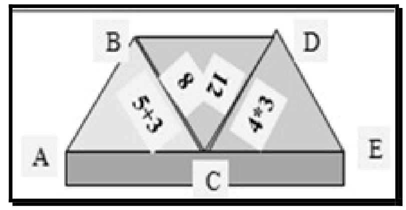


Fig. 2: Arithmetical exercise: two triangles are attached if their common edge is concatenating: (Contains an exercise on an edge of one triangle and the solution on the other edge). For example it is given:

$$\Delta ABC \approx \Delta BCD$$

because the common edge BC includes in the triangle ABC the exercise "5+3" and in the triangle ABC the following exercise "5+3" and in the triangle BCD the solution "8".

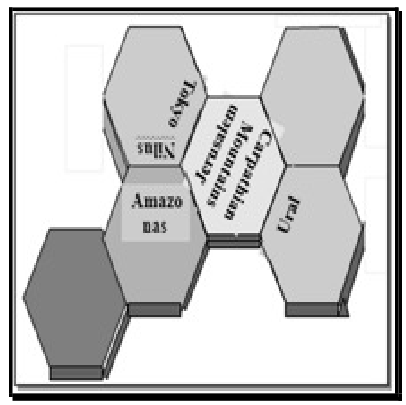


Fig. 3: The game "Country-City" with the help of hexagons.

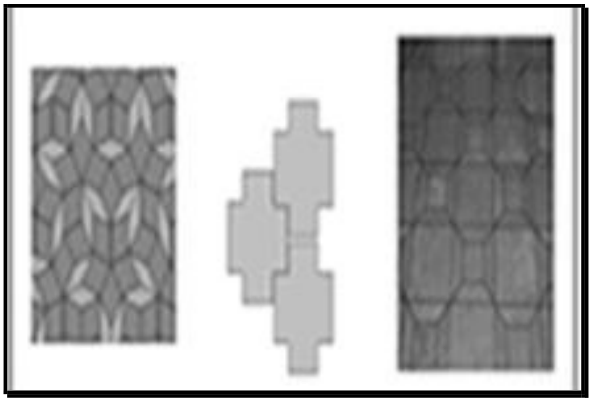


Fig.4: The possibility of choosing more composite shapes (see [5]).

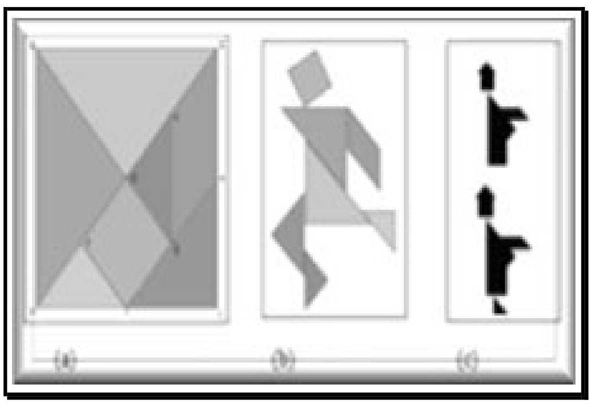
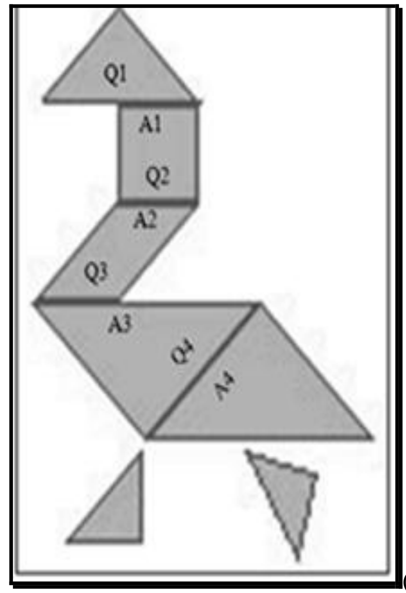


Fig.5: Tangram (see [6]) – a collection of shapes (a) which can be used to create various silhouettes (b and c).

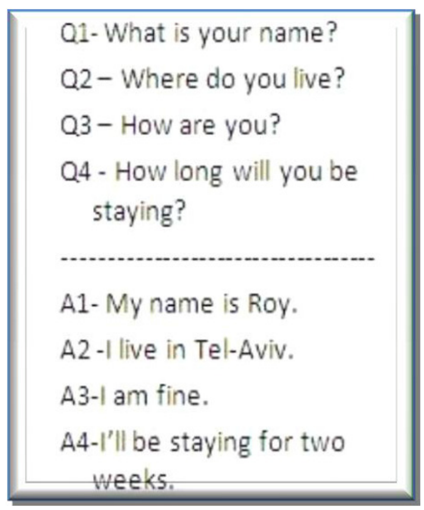
4. ABSTRACTION

One of the targets of the logic mosaic is to broaden the player's world with various levels of abstraction. For example, a mixture of properties such as color, hue, shape (Polygon, 3-dimensional, polyhedron), ovality level (circle, elipse), or one dimensional shapes: line, curve line, on the plannar or on the space. The characteristics of the color may be gradualy changed. In order to change the level of the color power, the use of a neutral color and trsnspsrent colors are recommended. The same extraordinarity (or the similar complexity of oddness) on each tile-part may be the mutual property of the attaching edges of two neighboring elements (tiles, part). Another level of complexity is using the 3D tiles.

The term ***"the diversity degree"*** may be used for searching higher order properties or investigating the combinations of lower order properties.



(a)



(b)

Fig. 6: (a) Tangram with the matching rules of the type "conservation" (see [6]): each edge with the question $\boldsymbol{Q_i}$ is a requirement to attach an answer $\boldsymbol{A_i}$ (Fig. 6b). In the creating mode the symbols Q_i and A_i representing the question and its corresponding possible answer will be submitted by the natural language conservation's sentences.

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Traditional Knowledge as a Beacon for a Civilization at Crossroads

Babita SINHA
Department of Humanities & Social Sciences
Indian Institute of Technology Roorkee, Roorkee 247667, India

P.K. GHOSH
Department of Metallurgy & Materials Sciences
Intellectual Property Rights Cell
Indian Institute of Technology Roorkee, Roorkee 247667, India

"When an elder dies, a Library burns"
— Afrikan Proverb

ABSTRACT

Modern society has entered into an era of development where scientific knowledge alone is now unable to provide the answers and solutions to the complexity of problems standing before mankind. There is increasing evidence of recent efforts to understand and incorporate solutions to a multitude of problems based on the tacit knowledge of indigenous people. This paper makes an attempt to highlight the need for and the modalities of incorporating traditional knowledge into development of solutions to problems plaguing mankind today.

Keywords: traditional knowledge, crossroads, scientific knowledge, conceptual approach, integration

INTRODUCTION

Knowledge Systems around the Globe are in foment and Traditional Knowledge is the centerpiece of the churning. The development of intellectual property rights has led to vociferous calls for the protection of 'traditional knowledge', to provide a counterbalance to the rights of companies in new technology [1]. The question that presents itself is 'What contribution can Traditional Knowledge make to the current existential concerns that are not being addressed by the modern system of knowledge?'

The Crossroads

The most often–quoted definition of sustainable development states that it is one that "meets the needs of the present without compromising the ability of future generations to meet their own needs"[2]. As we stand today we seem to be looking into a precipice of environmental disasters waiting to happen. The salinity of the Fertile crescent in Asia and Australia, the Dust Bowl in Canada in the 30's, the great sparrow campaign which killed 38 million in China, New Zealand's Dirty Dairying and the Killer-bees of Africa are just some examples of how Man's experiments with nature have gone wrong and inflicted a huge blow on our relationship with our environment. The list is dubiously long, spreading across the globe, coinciding with the rampant march of the western civilization as well as the blind rush towards technology by the not-so-developed nations. The debate surrounding sustainability of development is not a new one; however with each passing year it becomes more acutely important to realize and rectify the mistakes and recover whatever we can of the environment from the ruins.

At best the modern human civilization has a troubled relationship with Planet Earth. Ironically, history showcases no such major environmental conflict. Did our ancestors co-exist with nature and its species more responsibly? How did they eliminate the negative impacts of economic development? Is there something of critical importance that we have overlooked in our quest for development?

Science as we know and define it is pretty vast, however it is stringent and narrow in its acceptance of any practice that cannot be quantified, theorized or practiced and verified. Hence armed with proven scientific knowhow we have adopted a simplistic approach of replicating development, industrial and growth models across the world. Every part of our planet is unique and The One-Size-Fits-All strategy is seriously flawed. We have eroded agricultural land, destroyed precious forests, laid rivers and seas to waste and punched holes in our protective atmosphere, we have used chemical and biological weapons of mass destruction laying to waste the soil and its inhabitants for generations to come. We are on the path to self-destruction by doing so. However, there are still tracts of land and islands of harmony with nature that shine like a beacon of hope. These oases remind us that we know what to do and how to do it, but because we never bothered to prove it, document it, ratify it or study it, we ignored it for centuries!

The indigenous communities associated with such pristine ecosystems display a remarkable and enviable self sufficiency under adverse circumstances. Their co-existence with the laws of nature underlines the fact that relying on our instincts is in complete harmony with the laws of nature. *This is the paradigm shift that needs to come about in our society*. Non-reliance on such natural instincts and going with the dictates of established principles of modern science has commonly been the acceptable recourse even when the latter leads to adverse outcomes. This is especially true in case of existential and survival issues.

In the aftermath of the December 2004 tsunami off the coast of Indonesia, calls multiplied for high-technology solutions (installation of early warning systems using cutting-edge satellite and ocean buoy technologies) to prevent similar disastrous occurrences. However, solutions would be more relevant and comprehensive if the knowledge and experience of traditional communities is taken into consideration. “The cultures that support TK around the world are often living in marginal ecosystems, such as the Arctic, mountains, deserts and small islands. These marginal ecosystems are often the sources of key ecosystem services (e.g., role of mountain ranges in sustaining water balance) and are critical for maintaining the overall resilience and adaptive capacity of social-ecological systems are most vulnerable to climate change and will suffer the greatest change often for the worse as a result of climate change. Importantly, the TK of indigenous peoples is proving critically valuable service to the global community. Observations of ecosystem change by indigenous peoples are acting as a sentinel like warning system for climate change. More importantly, the long-term place-based adaptation approaches developed by indigenous peoples provide valuable examples for the global community of low-carbon sustainable lifestyle, critical to developing local adaptation strategies in the face of climate instability” [3].

Conflict and Congruence of TK with Scientific Knowledge

The realization that traditional knowledge is not redundant in today’s world is spreading quickly. The Rio Declaration, The Convention on Biological Diversity, The World Summit on Sustainable Development, The WIPO, WHO, UNESCO, UNDP, The UN Commission on Human Rights, The International Council of Science [4] have all underlined the importance of Traditional Knowledge for current and future growth.

Traditional knowledge is considered as a cumulative need-based outgrowth from the experiences of indigenous communities in their fight for survival. It is a result of observation, repeated usage and verification. It is a cumulative body of knowledge, know-how, practices and representations maintained and developed by peoples with extended histories of interaction with the natural environment. Traditional Knowledge encompasses several areas like traditional ‘folk’ songs, stories, legends, dreams, methods and practices. These sophisticated sets of understandings, interpretations and meanings are part and parcel of a cultural complex that encompasses language, naming and classification systems, resource use practices, ritual, spirituality and worldview [4].

However, modern society (industrial and post-industrial) has placed its faith on scientific knowledge, a part of the western system of codified and formalized knowledge developed through study, generalization and verification, while the more informal, tacit knowledge acquired through observations and experiences and passed on through an oral tradition were looked upon askance and relegated to the realms of unverifiable and hence unscientific and unusable facts.

The term scientific knowledge is attributed to some facts and principles that are acquired through the long process of inquiry and investigation. The investigation takes a long time because it goes through various aspects to come to a conclusion and the aspects include all the laws, theories, concepts and models. However, what needs to be emphasized is that scientific knowledge too is influenced by the social and cultural milieu in which it develops, not unlike the traditional knowledge.

Most people tend to trust and respect science because of its successful application in practically every field of human activity. However, what is becoming obvious is that the existing knowledge system with its emphasis on a regimental process of scientific enquiry, coupled with the constraints of a shrinking resource base, has failed to provide solutions to many modern day problems and in some cases has created a few of its own.

The Challenges

The challenges that threaten survival still exist though their origins have changed. Most of our seemingly insurmountable challenges today are not natural but manmade. They are the fall-out of unsustainable, environment unfriendly human activities which were deviants from the natural process. Our mode of interaction with nature changed considerably as did our response to the consequent changes. Modern science has stepped up to the challenge and produced solutions galore. However, the outcomes have been restricted by the extent of our satisfaction with the immediate fallout, even though it might be tempered with negative consequences, with little emphasis on generating everlasting regenerative solutions.

A search for sustainable solutions is leading to a fallback on the tried, tested and proven techniques and modalities, as represented by the traditional knowledge. However, this re-alignment with Traditional Knowledge must be tempered with caution and astute discrimination as sometimes it is not been merely difficult but almost impossible to find solutions even within the folds of Traditional Knowledge as the perceptions around it have changed considerably with advancement of science and technology.

METHODOLOGY

There is widespread evidence of people in many fields turning to traditional knowledge in search of solutions to everyday problems as well as for answers to weighty survival issues. It is therefore, becoming essential to make traditional knowledge a part of the formalized body of knowledge for its wider propagation and usage. However, for indigenous knowledge to co-exist meaningfully with conventional science, it has to be empowered through quantifiable means acceptable to the modern scientifically-oriented society, such as translation, documentation, verification and validation. For a considerable length of time, Traditional Knowledge was abandoned on the grounds of being un-scientific, hence there is a need to prove and re-establish its credentials. For this, relevant traditional knowledge must first be sourced and collected, processed for verification and validated through scientific analysis, and as a final step, justified through application, in order to bring it under the umbrella of the formal education system, thereby returning it to society in a modern, more palatable format.

In any attempt at integration what must be kept in mind is that traditional knowledge is need-based and confidence-based. Only that TK that addresses the needs of the people today is relevant for preservation and propagation. For instance, in the case of medicines and treatment of diseases, cures and options available several years ago may appear to be primitive and rudimentary when compared to options available today. Additionally, TK, which incorporates the non-technical insights, wisdom, ideas, perceptions and innovative capabilities [5], has so far been based on the confidence generated by the practitioners and propagated through the oral tradition. However, to enhance its acceptability and integration in modern society, it has to be relevantly analysed from the scientific perspective and logical reasoning to make it more compatible with the needs of the contemporary society.

Moreover, care must to be taken to devise an appropriate method of integration without losing the essence of the traditional knowledge while at the same time fulfilling the requirements of the western scientific system. It must be recognized that the two different sciences are based on different principles; hence the rule which applies to one does not translate to the other. For instance, in the case of the Indian Ayurvedic system of medicines, the question arises 'whether the herbs and metals used according to Ayurvedic principles does any harm to the human body if prescribed by an Ayurvedic doctor?' In the Western scientific paradigm it is customary to identify a traditional therapy and medicine, isolate the active ingredient, standardize the potency and clinically test its safety and efficacy outside of the remedy's traditional use. What needs to be studied is the authentic cultural treatment as a system of healing, not whether an isolated compound can be grafted into our modern medical system. We need to study the difference between an ingredient's chemical identification and its physiological medicinal and / or toxic properties [6].

Modalities for Integration

The modalities for integration of traditional knowledge within the modern knowledge system as conceptualized, is based on classification, interaction, study and research. For indigenous knowledge to be understood and incorporated into the modern development approach, it is necessary that the logic behind it be scientifically validated, as has also been advocated by other studies [7] [8]. In this model it is proposed that traditional knowledge is studied within the context of its practice, i.e. it must not be isolated from the domain of customs and traditions within which it has evolved. However, such knowledge has to be understood and examined from the scientific perspective as well, through interactions of the scientific community with the stakeholders and practitioners of TK.

Classification of TK

Traditional knowledge encompasses all aspects of life, be it food habits, social customs, agricultural practices, health and medicines etc. As more studies of indigenous knowledge become available, its relevance to development will become self-evident. Such studies, so the argument goes, should be archived in national and international centres in the form of databases; the information in these databases could be systematically classified [9].

Several classification systems have been developed including the TKRC (Traditional Knowledge Resource Classification) based on the structure of International Patent Classification (IPC), though it is limited to the Indian Systems of medicine, viz., Ayurveda, Unani, Siddha and Yoga. The classification system has to be widened to encompass other areas as well, which will facilitate greater awareness about the traditional knowledge systems. The collection and storage of indigenous knowledge should be supplemented with adequate dissemination and exchange among interested parties, using newsletters, journals and other media [10]. However, awareness generation is only the first step in the integration process.

The Proposed Model

Though, it is widely recognized that for successful integration, it is necessary that the logic behind it is scientifically validated, there is diversity in the methods advocated. Some argue that only the knowledge that are potentially relevant to development be studied and protected …. other forms of such knowledge, precisely because they are irrelevant to the needs of development, can be allowed to pass away [11]. International Council of Science [4] has advocated that a science curriculum must properly interact with local experiences and systems of traditional knowledge to be fully effective.

TK *Chaupal*, the ideation process: In this model it is proposed that traditional knowledge is studied within the context of its practice, i.e. it cannot be isolated from the domain of customs and traditions within which it has evolved. However, such knowledge has to be understood and examined from the scientific perspective as well through interaction of the scientific community with the stakeholders and practitioners of the TK. There is a need therefore, to devise suitable forums for incorporation and interaction with the traditional knowledge. One such forum that is proposed is **"TK *chaupals*"**. *The term 'Chaupal' refers to a community building or space in the rural areas of North India and Pakistan* [12]. In the popular perception a *chaupal* is any place where people "*sit and discuss their problems, celebrate their pleasures, share the pains of an individual, family or a particular group, sort out their disputes*." It is the hub of community life in villages. It is "*a sacred* *place of secular nature*" that "*guarantees freedom of speech and expression to everybody*" [13].

It is envisaged that the 'TK *chaupals'* will foster informal discussions initiating the process of 'discovery' of many of the forgotten traditional knowledge and subsequently of their revival and utilization. These interactive 'TK *chaupals*' will bring out the implications, importance and acceptability of such traditional practices and enable incorporation and integration into scientific analysis and research. It would also serve as an effective forum for understanding the concerns of the indigenous community, as well as of educating them of the scientific aspects uncovered, thereby ensuring better assimilation of the results by such communities.

An alternative Approach to Education & Research: Education is the process by which society deliberately transmits its accumulated knowledge, skills, and values from one generation to another. Traditional knowledge, which is an integral part of this accumulation, has, however, been lost in the transition. Traditional Knowledge has lost out on formal education to an extent that the educated person would dismiss TK as superstition or folklore. Down the years, this attitude towards TK alienated it from mainstream education system resulting in it acquiring the status of an antiquity and being relegated to the archives. The need of the hour, therefore, is for education to grow more broad-based and multi-dimensional in approach and develop a new approach wherein study of relevant areas of TK is incorporated into the existing course structures especially in higher education. The relevance of TK in research has already been highlighted in some field such as medicines and biotechnology. The main outcome of this integration would be to re-establish life decisions within the natural phenomena leading to a more sustainable system.

Dissemination: The outcome of the above process would impact the way education is disseminated. The multi-disciplinary approach would not only make it more broad-based but also re-establish survival decisions within the natural phenomena. The unsustainable use of resources on the one hand and alienation from knowledge gained through centuries of observation and practice, on the other, call for re-examining of the direction and shed new light on the path of modernizing the existing education system. Traditional Knowledge will have a pivotal role to play in shaping the future of mankind if used within the excellent scientific framework already in place.

Development of a suitable system calls for participation of all individuals and organizations from all parts of the world, with a rich heritage of traditional knowledge base and concerns in this perspective. This initiative will succeed if and only participation - so we invite all concerned to contribute and participate in this endeavour.

CONCLUSION

Countries around the world are trying to achieve sustainable and inclusive growth. However, many sections of society, including the indigenous communities, continue to be marginalized and their 'way of life', along with their natural habitats, customs, traditions and knowledge systems are being destroyed in the name of assimilation into the modern society. The current dissonance in the development process calls for a rethink of the path which the modern society should take. The local communities themselves are unable to make suitable choices regarding the knowledge that is crucial to their existence or those that have become redundant. Hence there is a need for careful selection of useful traditional knowledge and the only viable system appears to be scientific validation of TK to achieve conformity with modern scientific knowledge. Such integration of TK with scientific knowledge will create a rich knowledge base serving the entire mankind in search of feasible solutions.

With huge challenges thrown up frequently in the form of disease and deaths, mankind is in need of stepping up and salvaging the wisdom of our forefathers. As a race we need to re-orient and re-position our thinking. Science has been a success but not an unqualified one. It needs an arm and in some cases, a leg as well, to support its strides in the future. The strength it can derive from leaning into Traditional Knowledge is huge. There are challenges where science has been stonewalled and needs to find a way out. Traditional Knowledge is the key to a better future for mankind. In every field from medicine to food to agriculture, we must un-learn our un-sustainable ways and start drawing strength from our folklores, traditions, stories and practices. It is a complex task, one which will require us to believe that we can unravel the mysteries that are woven into the very fabric of our existence on this planet as well as devise suitable systems for incorporation and propagation down the passage of time. As custodians for our future generations it is our responsibility to begin carving a unique and yet untrodden path, one which unites our past wisdom with our present scientific brilliance. It is a journey sure to be filled with exciting new discoveries and fulfilling rewards for Planet Earth and its millions of inhabitants.

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The Music Retrieval Method Based on The Audio Feature Analysis Technique with The Real World Polyphonic Music

Chai-Jong Song, Seok-Pil Lee, Sung-Ju Park, Saim Shin, Dalwon Jang

Digital Media Research Center, KETI,
#1599, Sangam-dong, Mapo-gu,
Seoul, South Korea

ABSTRACT

This paper describes a method of the Music Retrieval Method based on audio feature analysis techniques. This method contains three major algorithms with newly proposed advanced way and the implementation of the whole system including client and server side prototype to be applied on time to market. The first one of the major algorithms is to extract the feature from the polyphonic music, which is the advanced version using the harmonic structure of vocal and musical instruments. The second one is to extract the feature and suppress the noise of user humming signal recorded from input device. Noise suppression algorithm makes merge of MS for stationary noise and IMCRA for non-stationary noise, and the feature is estimated with temporal and spectral autocorrelation simultaneously to reduce the pitch having and doubling problem. The last one is the fusion matching engine improved with DTW (Dynamic Time Warp), LS (Linear Scaling) and QBCode (Quantized Binary Code). This system is extremely targeting on industrial services such as music portal service, fixed stand-alone devices, mobile devices, and so on. Especially, our very first focus is the Korean KARAOKE system which is the one of very popular music entertainment services in Asia and the music portal service like Bugs music, Mnet, zillernet, and so on. We have cooperated with TJ media co. to commercialize this system.

Keywords: MIR, QbSH, Multi-F0, Melody extraction, Pitch contour, Matching engine, DTW, LS, QBcode.

1. INTRODUCTION

With the recent proliferation of digital contents, there are increasing demands for efficient management of the large digital contents' databases, and the tag based retrievals have been extensively used. But, the way of tagging manually is a laborious and time-consuming work. It has been reported that more than 40,000 albums are released in a year just for only USA music domain. To avoid such works, MIR (Music Information Retrieval) techniques are emerging rapidly rather than faster as we thought as an alternative way to manage a music database [1]. MIREX (Music Information Retrieval Evaluation eXchange) suggested by J. Stephen Downie, who is professor of University of Illinois, have given an impetus to developing MIR techniques for recent years. It has been held every year from 2005, and a lot of participants have competed with other teams having their own algorithms or systems[2]. Among various tasks in MIREX, QbSH (Query by Singing/Humming), which provides the music retrieval service to user who only knows some pieces of melody but nothing else, is started with the beginning of that contest[2]. In a few recent years, the applications related music are showing a steady growth with exploding smart phones and tablet users triggered by iphone. There are two popular music retrieval services commercially such as Soundhound and Shazam as you already know. Shazam has served music retrieval based on fingerprinting but QbSH. This is out of the focus of this paper, so we do not consider music fingerprinting anymore. Soundhound taken from online Midomi service has provided QbSH service only with humming feature database which is extracted from user humming to search music in advance. Like this, current QbSH method has been studied with the monophonic signal such as humming or MIDI. But, there are some problems for this method to provide the commercial service: Data sparseness when using humming database, additional works to transcribe the music manually when using MIDI database, and so on. It is difficult to adopt QbSH service for the various industrial fields in case of only targeting monophonic data. We propose the music retrieval method with polyphonic music such as MP3 to eliminate those problems. We are explaining the proposed method starting from briefly description of overall architecture.

2. OVERALL ARCHITECTURE

In this paper, we introduce the proposed music retrieval method with feature analysis technique. There are two main parts for description, the system implementation and the three proposed algorithms. The system implementation contains the client prototype for PC and mobile phone application of Android and server side prototype. The first one of the three major algorithms is to extract features from polyphonic music recordings, the next one is noise suppression and pitch extraction from user humming and the last one is matching algorithm to evaluate the similarity between two of those features. We are considering the three kinds of features: melody, rhythm and segmented section. We are only utilizing the melody and segmentation but not yet rhythm so far. The whole system is operated as followed.

At the client side device, recording user humming signal with background noise for 10 seconds and then suppressing noise, extracting melody from this signal and finally it transmits the query data formatted with MP-QF international standard to the server waiting for request as you expected. You can switch the noise suppression block turning on and off by the background noise circumstance. The server parses the received data and calculates the similarity score between queried data and features stored in database, and then recommends top 20 items with highest similarity score to client vice verse. There are three kinds of database of our system as called polyphonic, humming and segmentation. The polyphonic feature is mainly used to make the matching engine evaluate the similarity. The segmentation is to speed up matching algorithm by pre-clustering specific section of music structure such as intro and climax. For the standalone device, server and client function become one whole block without formatting query data.

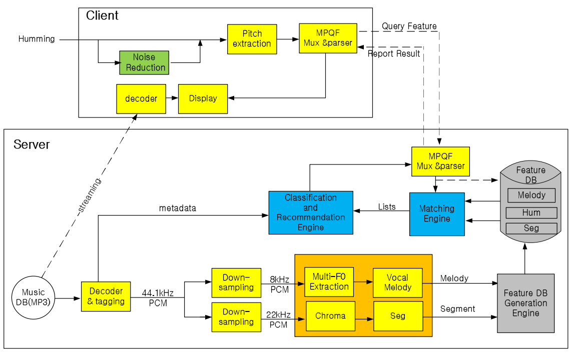

Figure 1. Overall system diagram

We have three steps to realize our system. At the beginning of the project, we have started with Roger Jang's corpus DB used for QbSH task of MIREX 2005 [3]. It has 8kHz sampling rate and 8bits per sample. We make the very first algorithms of pitch estimation for humming and matching engine get verified with this corpus which have the manuscript pitch vectors represented with semitones at every 32ms. Semitone is represented as Eq. (1).

$$\mathrm{Semitone} = 12\mathrm{x}\log_2\left(\frac{\mathrm{F0}}{440}\right) + 69 \qquad (1)$$

Here, F0 is fundamental frequency. At this stage, we develop the noise suppression algorithm for humming data with Aurora2 dataset which has stationary and non-stationary background noise including several categories of car, airport, subway, babble, restaurant, train, exhibition and street on the real circumstance. The noise level is settled to 10dB which is similar to real world humming situation. At the next stage, the matching engine is improve the performance with MIDI dataset and 1,200 humming clips recorded for pitch estimation. At the final stage, we have optimized matching engine and feature extraction algorithm with polyphonic music data.

3. PITCH ESTIMATION

As I mentioned briefly, pitch estimation algorithm is started with Roger Jang's corpus and Aurora2 noise dataset for user humming signal, and then we make it suitable to 1,200 humming dataset. Overall procedure for pitch estimation is described as Figure 2. The input signal is sampled at 8kHz with 16bits per sample. It is processed with 32ms frame size and 16ms hoping size. The autocorrelation is the most well-known method for finding pitch from periodic signal and also robust against the noise. It is the powerful tool but it is also the obvious fact that it also has the critical problem for pitch estimation.

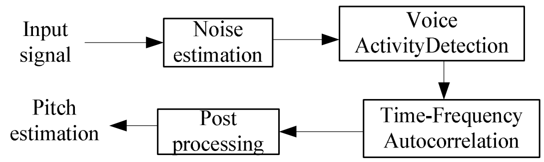

Figure 2. Pitch estimation flow gram

You can see often the pitch doubling problem at the low frequency with the time domain autocorrelation [4]. On the other hand, you might face the pitch halving problem at the high frequency with spectral autocorrelation. We propose the integrated time and frequency domain autocorrelation and salience interpolation algorithm. It makes those problems get solved with merging autocorrelation at each domain. But it has the limitation of resolution to represent pitch and fundamental frequency at each domain because they are inversely proportional relation. We can remove the trouble by taking the interpolation for the spectral index which is only near field index against the pitch index at time domain before merge. In addition, we can take advantage with the calculation efficiency by reducing FFT length. Time domain auto correlation is shown as Eq. (2).

$$\mathrm{R_t}(\tau) = \frac{\sum_{n=0}^{\mathrm{N_t}-\tau-1} \mathrm{x}[\mathrm{n}]\mathrm{x}[\mathrm{n}+\tau]}{\sqrt{\sum_{n=0}^{\mathrm{N_t}-\tau-1} \mathrm{x}^2[\mathrm{n}] \sum_{n=0}^{\mathrm{N_t}-\tau-1} \mathrm{x}^2[\mathrm{n}+\tau]}} \qquad (2)$$

Here, $\mathrm{x}[\mathrm{n}]$, τ, $\mathrm{N_t}$ is input signal, delay, and frame length respectively. The spectral autocorrelation is shown as Eq. (3).

$$\mathrm{R_w}(\tau) = \frac{\sum_{k=0}^{\mathrm{N_t}/2-\tau-1} \mathrm{X}[\mathrm{k}]\mathrm{X}[\mathrm{k}+\tau]}{\sqrt{\sum_{k=0}^{\mathrm{N_t}/2-\tau-1} \mathrm{X}^2[\mathrm{k}] \sum_{k=0}^{\mathrm{N_t}/2-\tau-1} \mathrm{X}^2[\mathrm{k}+\tau]}} \qquad (3)$$

Here, $\mathrm{X}[\mathrm{k}]$, τ, $\mathrm{N_t}$ is log magnitude spectrum, delay and FFT length of each frame. $\mathrm{R_t}(\tau)$ and $\mathrm{R_w}(\tau)$ is merged with different ratio after normalized with each energy. Merged autocorrelation depends on the weighting factor β settled at 0.5 through the various experiments. It shows the result that β is better less than 0.5 for woman, vice verse for man. Merging method of each autocorrelation is shown as Eq. (4).

$$\mathrm{R_f}(\sigma) = \beta \mathrm{R_t}(\sigma) + (1-\beta)\mathrm{R_w}(\sigma) \qquad (4)$$

At first, we estimate the some pitch candidates with the peak indexes of temporal autocorrelation, and take linear interpolation with only some indexes of spectral autocorrelation in contiguity with candidate pitches of time domain. Linear interpolation on frequency domain is shown as Eq. (5).

$$\mathrm{R_w}(\hat{\tau}) = \mathrm{R_w}(\hat{\tau_1}) + \frac{\mathrm{R_w}(\hat{\tau_2}) - \mathrm{R_w}(\hat{\tau_1})}{\hat{\tau_2} - \hat{\tau_1}}(\hat{\tau} - \hat{\tau_1}) \qquad (5)$$

Before spectral autocorrelation, the formant structure is flattened by whitening spectrum because the harmonic structure is broken easily at the high frequency. So we take the spectral autocorrelation after giving salience to the low frequency. Before estimating the pitch candidates, VAD (Voice Active Detection) module detects the voiced frame with high frame energy and low ZCR (Zero Crossing Rate) to extract correct pitch from noise humming data. Once judged to voiced frame, that is considered whether tainted by noise or not. If it is, noise suppression algorithm optimized for our QbSH system is activated for the noisy input. It takes the spectral magnitude of the noisy humming signal through the FFT analysis, and estimates the noise using MS (Minimum Statistics) which assumes that the tainted frames have the minimum power from the noisy signal and IMCRA (Improved Minima Controlled Recursive Averaging) which uses SNR of the statistic ratio between the voiced region and the unvoiced region [5]. Noise suppressed signal is calculated by taking IFFT. At the post-processing stage, the pitches as assumed shot noise are eliminated with median filter.

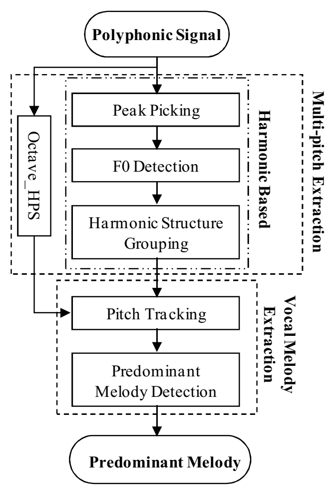

Figure 3. Melody extraction flow gram

4. MELODY EXTRACTION

The main melody from polyphonic signal is the reference dataset for our query system. Multiple fundamental frequencies as called multi-F0 have to be calculated before estimating main melody from polyphonic music signal which has the various instrument sources plus singer's vocal simultaneously. This topic has been researched by various papers for the last decade, but those articles have informed that estimating multi-F0 is not an easy task; especially when the accompaniment is stronger than main vocal [6][7][8][9]. You can see easily that it happens at the current popular music like dance, rock, something else. Keeping in mind this situation, we propose the method of tracking the main melody from the multi-F0 with the harmonic structure which is very important fact of vocal signal. All of musical instruments have the harmonic structure as well as human vocal but percussion instruments. The proposed method is shown as Figure 3.

Pre-processing: The music signal on the music database is sampled at 44.1 kHz with 16 bits per sample at stereo. This is down-sampled at 8 kHz and mono before pre-processing to emphasize the pitch information. It is processed by 16ms frame length with Hanning window and one frame look-ahead. The vocal region is detected with the zero crossing rate, frame energy, and the deviation of spectral peaks. We introduce the vocal enhancement module based on the multi frame processing and noise suppression algorithm to improve accuracy of vocal pitch. It is modified from adaptive noise suppression algorithm of IS-127 EVRC speech codec which has the advantage of enhanced performance with relative low complexity. Windowed signal is transformed into frequency domain with STFT, and then grouping frequency signal X[k] into 16 channels. The gain is calculated with SNR between input signal and noise level predicted by pre-determined method at each channel. Input signal is rearranged with this gain at each channel respectively. The noise suppressed input signal is obtained by inverse transformation. This paper assumes the input signal as "vocal melody + accompaniment" while EVRC assumes the input signal as "voice + background noise". This method improves up to maximum 10.7% accuracy rate for the melody extraction.

Multi-F0 Estimation: The multi-F0 candidates are estimated from the predominant multiple pitch calculated by the harmonic structure analysis. The multi-F0 is decided by grouping the pitches into several sets by checking validation of its continuity and AHS(average harmonic structure). The melody is obtained by tracking the estimated F0. Voiced or unvoiced frame is determined on the pre-processing stage. If it is judged to unvoiced frame, it assures that F0 does not exist, otherwise doing harmonic analysis. Multi-F0 is estimated through three processing module like peak picking, F0 detection and harmonic structure grouping. There are some peak combinations with F0 because polyphonic signal is mixed with several musical instrument sources. F0 with several harmonic peaks is evaluated by Eq. (6).

$$\begin{gathered}|\mathrm{X[k]}| > |\mathrm{X[k-1]}| \text{ and} \\ |\mathrm{X[k]}| > |\mathrm{X[k+1]}| \text{ and} \\ |\mathrm{X[k]}|\mathrm{PTH}_{\mathrm{l,h}}\end{gathered} \tag{6}$$

Here, $\mathrm{PTH}_{\mathrm{l,h}}$ is low and high band threshold for peaks. In general, average energy is different between two bands for the music signal, we make the point at 2kHz to split into two bands. PTH is adaptively decided by skewness of frequency envelop.

$$\mathrm{SK} = \sum_{\mathrm{k}=0}^{\mathrm{N}/2}(|\mathrm{X[k]}| - \overline{\mathrm{X}})^2 \tag{7}$$

Here, SK is skewness and $\overline{\mathrm{X}}$ is mean of |X[k]|. If SK=0 energy is symmetric, if SK>0 energy is leaned to low band, if SK<0 high band has the more energy than low band. So, if SK=0 then $\mathrm{PTH_l}, \mathrm{PTH_h} = \overline{\mathrm{X_a}}$ and if SK<0 then $\mathrm{PTH_l} = \overline{\mathrm{X_a}} - \sigma_\mathrm{a}, \mathrm{PTH_h} = \overline{\mathrm{X_h}} - \sigma_\mathrm{h}/2$, and if SK>0 then $\mathrm{PTH_l} = \overline{\mathrm{X_a}} - \sigma_\mathrm{a}/2, \mathrm{PTH_h} = \overline{\mathrm{X_h}} - \sigma_\mathrm{h}$.
Where, $\overline{\mathrm{X_a}}, \overline{\mathrm{X_h}}, \sigma_\mathrm{a}, \sigma_\mathrm{h}$ is mean value and standard deviation

for full band and high band respectively. F0 is limited from 150Hz to 1kHz. The distance of each peak is calculated by Eq. (8).

$$\Delta[u,v] = \text{peak}[u] - \text{peak}[v] \quad (8)$$

Here, u=v+1,…..,J, v=1,…..,J, J is total peak number for current frame. The harmonic relation is calculated between peak[v] and every F0 candidates.

Vocal melody extraction: If all of the F0 satisfies the ideal harmonic structure, real frequency peak will be at the harmonic peak which they must be. Following this process, you can take 5 F0 candidates at 150, 200, 300, 400, and 450. F0 is assumed as the maximum spectrum peak. AHS (Average Harmonic Structure) determine F0 significant degree by calculating the average energy of harmonic peaks. Vocal melody is tracking estimated F0 candidates of each frame.

Segmentation: Rhythmic feature including the tempo is defined by fluctuation pattern of the music clip. In the strict sense of the word, segmentation is not a feature for directly matching process. That is actually one of the pre-processing to enhance matching process by marking at the specific region of music. The modern poplar music can be divide into 5 sections as intro, outro, verse, bridge and refrain or chorus. The musical structure analysis method is developed by several studies, but it is out of focus. The focus of this paper is finding the phrase of music which is hummed more often by users. To make it successfully, we utilize the fact that the most modern western pop music has the repeat parts on rhythm and lyrics. Some papers provide the music thumbnail using this feature because it is able to find the climax or interesting part with this fact [10] [11]. Many low level audio features are reported for the segmentation processing like MFCC (Mel Frequency Cepstral Coefficient), chroma, key, fluctuation, energy, ZCR, and so on. We will get the chroma vector which is commonly known as one of the most suitable features for musical structure analysis because it is not dependent on the timbre of particular musical instruments or vocal sound while MFCC is [12]. The segmentation is realized by combining analysis and reconstruction of the audio data. Input audio signal has 20kHz sampling rate, 16 bits per sample, then the STFT with 4096 sample Hanning window is calculated by FFT with the 50 % overlap hop size. Segmentation is realized by following procedure. At first, 12 dimensional chroma vector is calculated from the magnitude spectrum with log-scale band pass filter.

$$V_t[c] = \sum_{k\in Sc}^{N-1} \frac{X_t[k]}{N_c}, c = \{0, \ldots, 11\} \quad (9)$$

here, $V_t[c]$ is chroma vector for t-th frame, Sc is chroma set for each octave, $X_t[k]$ is magnitude spectrum and k is its index. Each element of chroma vector represent one of the pitch classes respectively such as C, C#, D, D#, E, F, F#, G, G#, A, A# and B. It is sum of all values of pitch classes over 6 octaves corresponding from 3 to 8. Then the similarity matrix is calculated by normalized Euclidian distance with chroma vector against time lag.

$$S(t,l) = \frac{\left|\frac{V_t[c]}{m\ axV_t[c]} - \frac{V_t[c-l]}{m\ axV_t[c-l]}\right|}{\sqrt{12}} \quad (10)$$

S(t,l) is satisfied $0 \le s(t,l) \le 1$. It shows the repeated section with high score along the horizontal line. The threshold for repeated section is calculated by an automatic threshold selection method based on a discriminant criterion [13]. You can find the optimal threshold by maximizing total variance between two classes.

$$\sigma_t{}^2 = \omega_0\omega_1(\mu_1 - \mu_0)^2 \quad (11)$$

Here, ω_0, ω_1 is probabilities of class and μ_0, μ_1 is mean of peaks in each class.

5. MATCHING

The matching engine measures the similarity between pitch contour from humming and melody contour from the music. It returns the top 20 candidates with higher score from fusion matching method which is proposed by this paper. This proposed method is taken and improved from three kinds of algorithm, DTW (Dynamic Time Warping), LS (Linear Scaling) and QB (Quantized Binary) code [14]. It is starting with eliminating the silent duration from pitch and melody contour since it does not have any information for measuring the similarity. Then It normalizes two contours as test and reference vector through Mean-shifting, Median and Average filtering, Min-max scaling.

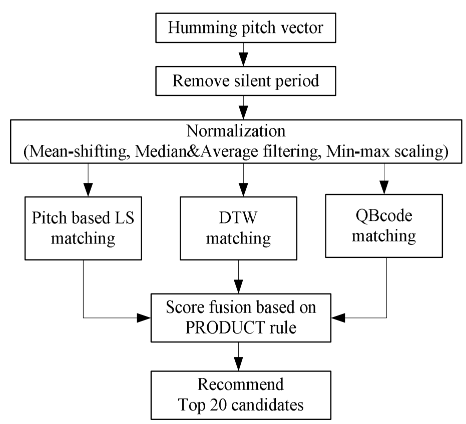

Figure 4. Matching engine flow gram

It is why doing Mean-shift filtering that each humming might be located at higher or lower notes rather than original version of music. It has to eliminate the difference and adjust the level of test and reference vector. Median & Average filtering with 5-tap is adopted to remove the peak point caused by surround noise, shivering or vibration of sound tone. Min-max scaling is applied to compensate the distance of amplitude between two vector sequences. After normalize the two vectors, three algorithms calculate the similarity scores simultaneously, then those scores are combined with weighting into single fusion score that is the main fact to determine the candidates.

Dynamic Time Warping: The major one of three algorithms is the improved DTW which is the popular one of Dynamic Programming to measure the distance between two patterns with different length. Conventional DTW has the several important constraints such as alignment of start and end point, local region constraint, and something else in common, but proposed DTW does not have any constraints. In addition, it calculates the distance between two vectors with log scale to choose the one that has the more elements with small distance, if the distance of similarity is the same. Here is an example. Test vector is [1,2,1,0,-1], and reference vectors are [2,1,-1,0,4] and [4,5,3,0,2]. It is the same distance for two reference vector with conventional method. You can select the first one with log scale distance measurement. We can take the improvement by removing the alignment of start and end point because it is able to increase the possibility of matching the start point and length of sequence between two vectors.

Quantized Binary code: QBcode has the 4 section of normalized vector and different binary codes are assigned to each section as '000', '001', '011' and '111'. The distance for QBcode is calculated with hamming distance (HD) between two vectors. We decide whether applying DTW or not with this humming distance.

Linear Scaling: LS algorithm is the simplest and quite effective one for patterns which have the different length. The main idea is rescaling test vector into several different lengths for the reference vector. Especially humming length depends on who is humming. So, humming data should be compressed or stretched to match with reference data. Test vector are rescale by scale factor from x1.0 to x2.0 with 5 steps. The distance is measured with the log scale for the same reason of DTW.

Score level fusion: The three scores from the above different matching algorithms are merged into the one fusion score. There are many methods for score level fusion as MIN rule, MAX rule, SUM rule and so on. The fusion score is calculated with the PRODUCT rule which multiply two scores. Basically, Proposed DTW carries out the most important role on the matching stage, and LS and QBCode is complement for DTW. So it gives the weight as 0.5, 0.2 and 0.3 to DTW, LS and QBcode respectively. The matching engine recommends top 20 candidates with higher fusion scores.

6. EXPREMENTS

We have built the three kinds of reference dataset, one humming test set and MP3 music database with tags for streaming service. The reference dataset is changed from Jang's corpus, and then main melody of MIDI and then finally to the melody contour of polyphonic music.

Datasets: The reference dataset contains vector sequence and segmentation from 2,000 MP3. Humming test set is consisted of 1,200 humming vector sequences against 100 songs as called AFA100 which is among 2,000 songs referred to MNet music chart that is the most popular one of Korean music portal services. We also have 2,000 MIDI data from KARAOKE system to verify our matching algorithm. We include this MIDI data into our system for Korean KAROKE service at implementation phase. The music dataset covers 7 different genres with ballad, dance, children song, carol, R&B (rhythm and blues), rock, trot and well-known American pop. The 1,200 humming clips with 12 second duration are recorded against AFA100 to evaluate the algorithms because it is hard to hum at every time of testing the algorithms. It is consisted with almost same ratio of sing and humming and recorded from 29 persons. Three among them have the experience of music related study at university and others not. We analysis and classify that into 3 groups as beginning, climax part and others. We figure out that beginning part is a slight over 60% and climax part is about 30%. It did not expect that the beginning part is almost twice of climax. We evaluate the performance with this humming set.

Evaluation: we have evaluated above three algorithms as pitch extraction from user humming, melody extraction from polyphonic music and matching algorithm between test and reference vectors. The evaluation for the pitch extraction algorithm is shown as Table 1. We choose G.729 and YIN as well-known algorithm for pitch estimation for evaluating proposed method [4][15].

Environments		G.729	YIN	Proposed
clean		94.7	97.3	97.8
babble	10dB	80	81.4	88
	0dB	45.7	53	55.7
volve	10dB	93.6	95.7	97.4
	0dB	83.3	80.1	91.6
white	10dB	87.7	85.9	96
	0dB	60.7	53.3	85.7
total average		85.4	86.8	92.1

Table 1. Evaluation with GER-10%

The second evaluation is the melody extraction algorithm with two methods as MMR used on TREC Q&A and RPA and RCA used on MIREX contest for melody extraction task. MMR is defined as Eq. (12).

$$\mathrm{MMR} = \frac{1}{\mathrm{N}} \sum_{\mathrm{n}=1}^{\mathrm{N}} \frac{1}{\mathrm{rank}_{\mathrm{n}}} \tag{12}$$

Here, N is total number of frames, $\mathrm{rank_n}$ is F0 rank of n-th frame. We have the tolerance of 1/4 tone. We take 0.86 average of MMR. We take the ADC 2004 dataset for evaluating the algorithm because the Korean dataset we have does not have the groudtruth [16]. The last one is the matching algorithm evaluation with MMR method for the recorded 1,200 humming clips. We evaluate the two input steps as 32ms and 64ms. The evaluation condition as followed: 1,200 humming clips for test vector, 2,000 polyphonic songs with from 3 to 6 minutes duration for reference vector on Intel i7 973 with 8MB memory.

Participant	RPA(%)	RCA(%)
Cao and Li	85.625	86.205
Durrieu & ichard	86.96	87.398
Hsu, Jang & hen	63.11	74.101
Joo, Jo & Yoo	81.959	85.798
Dressler	85.969	86.424
Wendelboe	83.135	86.593
Cancela	86.962	87.545
Rao and Rao	81.446	88.038
Ono & Sagayama	59.768	72.129
Proposed Method	90.418	92.27

Table 2. MIREX 2009 melody extraction result

	Top1	Top10	Top20	MRR	Time(sec)
32ms	74.90%	89.20%	92.20%	0.793	12.4
64ms	71.10%	80.10%	83.70%	0.738	4.7

Table 3. Evaluation of matching engine

Implementation: We have implemented three kinds of prototype agents for pitch extraction, melody extraction and matching engine. We also implement two kinds of application for commercial service as server/client version for PC and Android client application. The client application records the humming through the input device as microphone, then extract and send the pitch sequence to the server side and then waiting for response of server. The server is waiting for query after initializing the feature DB, then starting the matching process with receiving query from client. It sends the top 20 candidates with metadata including title, singer, cropped lyrics, genre parsed from MP3 tags to the client. The client chooses the one of recommends, server starts the streaming of data. If it is the finding one, the client send the number of selected item, then server adds the queried humming pitch to humming DB and update the feature DB status and increase the priority of that song. The database structure is built by the technique of the multi dimensional index which provides the efficient search.

7. CONCLUSION

In this paper, we proposed three new algorithms of pitch extraction, melody extraction and matching algorithm for QbSH system with real world polyphonic music. For the pitch extraction algorithm, we propose new idea with merging time and frequency domain autocorrelation with salience interpolation to remove the pitch halving at high frequency and the pitch doubling at low frequency. On the melody extraction stage, which is the most important part for the QbSH with polyphonic music, the algorithm based on the harmonic structure is proposed and segmentation for finding the intro and the climax section is proposed. The last algorithm for the matching engine utilizing score level fusion with three different algorithm as DTW,LS and QBcode is proposed. Finally, we implement the application for PC and smart phone. In future works, we have the plan to enhance the matching accuracy and implement DSP for embedded system.

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Innovation Communication with a Knowledge-based Information Leitstand - A Proposal for Matching Information Supply with Information Demand

Dr. Martin Stößlein
Professor at the Faculty of Management and Economics, Dalian University of Technology,
2 Linggong Lu, 116024 Dalian, P.R. China
stoessma@dlut.edu.edu
stoessma@udayton.edu

ABSTRACT

Numerous new product developments demonstrate that technologies (e.g., WAP, TD-SCDMA) can fall below demand forecasts. Innovation alone does not guarantee market success. Communication - especially when using acronyms - often makes it too intricate for customers to grasp the advantage of technological advancements, or for investors to forecast product margins. Consequently, stakeholders remain unsatisfied and share unfavorable opinions on the Internet. In this paper, we provide selected ideas on how to make technology work for business; specifically, how organizations can best influence, appeal to and canvass stakeholders about their innovations whilst not appearing too aggressive. We propose that innovation communication processes could be enriched with a Knowledge-based Innovation Information Leitstand (ICL) to match information supply with information demand.

KEYWORDS: Information Requirement Analysis, Leitstand, Stakeholder Communication, Innovation Communication, Personalization

1. PROBLEM SITUATION

Having a rich technology portfolio and innovative products, and a 'new product development (NPD) process' available is a necessity, but these alone seem insufficient for product success or the creation of new markets. Typically, some 80% of 5,000 new products launched in US supermarkets each year are unsuccessful [1]. In 2004, only 15% of new brands and products at Proctor & Gamble paid off [2].

Many innovative products fail because companies neglect to adapt strategies, acquire marketing knowledge, and establish networks [3]. Besides poor market research, defects and ineffective supply chain operations, poor communication during the product launch is also a well-known reason for failure [1]. Indeed, poor implementation of innovations results in lost sales of more than 40 billion Euros in Central Europe every year [4].

In this paper, we argue that it is not only technology that is an ingredient for success; it often boils down to "smart" innovation communication with relevant target groups. The mantra of Juergen Strube, the former CEO of BASF - "that which we cannot communicate, can't be produced and realized" - rightly sums up the importance of communication.

'Innovation communication' is not a new concept; for decades companies have informed the general public about their innovations in magazines, on TV, and in brochures at technology fairs. However, electronic media via the Internet provide a rich opportunity to revise traditional, i.e. often persuasive, communication strategies, and enable companies to communicate with every Internet user in a personal way at his or her work place or in their home. Electronic stakeholder communication (e.g., with and to key customers, investors) with individualized and situation-oriented information could be a success factor for companies in general, and, more specifically here, for creating and disseminating innovations.

Since products are increasingly co-created with potential customers ("open innovation") and introduced online, we have perceived demand for a 'tool' enabling managers to "power up" the effectiveness and efficiency of innovation communication processes. We call this 'tool' an Innovation Communication Leitstand (ICL) in order to emphasize its closeness to highly automated flow processes of the Leitstand concept in production planning systems (see [5]; the German 'Leitstand' can be translated as control center or management cockpit).

2. MANAGERIAL RELEVANCE

We perceive a particular need to employ an ICL during the early stages of a new product development (NPD) process (that converts embryonic ideas into salable products or service) including market launch processes and early recalls. We have observed that, particularly during the NPD process, relations with relevant target groups for a new product are often less developed. Second, at this stage of a company's life cycle, it is vital to build up social capital and foster a company's reputation in a particularly short time frame. Third, project teams during NDP processes seldom have the luxury of time to enthusiastically and coherently notify key customers, investors, and other interested parties about their latest ventures and technical developments using electronic media. Often communication experts are not integrated at early product-development stages. An ICL may be of additional value at companies in those industries with short product cycles, high 'clock speed', or 'blue ocean strategies.

Despite the increasing importance for innovation communication on the Internet, typical reasons why managers can be against 'fashionable' Web 2.0 instruments (Wikis, social media sites, Twitter etc.) can be identified: a feeling of losing power and influence (as well as losing time and nerves), or simply being averse to correcting examples of bad practice. Nevertheless, social media sites change the way people communicate, collaborate, build relations, and make decisions. Impressively, 25% of the German population are active users on Facebook alone. It is on social media sites that users demand swift corporate information and quick reactions to their inquiries, where users check recommendations to buy a new product, or where users share thoughts and opinions with friends. In failing to be where stakeholders are virtually, companies may risk 'missing the boat'.

3 RESEARCH QUESTIONS AND METHODOLOGY

In our current research, we explore to what extent (social media) websites provide opportunities for organizations to launch novel products and services. What are the requirements, system components and functionalities of a knowledge-based ICL that can support innovation communication processes?

Innovation communication in social media is one facet of our research into electronic stakeholder communication that started as the research project AIDAR at the University of Erlangen-Nuremberg as early as 2000. We identified, conceptualized, and evaluated value-based approaches how organizations can increase corporate value with 'smart' communication [6]. Using knowledge-based information systems proved to be exceptionally promising at certain stages of product and company life-cycles (e.g., product launches, crisis situations).

Following the paradigm of "research through prototyping", we proceeded through the following five steps [7]: (1) conceptual framework (defining the research question, key functionalities, analyzing the state-of-the-art), (2) system architecture (outlining of components and their relations), (3) systems design (modeling of data, functions/objects), (4) implementation of prototypes, and (5) evaluation (testing with laboratory studies, implementations and surveys). Thus, it became clear that we needed not only to build and extend theoretical foundations, but also to design a pragmatic instrument that allows organizations to build up their own information leitstand.

4. OVERVIEW OF THE THEORETICAL FOUNDATIONS

Research into ICL amalgamates, builds on, and initiates the enhancement of ideas in Management Science, Innovation Marketing, Relationship Management, Communication Science and Business Information Science, as briefly outlined here:

- An ICL may literally replace broad advertising campaigns. Social media sites allow a high degree of personalized communication. Technically speaking, a user model in an ICL can be easily developed from the information that a Internet user has shared publicly (e.g., about preferences, attitudes, expectations, locations).
- Communication science supports our decade-long hypothesis that electronic stakeholder communication is crucial to corporate success, in particular, during the times of innovation management [8].
- The value of open innovation is well discussed in management and business information science. However, how innovation communication could be enhanced by a knowledge-based stakeholder information systems (or Leitstand) has not yet been given any serious consideration in research.

Further details about the foundations can be found at [6].

5. KNOWLEDGE-BASED INNOVATION COMMUNICATION LEITSTAND (ICL)

Objectives

An Innovation Communication Leitstand (ICL) helps firms to communicate with the "right" individuals and groups with the "right" business content using the "right" channels at the "right" moment, rather than attempting to communicate more generally with everyone.

It should be explicitly noted that the objective of ICL is not to substitute traditional innovation communication between the company and its environment, e.g., using focus groups, advertisement campaigns or technology fairs. More importantly, an ICL aims at building up and maintaining good rapport with stakeholders on the Internet.

Tasks

The different tasks of an ICL can be grouped in the following categories:

1) Collecting information from the environment to the firm:

- monitor technological trends and early market signals;
- semi-automatically summarize news and notify managers.

2) Exchanging information between a firm and its environment: listen to the voices of stakeholders:

- engage geographically distributed stakeholders in dialog and interaction so as to foster innovation communities;
- systematically toss up ideas, provide discuss platforms, and record stakeholder feedback;
- respond to stakeholders in a personal way.

3) Disseminating information from the firm to its environment:

- translate (usually complex) novelties into personalized and situation-oriented messages;
- notify target groups in rapid response to events.

It becomes clear that the ICL integrates to some extent elements from Management Information Systems, and to a larger extent elements from Stakeholder Information Systems. An ICL could thus be understood as part of a centralized Stakeholder Communication Leitstand [6].

Advantages

Innovation communication using an ICL could lead to several advantages across innovation management processes:

- building up and maintaining stakeholder relations through making each stakeholder feel special (e.g., like a co-inventor, personalized communication);
- making innovations and technologies comprehensive to target groups in order to help them make better informed decisions;
- initiate ideas and new concepts for products and services among stakeholders;
- speed up new product-development processes through crowd-sourcing ideas and pre-assessed ideas from stakeholders (enhance innovation capabilities);
- gauge product risks and associated costs (e.g., quickly validate early ideas, back up forecasts);
- lower development costs (avoid expensive prototypes, and expensive testing situations).

6. INNOVATION COMMUNICATION PRACTICE ON THE INTERNET

In the following, we outline selected examples of innovation communication according to the key tasks of an ICL described in section 5. We have noted that communication which appears "quiet", modest, subtle, "personal", and not to overwhelm the recipients seems to be the most promising.

Collecting information from the environment to the firm:

- To sense early warning signals, Delta Air Lines crawls social media sites for any relevant comment about their innovative and standard services. The airline is said to make every effort to respond to all comments.
- At iXiGO, an infomediary travel search engine, several of the staff monitor Internet forums and blogs. Comments are answered personally by one of the co-founders of the firm.

Exchanging information between a firm and its environment:

- In 2010, Henkel launched a design competition for a best-selling hand dishwashing detergent on Facebook. Internet users submitted more than 50,000 ideas and were invited to vote for their best choice. However, it was not the design with the highest vote that was manufactured but only the 10^{th} top choice. Changed rules of the game initialized a storm of protest among Internet users, some of which predicted the end of the democracy.
- Starbucks designed a special discussion platform (http://mystarbucksidea.force.com/) for customers to submit ideas, see other ideas, vote on them, and see how the company implemented the ideas. Out of 100,000 ideas, the company considered around 100.
- In addition to Starbucks, at Tchibo customers are invited to share problems, ideas and solutions across all of this German coffee manufacturer and retailer's product categories.
- Fostering innovation communities, IBM invited more than 100,000 employees, customers, and other stakeholders to brainstorming and discussion sessions ("InnovationJam"). During a set period of 72 hours, these groups exchanged ideas on how to use emerging technologies to improve business and society. For example, "Do RFID-tagged bracelets improve the traveler's experience at the airport?" The event sparked numerous ideas for IBM.

Disseminating information from the firm to its environment:

1) Addressing stakeholder and roles:

- To promote his innovation of a "new vehicle", Dean Kamen addressed key stakeholders. He managed to persuade Steve Job, CEO of Apple, to comment that streets and pavements of cities would be redesigned to accommodate this invention. Journalists reported that Harvard Business Press had pledged Kamen a considerable honorarium in advance for a book about a 'new vehicle' (notably, Kamen has not shared any specific information about the two-wheeled self-balancing personal transportation device, later manufactured by Segway).
- IXiGo (see above) choose Facebook to advertise its new service not only for cost reasons but to target potential customers. Their plan, that people talk about their novelty, took off: the company currently has more than 90,000 Facebook friends.

2) Tailoring business content to stakeholders, roles, and events:

- Although Nokia has the highest number of cell phone patents world-wide, the company does not use messages such as "Nokia is the No. 1" or "Use Nokia for a happier life". Instead, the company seems to have analyzed consumer expectations reflected in their humble innovation communication slogan "connecting people".
- Since Siemens generates around 35 innovations each workday, the company is spoiled for choice to filter its information supply. The firm employs dozens of specialists to decide which news should be forwarded via which channel to the "public's ears and eyes".
- Best Buy CEO Brian Dunn is known to be keen for his activities on social media sites. Indeed, he recognized early on that interacting with customers and employees about new products and services alone may not be sufficient. Sharing the latest thinking about basketball and everyday news creates an "equal playing field" that obviously is appealing to stakeholders. By allowing Internet users to peek into the "living room" of his mind, he creates good relational experiences for users.
- Dean Kaman (see above) has deliberately not fulfilled all information demands about his invention all at once. Instead, he has disclosed as little (relevant) information as necessary - virtually drop-by-drop - so as to spark curiosity among his followers who started vividly speculating about the design and functionality of the new vehicle.
- BASF makes sophisticated technical topics understandable for numerous groups, even for children (as prospective stakeholders). The "science of survival" exhibition may serve as best practice.
- In 2004, Coca Cola launched its new product Dasani on the British mineral water market. However, the company was accused of just filtering ordinary tap water from outer London, which led to one of the biggest PR disasters ever, as the Financial Times described it. Innovation communication was not able to pour oil on troubled waters: dubious opinions from "experts" abounded, and consumers and pressure groups learned that the human body consists of 70% of water. This was a poor match between information demands and information supply at this critical moment.

3) Adjusting business content to channels:

- At BASF, we witnessed that the company informs stakeholders about innovations via various electronic channels. For example, podcasts present a broad range of chemical innovations: from "intelligent" coast protection to dyeing hair.
- Padmasree Warrior (CTO of Cisco) early recognized the value of rich-media experiences for stakeholders. With over 1.5 million followers on Twitter, she tweets on a range of topics from new products to her own poems, and discusses latest views on technologies.
- Ben Verwaayen (CEO of Alcatel-Lucent) uses an intranet blog to connect with over 80,000 employees. He appreciates receiving feedback on new strategy directions and product initiatives.
- Best Buy customers in the US have different options to interact online. Using the "GeekSquad service", they can describe problems, suggest solutions, and receive answers. Additionally, by using "@twelpforce" on Twitter, they enjoy service 24/7 free of charge.

7. KEY DESIGN PRINCIPLES FOR ICL

The following ten key steps - to make innovations work - may have two purposes. Leading questions can also used as a quick checklist to refine corporate communication strategies. More importantly, the steps pragmatically illustrate how we build up our knowledge-base in the ICL in order to match information demand with information supply during innovation communication processes.

Is the product or service of high innovative degree?
A high degree of novelty is the prerequisite for applying this type of communication strategy. Hence, the term "innovation" is more broadly defined in public parlance than Schumpeter's narrow definition (that also requires a successful implementtation and economically usage). Consequently, companies are forced to deviate from the exact legal interpretation, which may also be based on intellectual property rights, and furthermore include "inventions" or "new product with highly visible benefits" or "formerly unknown".

On the contrary, aiming to boost corporate reputation with an ICL is naturally less promising in cases of "just-good-enough products" or products that tend to be derivatives, or simply perceived as new twists on old themes by customers, similarly when a company adorns itself with "borrowed plumes".

Can the innovation be commercially successful?
Innovations need to be evaluated to assess what extent they meet a (potential) consumer demand; simply pushing innovation in a market seems less than promising. However, examples show that this general wisdom seems not to be commonplace:

- Before Apple gained an enviable reputation as an innovation leader, numerous of their high-tech products hit the market with a dull thud, such as Lisa (PC), Quicktake (camera), and Pippin (game console). One reason for this might be that consumers just did not know what to do with them.
- "TD-SCDMA" was aimed as a standard for mobile telephony in Mainland China. To ensure that a specific 'indigenous innovation' was developed (planning products is of particular interest in a command economy), hefty financial support was given to avoid paying licensing fees to "Western patent holders". However, mobile companies in China decided to use serviceable alternatives that were available on the world market. Thus, innovation made good headlines, but reached only 60,000 users.

Identifying early market signals help evaluate the marketability of an innovation. As a first step, an ILS can therefore be connected with GoogleAlerts, TweetDeck, Radian6 to filter electronically available information on the Internet, and to forward relevant news to decision makers. Certain key words define "filering rules" in the ILS.

What is the target group?
Specific target groups for communication efforts have to be defined. Indeed, individuals relevant to the roll-out of innovations can vary greatly among regions. For example, in North America both key customers and investors have to be considered, while in Mainland China the role of government officials plays the crucial role. Individuals and pressure groups that could prevent innovation success must also be on the radar.

Targeting 'stakeholders' for innovation communication seems promising because they are the individuals and institutions who either influence the company's performance or are influenced by it. Building on Freeman's stakeholder definition [9], we distinguish six major stakeholder groups in the ICL: customers, suppliers, employees, the general public (including supervisory boards), shareholders, debt holders. These groups may be further broken down; e.g., 'shareholder' into seed investors, angel investors, or private equity investors. In the ICL ("stakeholder map"), we came up with around 150 stakeholders.

The key rationale for private companies in targeting stakeholders is that there has long been a positive relationship between a company's value and its reputation (see table with more than 60 citations [6]. Engaging stakeholders in the exchange of ideas can even lead to high revenue and high cost-savings [10].

What are the stakeholders' roles?
Stakeholders have specific roles in helping to cater for specific information requirements. In short, the set of roles of a stakeholder can be determined by his or her decision, task and expectations, responsibilities, location, etc. ("decision models"). Various research findings from several management disciplines provide a jump-start in building up "role definetions" during the period of innovation diffusion in the market:

- During the technology evaluation process, several innovator types can be identified: instrumentalists, consensus builders, searchers, debaters and assessors [11].
- Distinct generation cohorts may help roles, e.g., customer roles. For example, six typical roles can been identified in Mainland China [12]: the lost generation, the emerging middle class, the girls of the economic miracle, the little emperors, the vibrant youth, and the new elite.
- Decision makers are influenced by location and its inherent culture. For example, features of leadership roles such as degree of visionary, team role, and performance-orientation vary across 22 European countries [13]. In Mainland China, different cohorts of leaders show different degrees of individualism, collectivism, and Confucianism dependent on their exposure to Western culture [14].

What triggers information delivery?
Stakeholder information delivery is stimulated by triggers that can either originate within the company or come in from the outside world. For example, a pharmaceutical company may launch innovation communication in response to successful product tests or financial government grants. Distributing information at the "right time" can add a dramaturgical flavor.

We therefore built up a "trigger repository" in the ICL focusing on triggers that occur frequently and are typical in specific industries (80-20 rule). Around 450 triggers were attributed to events originating in the company sphere (due to human beings and techniques) and the environmental sphere (due to economy, ecology, politics, legislation, technology and social environment). Since large companies typically do not have too few, but instead too many innovations, a "prioritization mechanism" had to be developed: to prioritize innovations, who to inform, and how to inform.

What triggers the co-creation of innovations?
To gather valuable input for or about product ideas, executives often consult trusted stakeholders (industry experts, consultants, leading government officials) and ask for their opinions.

To serve as a means of quickly collecting stakeholders' points of view (e.g., open innovation), the ICL transfers the pending decision problem (e.g., evaluation of the new product idea) into an online questionnaire. We therefore stored numerous question items in a "survey engine" that may prepare a simply online questionnaire or a more advanced web-based Delphi study. A systematic technology assessment with a knowledge-based Stakeholder Information Leitstand can be found at [15].

What is the business content?
Users' objective information requirements, i.e. business content, can be deduced from the triggers (e.g., a successful product pre-test) and stakeholders' respective role(s). However, it is quite a balancing act to provide neither too little nor too much information to stakeholders.

On the one hand, an information under-supply can often be observed on websites. A recent survey of more than 400,000 Chinese Internet users demonstrated that a considerable number of respondents were not satisfied with public websites, many of which have not been updated for a long time; furthermore, users' opinions and messages to companies were often ignored [16]. In our own empirical research amongst more than 150 young professionals, we identified a great deal of room for improvement in the way that companies communicate with their stakeholders. Often companies simply do not know what information to deliver, and provide professional answers to inquiries only in very rare cases [17]. On the other hand, information over-supply could also be observed, leaving stakeholders overwhelmed. In an attempt to market products as new or outstanding, many Chinese companies test specific terms to the limit, including adjectives such as '"high-end", "luxury", "world-class", "royal" and "healthy". Hotels advertise with "Buffet - an innovative dining experience".

To provide a 'critical mass' for decision makers, our leitstand contains business content for several hundred roles, triggers, and 25 industries.

A special type of information demand is that of information duties. However, small companies (and not only these) often become easily overwhelmed by the sheer weight of legal information duties to government bodies. Integrating an "information duty registry" in an ICL, we were able to automate communication processes (e.g., for new product approval requests to a Food and Drug Administration).

What business content must not be delivered to the environment?
"Innovation communication" does not imply the sharing of all technological details about innovations to third parties. Restricted information may include corporate/trade secrets, untested technological know-how, suppliers' prototypes, or intellectual property.

We therefore implemented in the ICL mechanisms to protect intellectual property based on information filtering and Text Mining techniques ("filter mechanism").

How is business content adjusted to personal preferences?
To secure a user's optimal experience on the Internet, it is vital to further adjust objective information categories to personal likes and dislikes or even the current or prospective location. For example, studies have shown that persons with an engineering background prefer tables, while those with management education prefer graphic displays. Consequently, results take the form of different display formats.

Therefore we have implemented in the ICL numerous "preference rules" derived from insights from the overlapping field of information science and psychology about visualization and presentation of information.

Which channels should be used to communicate with stakeholders?
The collection of feedback or the delivery of the preferred information can arrive through a variety of channels.

We basically distinguish two types in the ICL: communication platforms, e.g., corporate website, social network sites (Facebook, Renren), blogs, wikis, instant message services (Twitter, Weibo), whiteboarding, and display devices (e.g., PCs, smartphones, tablets, netbooks, information kiosks). We therefore pre-defined relevant channels in "channel rules".

8. EXAMPLE OF BUSINESS CONTENT

This example gives a flavor of the extent to which information requirements differ just for one trigger, e.g. during the launch of a new product: while investors are interested in the technology roadmap and cash flow forecasts, consumers would be more interested in the way the product affects their health and well-being (Figure 1).
.

Trigger **Successful test of a high-tech product**

Stakeholder	Selected information requirements
Customer	Time of product availability, product features, health benefits, instructions, retailer locations, price range, service, ...
Supplier	Order quantity of raw materials, quality requirements, long-term market forecasts, technology attractiveness, cooperation requirements, ...
Employee	Production start, market launch, project roadmap, required skill sets, number of patentable discoveries in the past, ...
Public	Market forecast, percentage of projects in cooperation with third parties, research and development expenditures, innovation type, cooperation partners, major test results, technology characteristics and advantages for users, innovation barriers, trigger of innovation, ...
Shareholder	Cash flow forecasts, expected market position, test results, SWOT analyses, risk position, technology roadmap, R&D hit rate, scenarios, percentage of customer driven projects, budget size, disruptive potential, position on s-curve, cost savings, further development potential, compatibility, results of experiments, competitor analysis, customer segments, ...
Debt holder	Financial reserves, insurances, research pipeline, technology attractiveness, velocity of technological realization, competence portfolio, risk exposure (technology, time, costs), interpretation of test results, lifecycle of the technology, environmental concerns, ...

Figure 1: Selected Business Content for a Specific Trigger

9. CONCEPTUAL MODEL OF INNOVATION COMMUNICATION LEITSTAND (ICL)

Figure 2 highlights selected expert system components and the information flows between the corporate environment and the proposed knowledge-based Innovation Communication Leitstand. This type of ICL may be chosen by an organization aiming to integrate stakeholders in new product development processes.

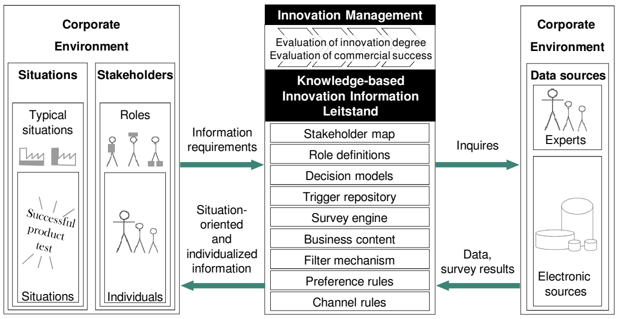

Figure 2: Selected Key Components of ICL

Further technical details such as the knowledge base of an ICL, the "heart" of the system, can be found at [6].

10. CONCLUSION

Technology is often seen as a silver bullet for corporate success; but in reality, it very seldom works in this way. Without proper communication processes creating connections between the innovation and all stakeholders, a new product or service may be at high risk to fail.

The contribution of this paper is a first step in inspiring top managers to bring innovation communication on the Internet to a higher level, and thus to set the foundation for achieving a sustainable and resilient enterprise. Since stakeholders' influence and interest in companies has been increasing, situation-oriented and individualized innovation communication is fast becoming a critical success factor for a relationship-based economy.

Although implementation of a knowledge-based Information Communication Leitstand (ICL) is increasingly feasible because of technological progress, we have observed that organizations do not fully exploit their opportunities to differentiate themselves from competitors in their electronic stakeholder communication strategy.

We hypothesize that organizations adopting innovation communication with ICL will be more successful than others, in matching stakeholders' information supply and demand, and thus smoothing their decision-making processes and fulfilling stakeholder expectations. Automated processes with an ICL may be particular advantageous for small- and mid-sized companies, the common business type of entrepreneurial ventures.

Interested in sharing your opinion about innovation communication strategy as a success factor? We would value your comments and participation in completing our short survey, accessible at:

www.stakeholder-communication.com

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Developing the Discovery Layer in the University Research e-Infrastructure

Malcolm WOLSKI, Joanna RICHARDSON, Mark FALLU, Robyn REBOLLO, Joanne MORRIS
Division of Information Services, Griffith University
Brisbane, Queensland 4111, Australia

Abstract

Governments worldwide are faced with the challenge of creating research e-infrastructures to not only manage but also make accessible and discoverable increasingly large amounts of research data. Universities in turn are under pressure to ensure that their research strategies and support services are aligned with these national imperatives. This paper describes a nationally funded Australian university initiative to build a research e-infrastructure layer which connects individual researchers and the University to the Research Data Australia service in order to expose details of their research activity as well as available research data outputs. As governments work towards fully functional e-infrastructures which will be both cross-disciplinary and cross-border, the semantic metadata exchange service described in this paper offers a model which supports the interactive discovery of, and navigation to, content that may reside locally or across the world.

Keywords: Research infrastructure, VIVO, semantic web, Vitro, discovery systems, Kepler

1. Introduction

In a submission to the European Commission, Kroes [1] writes: "Information and Communication Technologies (ICT) are the most recent transformational factors in science. They enable close and almost instantaneous collaboration between scientists all over the world and they provide access to unprecedented volumes of scientific information." ICT have helped to create a world in which knowledge—and its application—is seen as a key to global competitiveness and national prosperity is viewed as underpinned by knowledge innovation [2]. Within this context, governments worldwide are grappling with the challenges of creating robust research e-infrastructures which can not only manage this information but also ensure its discoverability and accessibility.

2. Australian National Data Service

As part of the Australian government's NCRIS (National Collaborative Research Infrastructure Strategy) initiative, the Australian National Data Service (ANDS) was formed to support the "Platforms for Collaboration" capability. The service is underpinned by two fundamental concepts: (1) with the evolution of new means of data capture and storage, data has become an increasingly important component of the research endeavour, and (2) research collaboration is fundamental to the resolution of the major challenges facing humanity in the twenty-first century [3].

ANDS is building the Research Data Australia (RDA) service [4]. It consists of web pages describing data collections produced by or relevant to Australian researchers. RDA publishes only the descriptive metadata; it is at the discretion of the custodian whether access, i.e. links, will be provided to the corresponding data. Behind RDA lies the Australian Research Data Commons (ARDC) which is the infrastructure and systems needed to support data and metadata capture, publication feeds, and applications such as data integration, visualisation and analysis.

3. ANDS Objectives

The long term (ten year) objectives for data management within the Australian National Data Service (ANDS) are to:

- Increase the amount of research data that is routinely deposited into stable, accessible and sustainable data management and preservation environments
- Enable Australian researchers to discover, exchange, reuse and combine data from other researchers and other domains within their own research in new ways
- Facilitate the sharing of Australian data to support international and nationally distributed multidisciplinary research teams
- Support the development of data management services and support within institutions that promote good data management practices for researchers

Key stakeholders in the Australian research environment—ANDS, National Library of Australia, funding bodies such as the Australian Research Council and the National Health and Medical Research Council, research institutes and universities—all have knowledge to be shared. In building its national collaborative infrastructure, ANDS has utilised a federated approach which supports multi-layers, i.e. RDA aggregates at the national level data about Australian research which has been aggregated at the local level.

Critical to the model is the ability to enhance discoverability and accessibility of all aspects of research to improve knowledge communication. The connectivity between research data and researchers is important, especially for purposes of re-use and in cross-disciplinary research. Identifying relationships between people, institutions, projects and the relevant research data created enhances opportunities for collaboration and new research [5] [6].

This paper describes how Griffith University has built a research e-infrastructure layer which connects individual researchers and the University to the Research Data Australia service. The local technical framework developed for the service is based on semantic web, triple store and open access technology.

4. Griffith University's Metadata Exchange Hub

A Metadata Exchange Hub has been developed as part of an ANDS-EIF (Education Investment Fund) funded project involving collaboration between Griffith University and the Queensland University of Technology. The Hub was built to meet ANDS' requirements for institutions to provide aggregated metadata store solutions to populate Research Data Australia (RDA). The metadata feeds encapsulate metadata providing high-level descriptions of research datasets and entities related to them, such as researchers, research groups, research projects and research services. The metadata schema used is the Registry Interchange Format - Collections and Services (RIF-CS) [7], which is a subset of the ISO standard 2146 [8]. The development of a metadata aggregator (Hub) has become a core piece of infrastructure [9].

To populate RDA, the metadata is harvested from institutions via the Open Archives Initiative's Protocol for Metadata Handling (OAI-PMH). This protocol is a HTTP REST based web service with six methods defined for interrogation and harvesting of structured metadata. The default metadata schema for OAI-PMH is Dublin Core, but other schemas may also be used. For the purposes of transporting and aggregating research metadata for RDA, the RIF-CS schema is used. RIF-CS is a high level schema that defines four classes of objects – collections, parties, activities and services. The objects of these classes may be related to each other via relationships defined in a controlled vocabulary [10]. RIF-CS can also be effectively modelled using Resource Description Framework (RDF) and related semantic web standards. See Figure 1.

An important part of Griffith University's Metadata Exchange Hub is to expose the relationships –using RIF-CS—among researchers, their projects and their research outputs, as illustrated in Figure 1. These relationships form a linked graph. For example, Mary Jane (party) has the relationship (is a participant, i.e. researcher) of a project (activity) but also has the relationship (manages) datasets that, in turn, has relationship (is part of) Collection A, etc.

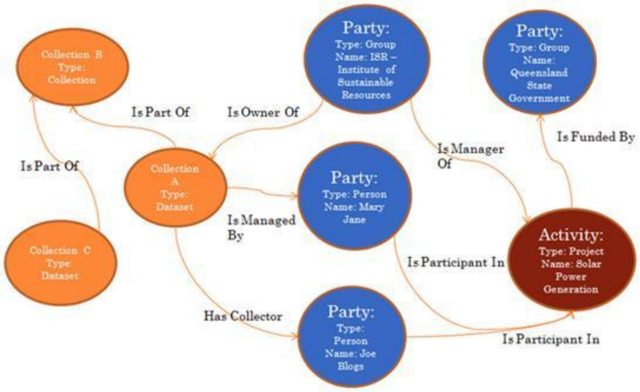

Figure 1: RIF-CS – Linked Data

As part of the ANDS-EIF project, staff analysed the pros and cons of existing software solutions as the potential foundation for the Hub. Since the major project driver was to develop an open source solution which could be used as an exemplar / good practice for Australian universities which want to be part of the national collaborative research infrastructure, the Project Team decided to use a semantic web solution called VIVO as the metadata store, which also includes mechanisms for the editing and display of Hub metadata. Other software used for the project included Kepler [11] for data workflow and transformation, OAI-CAT [12] for OAI-PMH provision, and custom Java code for object Identifier creation.

5. Architecture of the Hub

The following diagram (Figure 2) is a simple illustration of the Metadata Exchange Hub components. VIVO, which is based on technology developed at Cornell, has been implemented with minimal changes to the underlying software architecture. Research activity metadata is uploaded to Research Data Australia (RDA) using the Registry Interchange Format - Collections and Services (RIF-CS).

As part of the Metadata Exchange Hub project in Australia, a number of additions have been made to VIVO to support the requirements of the ANDS' metadata stores program, including (a) an extended ontology capable of fully expressing RIF-CS and modelling research activity in Australian research institutions; (b) an OAI-PMH provider for OAI-PMH feeds; (c) customised web page templates for presentation; and (d) workflow modules, e.g. Kepler, to support data ingestion and transformation. A more detailed explanation of key modules follows.

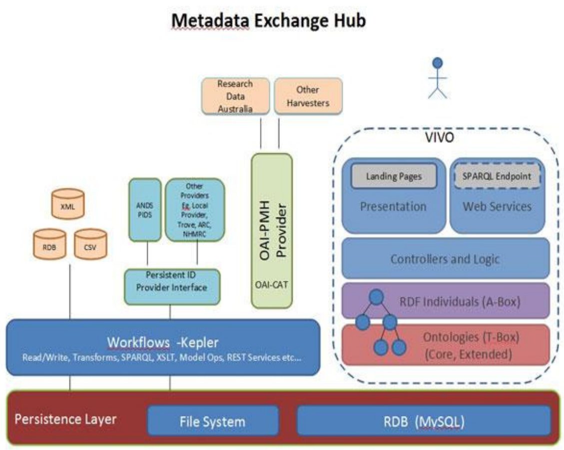

Figure 2: Architecture of the Metadata Exchange Hub

In 2009 the National Institutes of Health funded a US$12.2 million project to create a web-based infrastructure to facilitate the discovery of researchers and collaborators across the United States. This project is known as VIVOWeb and is built upon Vitro, a technology developed at Cornell in 2003 and renamed as VIVO. VIVO is an open source semantic web application that allows institutions to ingest and link institutional metadata; allows users to browse and search; and ensures that the institutions retain control over how their data is accessed. It is fundamentally a Java web application with a persistence layer that represents information using RDF and OWL (Web Ontology Language) and is built on the Jena semantic web framework, a triple store [13].

Ontologies are designed as sets of rules and languages that enable data and information sets of different machine readable systems to be implemented cohesively into one comprehensive domain. An important part of the project has involved the development of a national research-focused ontology, based on the core Vitro ontology, which has been successfully deployed in the first version of the tool. Various extensions were made to the set of standards in VIVO 1.0 to meet ANDS' requirements. Classes were added for research collection metadata and for describing subject codes. Object properties were added for RIF-CS relationships. Data properties were added for identifiers and to support the generation of RIF-CS feeds. Collectively they provide a coherent framework for mapping the bulk of institutional research activity in Australia. The table below lists external ontologies that are included in this customised version of VIVO. Ontologies identified with an asterisk (*) include RIF-CS elements.

Ontology	Namespace
ANDSHarvest*	http://www.ands.org.au/ontologies/ns/0.1/VITRO-ANDS.owl#
Bibontology	http://purl.org/ontology/bibo/
Dublin Core elements	http://purl.org/dc/elements/1.1/
Dublin Core terms*	http://purl.org/dc/terms/
Event Ontology*	http://purl.org/NET/c4dm/event.owl#
FOAF*	http://xmlns.com/foaf/0.1/
FOR 2008 Ontology	http://purl.org/asc/1297.0/2008/for/
geopolitical.owl	http://aims.fao.org/aos/geopolitical.owl#
ns	http://www.w3.org/2006/vcard/ns#
SEO 2008 Ontology	http://purl.org/asc/1297.0/2008/seo/
SEO 1998 Ontology	http://purl.org/asc/1297.0/1998/seo/
SKOS (Simple Knowledge Organization System)*	http://www.w3.org/2004/02/skos/core#
time	http://www.w3.org/2006/time#
Vitro public constructs	http://vitro.mannlib.cornell.edu/
VIVO core*	http://vivoweb.org/ontology/core#
TOA 1993 Ontology	http://purl.org/asc/1297.0/1993/toa/
RFCD 1998 Ontology	http://purl.org/asc/1297.0/1998/rfcd/
Griffith Specific Extensions	accessible via VITRO/VIVO Group

Table 1: Vitro-ANDS Ontology

The VITRO-ANDS ontology is customisable and extensible to cater for specific research requirements. Planned future developments include extensions to better characterise the research outputs of the creative and performing arts sector. Additionally the ontology has been used successfully to model non-research activities such as commercial consultancies.

The core of the VIVO system is an RDF triple store. This is used to model and store data and is an alternative to systems that use traditional relation tables. The triple store can be conceptually divided into two parts: the T-Box and the A-Box. The T-Box (Terminology Box) is the generic data model that describes the relationships between types of institutional data, e.g. projects have Chief Investigators. The VITRO-ANDS ontology forms the T-Box component of the VIVO system. The A-Box (Assertion Box) contains descriptions of specific instances of data, e.g. John Smith (party) has the role (chief investigator) in the project (activity).

There are many software tools and frameworks that may be used for data workflow and transformation. Some are built for a specific purpose or set of use cases. Others are targeted at more general applications. The Hub provides solutions that have been constructed based upon the Kepler workflow software. Kepler also makes use of other standards, languages and software for implementation of parts of its functionality, and sometimes provides a wrapper around functionality found in other software libraries. Some of the benefits of Kepler which made it suitable for the Metadata Exchange Hub project include:

a) Modular system for encapsulating functionality with data-typed interfaces for connecting modules
b) Large library of existing Kepler actors (modules)
c) Relatively easy method for extending Kepler with new actors
d) Cross platform (uses Java)
e) Execution of workflows from both GUI on the desktop and command line on a server
f) Different execution models and flow control mechanisms
g) The GUI can provide an effective means for rapid prototyping

The following Kepler actors were found to be useful for the Metadata Exchange Hub project: FileReader, FileWriter, FileCopier, String To XML, XML Assembler, XML Disassembler, XPath Processor, XSLT Processor, RestService, Open Database Connection, Database Query and PythonActor. The Project Team did have to write some custom actors, particularly for operations involving the Jena API as well as CSV to XML conversions.

A typical simple workflow for ingesting data into VIVO might look like the following: Read CSV file, transform to RDF, merge with existing model and save to Database. The workflow below (Figure 3) implements this and is an example of an ETL (Extract, Transform and Load) process.

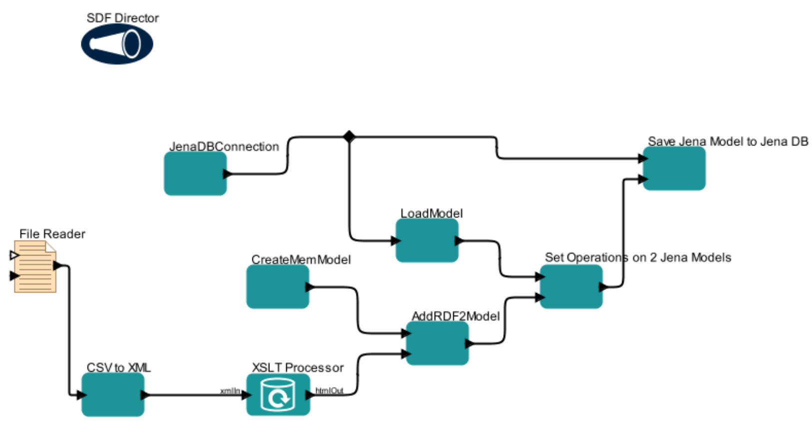

Figure 3: Kepler Workflow in VIVO for Data Ingest

The next diagram (Figure 4) illustrates the workflow that maps the subset of information required for harvesting to RDA. Metadata from the Hub (in the Vitro ontology) is mapped to a RIF-CS formatted feed available via OAI-PMH. The SPARQL query is a parameter that is supplied to the Kepler workflow. Results are automatically serialised as RDF XML and converted to RIF-CS by a custom XSLT routine that maps entities from the internal Vitro ontology to RIF-CS formatted XML, which is then capable of being processed and made available by OAICat

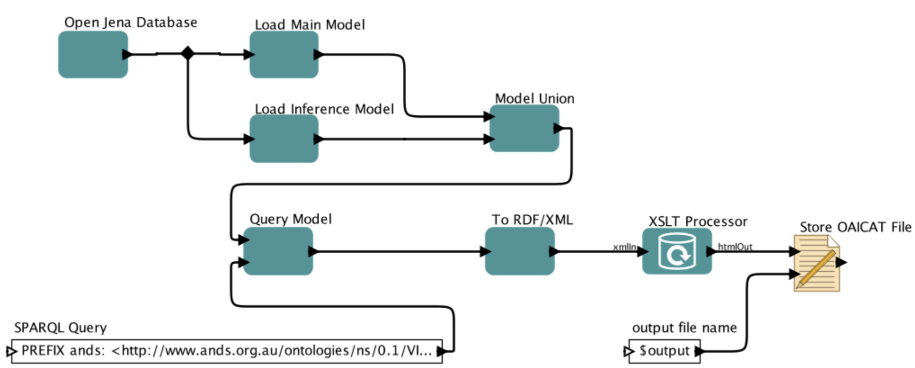

Figure 4: Kepler Workflow in VIVO for Harvesting

The architecture of the Hub has been designed to allow for automatic machine to machine communication for the ingestion of University research activity data. Nominated relevant metadata is harvested from the University's repositories, data stores and corporate systems in its native form. The process of automatic disambiguating entities within data sources can be difficult and has not yet been implemented within the Hub. The VIVO Harvester in the US has done some initial work; however, this is a much needed area of development for the future.

The system first attempts to determine whether persistent identifiers exist for any people or projects in national systems. Key national systems are operated by the National Library of Australia (Trove, People Australia), Australian Research Council (ARC), and the National Health and Medical Research Council (NHMRC). In the case of Trove and ANDS, if no persistent identifiers exist, requests are made (machine to machine) to create an ID, e.g. new researcher person ID.

Kepler workflows automate the translation of metadata from the format in institutional stores to appropriately formatted RDF triples. Kepler workflows then insert the RDF triples representing the institutional data into the triple store (forming the A-Box). This automatically creates human readable HTML landing pages on the fly based upon RDF triples. Links between entities, e.g. People who are Chief Investigators of Projects, are made explicit in the form of hyperlinks. These links are bidirectional, i.e. they link from person to project and back from project to the person. This happens automatically, even if the link was not explicit in the original data store. Kepler workflows then trigger SPARQL queries within VIVO. These queries return all of the research activity data as triples. XSLT is used to transform the serialised triples from the VITRO-ANDS ontology to RIF-CS formatted XML.

The final process is to make the RIF-CS formatted metadata available for harvest via an OAI-PMH interface using the OAI-CAT component. Research Data Australia will periodically harvest the new and updated institutional data via this interface.

6. Discussion

Although the Metadata Exchange Hub is in pilot, metadata collected to date has been harvested by both Research Data Australia and the National Library of Australia's Trove resource discovery system. In addition it is currently being interrogated internally by University researchers. University funds have been allocated as a high priority to move this system into production. Work is underway to finalise the automated updating of research activity data from enterprise systems with an anticipated rollout by mid 2011. The use of Google Analytics will not only provide feedback on system usage but also will expose trends or peaks for subject analysis.

Because the Hub is based on linked open data, the metadata feeds expose the relationships among researchers, their research groups, their projects and their research outputs, including datasets. This means that research information is available for publishing in a "profile". Therefore the Hub creates individual "Researcher Profiles", which provide a history of research undertaken by a respective researcher. Similarly a "Research Group Profile" provides a history of research undertaken by a respective research group, e.g. research centre. Both have links to the actual research data, which supports the ANDS' objectives outlined previously. These "profiles" will be uploaded to both RDA and Trove.

For the postgraduate student, for example, a Profile can be used as a tool to identify seminal research undertaken by experts within the group including their respective supervisor or indeed to select a potential supervisor. The Profiles include the use of visualisation technologies to graphically represent the relationships described above. This allows the student to rapidly follow links in a non-linear fashion without losing the original context.

The Hub also plays an important role through feeds into the University discovery services. For example, Griffith has recently deployed the Serials Solutions' Summon web-based discovery service as the library search / discovery tool. It is now possible to utilise the Metadata Exchange Hub to push key research information through to the Summon library search tool, making it another resource available for scholarly purposes.

7. Conclusion

From the perspective of knowledge communication within the new research environment of universities, it is important that research activity be exposed at the University level in a managed way that creates a rich discovery environment. Semantic Web technology is ideal for use as a federated architecture for integrating metadata from diverse systems. Over time there will be increasing pressure for this sort of automatic and reliable linking functionality in discovery systems.

Because of the ability of the Metadata Exchange Hub to ingest data from a wide range of sources and then export information via filterable views, the system offers value to a number of key elements within a university, e.g. central IT administration, the library, and the research / academic community. In addition, it has wider potential non-university applicability such as for central records, museums, government department archives, and the creation of knowledge bases, i.e. adapting the technology itself for other discovery environments. Therefore, as governments work towards fully functional e-infrastructures which will be both cross-disciplinary and cross-border, the semantic metadata exchange service described in this paper offers a model which supports the interactive discovery of, and navigation to, content that may reside locally or across the world.

8. Acknowledgement

The authors wish to acknowledge the work of the Research Collection Metadata Exchange Hub Project Team--a joint effort among Griffith University, Queensland University of Technology and the Australian National Data Service--for the technical aspects of this paper.

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Geometric and Network Model for Knowledge Structure and Mindspace

Chris ARNEY
Department of Mathematical Sciences, United States Military Academy
West Point, NY 10996, USA

ABSTRACT

This paper describes an adaptive, complex network architecture for knowledge representation in virtual mindspace. Structures and processes for knowing, remembering, thinking, learning, deciding, and communicating describe a virtual geometric space (mathematical model) of a notional mind. This mindspace model can be visualized as a workspace and this paper provides a glimpse of a virtual model of the mind.

Keywords: Mind, Network, Communication, Language, Model, Mathematics, Geometry

1. INTRODUCTION

The basic foundations for our mindspace framework (mathematical model) are:

1) The mindspace (storage space for knowledge) has an inherent dynamic geometric and network structure -- an architecture that provides for remembering, thinking, learning and communication.
2) The basic elements of mathematics (cardinality, direction, connection, and thus network structure) are hard-wired in the human mind to provide the capability to build the structure of the mindspace and execute the processes.
3) In this mindspace structure, there are regional (lower-dimensional) structures formed as densely filled polytopes that show supreme architectural and structural efficiency -- orthogonal dimensions, extremely dense storage and patterned arrangements, and highly connected.
4) Knowledge location is important, links and connections are important, dimension is important, and dynamics are very important. The knowledge mindspace network provides an efficient, effective, and powerful structure for ideas and links -- remembering, thinking, learning and communicating.
5) The organization, connections, complexity, patterns, dimensionality of the structure of one's mindspace corresponds to a form of intelligence.
6) Our mindspace structure is more complex geometry than previously considered distance-based ontologies and taxonomies in cognitive space models and more robust than vector-space (linear) models for language or learning.

Some definitions that provide for the description of the mindspace and our model:

- ideaspace: Virtual (extremely high dimension) infinite space of all ideas
- mindspace: Virtual (extremely high dimension) uniquely structured space/network of all ideas of a unique sentient entity
- mindset: the dynamic collection of beliefs (to include knowledge), perceptions, and recalled experience of a sentient entity (the known points)
- idea (knowledge/information/thought): a point (or region) in ideaspace or mindspace with its connection to other information.
- communication: transmits language from speaker to listener, who tries to establish (find) the point or region in the entity's own mindset, modifying the mindstate. The point exists before the language is received. If the communication was successful, the idea is or becomes part of the listener's mindset.
- learning: active process that results in a change to the mindspace

We focus on the geometric and network descriptions of this architecture using network metric techniques (attributes, measures, properties). We show examples of how these mathematical structures are assembled into a mindspace architecture. Another example provides for visualization of how geometric and network structures change during the process of learning.

Our mindspace model, previously introduced in Arney [1], is considerably more sophisticated in terms of dimension and structure than other models. In its simplest views, building a mindspace is like creating a library --- placing ideas in a logical organization – or building the Internet – linking information. However, it is much more complex than either of these. In this paper, we use network architecture analogies to describe these complex aspects of mindspace structure. In many ways, we are restricted by our low-dimensional vision and become limited as we consider such higher-dimensional geometry.

2. GEOMETRIES

We begin by briefly describing the roles geometries that play in the fundamental concepts of knowledge as was described in more detail in Arney [1, 2]. The architecture of a mindspace is forever changing and growing --- becoming more and more complex, vast and elaborate. The original mind structure starts with one rather simple, linear dimension --- virtual in its conceptualization and innate in this virtual component of the brain, literally coded in the DNA. Before birth, thoughts enter the mind becoming ideas (data) of basic knowledge. These simple thoughts of survival and comfort (determination of hot, cold, comfort, pain) come from senses and enter into a rudimentary mindspace structure. The mind forms this virtual space from nature's only innate and omniscient form of language – the coded language of geometric mathematics in the DNA. This structure comes from instinctive mental capabilities to measure (determine more, less, the same). From that instinct comes number sense (crude counting and direction --- up, down, many, few) and eventually a construction of order and characterization and finally a sufficient geometry of a network to store the knowledge that enters the mind from the senses. That one-dimensional geometry of a developing mind is initially like an elementary school number line -- able to hold organized ideas in mind locations. As more learning takes place, the structure of the one-dimensional mind is too limiting for the types of complex thoughts that have formed. It is only then that the virtual mind uses its innate quality to grow and expand into an entirely new dimension giving the mind a new perspective on all previously held ideas and changing the way new ideas are stored and connected. As thoughts need new depth and complexity, the mind constructs more and more dimensions. Not all of these dimensions are orthogonal or even useful for very long. Some of the dimensions overlap in strange but important and powerful ways to create a growing structure with an extremely complex geometry. This learning, growing, expanding process continues as people become learners and thinkers possessing amazing minds with highly efficient capacities to learn and remember and understand. Memory and knowledge come from the basic organization of the mind --- placing the right ideas in the right places, keeping related ideas appropriately linked.

The mindspace globally possesses a large, detailed, highly connected, high-dimensional network architecture that stores important ideas in this organized and efficient structure. The rich internal ontology/taxonomy makes basic ideas highly accessible and readily available to enable the mind to learn, think, dream, and hope. The mind also has local or regional (lower-dimensional) areas called polytopes that show supreme efficiency – and dense in the storage and arrangement of ideas. They are special geometries built by the mind in a special form to store information involving a specific topic. Usually the topic area will hold a large number of related ideas involving profound understanding of a complex topic. A highly developed polytope is the result of constructive learning to efficiently and neatly place the results in a compact multi-dimensional solid region for organizational purposes. The result is a geometric structure representing substantial topical knowledge. The size, shape, and organizational health of a polytope are indicative of its design and use by the mindspace.

Our model places human perspectives within the geometry of virtual spaces where each individual entity has its own mindspace, resulting in a unique categorization/storage of ideas and many processes that make up the notion of thought. This geometric model of the mindspace was described by Arney [1, 2]. Meadows [1] and Edwards [2] describe similar two-, three- or low-dimensional geometric space to describe and categorize thoughts, memories and ideas. These models are also appropriate for artificial intelligence knowledge representation.

3. MINDSPACE MODEL

We briefly describe elements of our mindspace model that was introduced in Arney [1]. Mindspaces, like the one described, can be understood as "workspaces of the mind" as described by Baars [5], and, therefore, through this paper, we provide a glimpse of a mind's structure and processing. Unfortunately, we have no precise way to describe or visualize the vastness of the intricate high-dimensional space or the complex geometries of the mind.

4. STRUCTURES

Polytopes

The non-linear, complex geometric forms of related ideas are mathematical polytopes. They take up large, densely compact regions encompassing several dimensions in a mindspace. These are special geometries built by the mind in a special patterned form to store information involving a specific topic. Usually the topic area will hold a large number of linked ideas involving profound understanding of a complex topic. A highly developed polytope is the result of constructive learning to efficiently and neatly place the results in a compact multi-dimensional region for organizational purposes. The result is a geometric network structure representing substantial topical knowledge. The size, shape, and organizational health of each polytope are indicative of its use by the mindspace.

Dead Zones

The nearly empty areas of a mindspace are either immature regions of new construction ready to be filled with new ideas or spaces that contain old sets of ideas that have been mostly forgotten or discarded as unimportant or unneeded. It may seem like a waste to have an entire dimensional sub-region of a mind completely or nearly empty. However, these structures are the results of an active mind that constantly moves forward in its thinking and perspective. Valuable ideas stay in the active mindspace, and abandoned, unimportant ideas fade away. Small finite dead areas of the mind are hardly important to the overall vastness of a functioning active mind. Likewise, the mind has the capacity to forget, confuse, misplace, and be sloppy or lazy.

5. NETWORK

When describing the network architectures, in particular the connections of ideas, simple notional visualizations enable us to see some of the networking aspects of the mindspace. However, because we are limited to two-dimensional projections, many of the characteristics of the mindspace remain hidden although formal network metrics can help us understand the higher dimensional structures. We show simulated examples in two dimensions even though they are restrictive and far simpler than real mindspace structures.

Example 1: In Figure 1, we show a simple mindspace idea that contains a network of 24 nodes. This type of simple network structure is the building block for the myriad of structures in a mindspace.

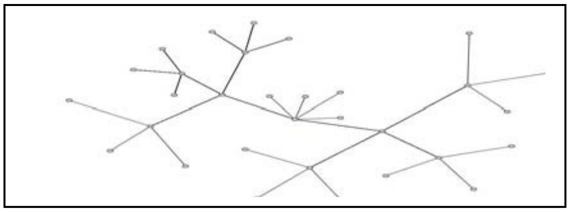

Figure 1: A notional 24-node idea showing its network-like structure and links

Figure 2 shows the same structure with simulated data that could come from a simple report an entity (human worker or an intelligent machine) has to track weather and work data.

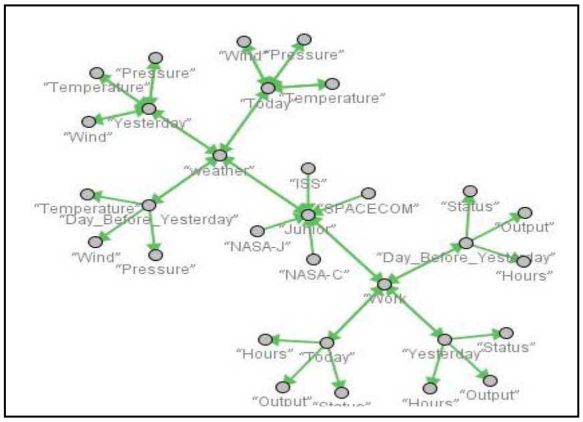

Figure 2: The simple 24-node idea with organizational data for a 3-day period.

This kind of idea structure can become more complex as more ideas are linked or more information is needed to be tracked. Figure 3 shows a 9-day structure of the same data types found in Figure 2.

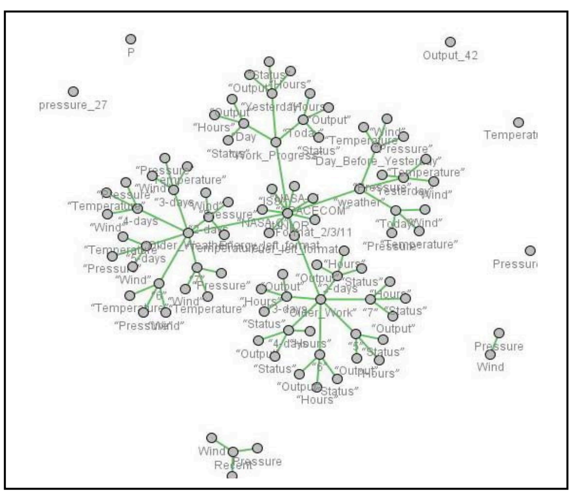

Figure 3: The same simple idea as it increases in size to 90 nodes to hold 9 days of data.

The network structure can show various types of mind organization. Figure 4 shows a seemingly random structure (on the left) and an over- or strangely-organized (circular) structure on the right of the same data as shown in Figure 3.

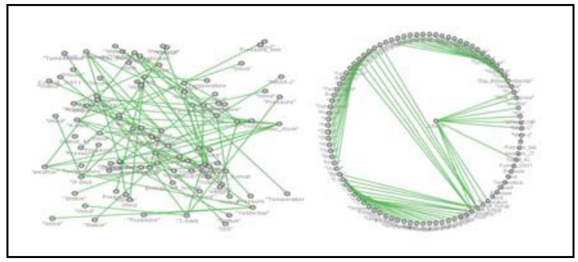

Figure 4 (left and right): The same data as shown in Figure 3 in random network form on the left and in a circular network form on the right.

So far, our ideas in this example have been very simple. Figure 5 shows the notional network structure for a more complex idea with numerous links but no central or focal point and therefore, a large, but linearly patterned idea.

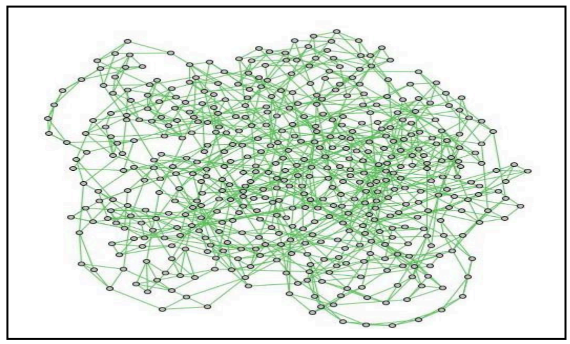

Figure 5: This network of 300 nodes is highly connected with no focal aspects.

Figure 6 shows a dense network of a complex idea with many basic foundations and foci that weave together different concepts. Figure 6 also shows a few isolated ideas that are not linked to the central one or, in some cases, the links to these components of the idea are no longer active and valid having been discarded by mindspace processes.

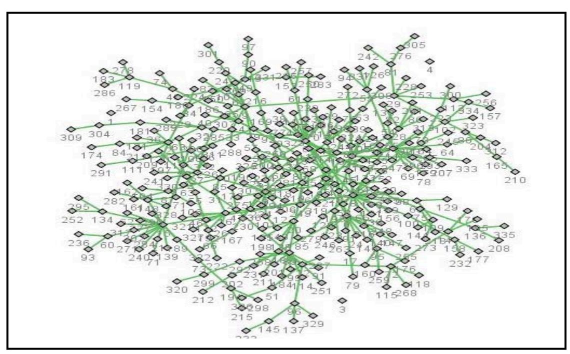

Figure 6: This mindspace idea shows a dense network structure of 350 nodes.

Sometimes the isolated simple facts are as significant as the structure network of the main idea. Figure 7 shows an example of this situation with a central core of ideas along with many isolated but patterned ideas in the mindspace.

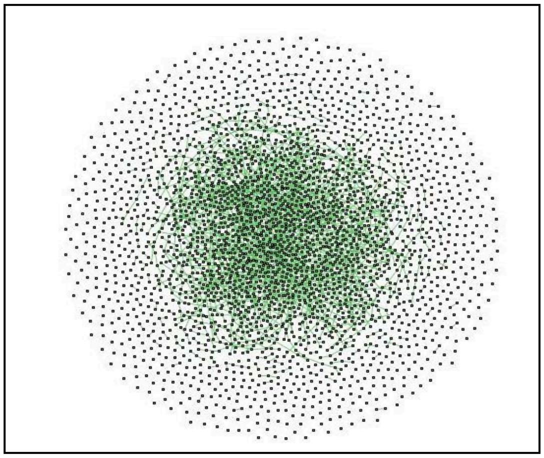

Figure 7: This dense network of a complex main idea is surrounded in the mindspace by isolated, but simple data ideas.

6. PROCESSES

We now take a brief look at some of the processes that take place in the mind -- thinking, learning, memorizing, intuiting, inquiring, deciding, creating, forgetting, imaging, and communicating. These mindspace processes affect the richness, robustness, clarity of ideas. They can take lesser value ideas (data or information directly from sensors or mindspace locations) and enhance them through the process to higher-values of knowledge or intelligence by linking the ideas in building a network-like framework for the thought. The ultimate goal is a mindspace that contains knowledge and possesses robust processes to assemble complex thoughts and produce intelligence. Both structure and processes contribute to this goal.

Thinking

The mind actually multi-processes by accessing, combining and, therefore, thinking several ideas at once. These ideas may be for related purpose or not. Accessing all these ideas in a rapid fashion provides for a powerful process. The duration of the activation of thought is created by a combination of efficiency, intensity, and function of the thought. The simultaneous accessing of many ideas for one purpose indicates a complex, multifaceted thought encompassing many basic or sub-thoughts. The more patterned in either space or time, the more organized or ordered the thought. And when the basic ideas are located in topical polytopes, the intensity and efficiency of the process can be enhanced. Thinking has many different aspects --- sometimes the mind analyzes existing ideas, sometimes combines ideas, and sometimes uses reasoning to refine an idea. While some kinds of thinking can be casual and informal, critical thinking is much deeper and more formal. Critical thinking examines the evidence that supports the idea and then uses the idea to make a decision, solve a problem, or answer the question under consideration.

Learning

What happens when someone needs to know something new? Learning pathways are forged to idea locations in the mindspace. This makes for a mind-expanding process. New ideas are constructed, linked into an existing idea when appropriate, and eventually the mind gains an entirely new perspective. One possible result is the unfolding of an entirely new dimension in the mindspace. Recently learned material and some previously known material is migrating to this new dimensional space. This event is the expansion of a mind.

Another learning process could just expand a current idea by linking new components to existing. The following example shows a learning simulation of a basic skill usually learned early in childhood. The intent of the example is to show that the dynamics of the mind are as complex as its structure and processes.

Example 2 (Learning Simulation): In this example, we start with a mind that knows the idea (skill) of the addition operation in arithmetic. This mindspace has connected the addition idea (skill) to other basic number ideas as shown in Figure 8. This network of ideas becomes one connected idea that enables the mind to think in a more sophisticated and capable manner as it processes arithmetic addition.

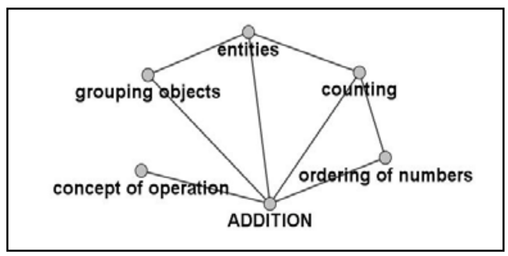

Figure 8: This is a notional mindspace model for a learning entity that knows "addition".

In this example, as the mind obtains the new idea (skill) of subtraction through learning, it connects this new idea to its previous idea of addition and some of the other the associated ideas in the network. This learning act produces the new idea structure as shown in Figure 9.

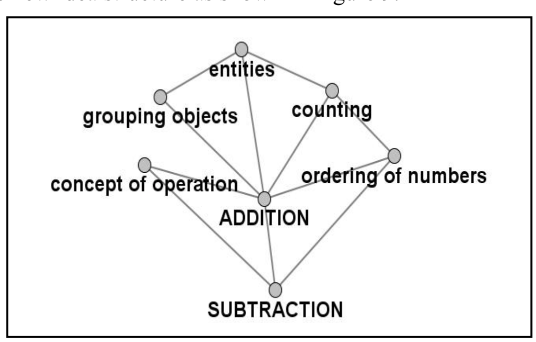

Figure 9: The new mindspace model once the entity has learned "subtraction".

This new network of ideas then empowers the learner to further its learning and thinking capabilities by connecting three new ideas to the network and strengthening existing links. Figure 10 shows the result of adding new ideas (skills) of “counting backwards”, “negative numbers”, and “number-line” to form the new network for this idea.

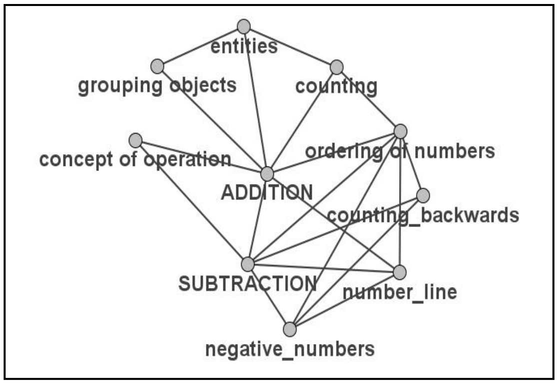

Figure 10: The notional network of the idea grows as new ideas connect to existing ideas.

Finally, the mind is able to construct even further and more complex ideas in its dynamic learning mode. More sophisticated ideas for “sequences” and “relationships” join this network structure through the processes of learning and thinking to produce the highly-connected network idea for “addition” shown in Figure 11. The complexity of the network grows as learning takes place and capabilities increase.

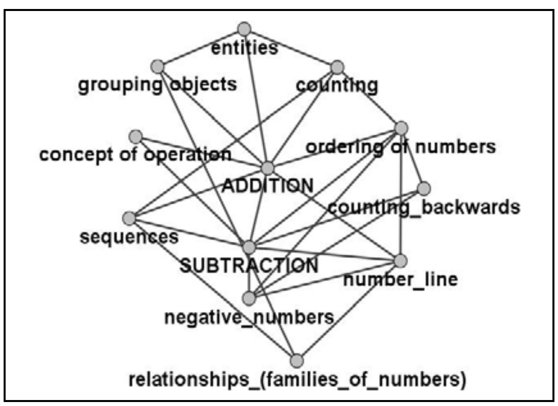

Figure 11: This dynamic learning simulation reaches its next stage with 12 highly-connected nodes. The “addition” node is directly connected to 8 other nodes.

Of course, this simulation example is extremely simplified because of dimension and visualization limitations. However, the dynamics of learning and thinking can continue to enrich existing ideas and connections. Even the more complex network model for the idea of “addition” in a more mature learner as shown in Figure 12 is highly simplified. However, the richness of connections and ideas clusters of a polytope are visible in this model shown in Figure 12. This idea model is probably more in tune with the simple ideas that populate the mindspace of many entities.

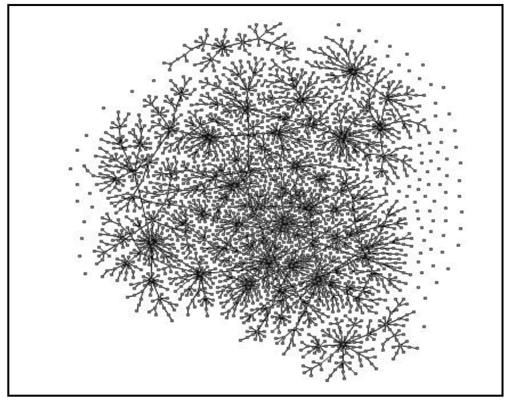

Figure 12: This notional model of the connections and ideas for arithmetic skills in a mature learner show clusters and isolated idea components of various sizes and shapes.

Memorizing

Some people are adept at memorizing lyrics and tunes of songs. This is a skill that shows how an organized mind can learn new patterned information. Often the storage area for songs is an efficient, special designed polytope. Memorization of highly ordered facts or numeric data --- such as phone numbers or sets of alphabetic data – can be an organized process. Some minds build special structures for this kind of data --- patterned, but not at the complexity level of idea polytopes – and other minds use normal memory locations for this kind of information as well. The mind’s ability to build taxonomies and ontologies (mind maps of spatial representations of ideas) to store basic information enables it to hold considerable trivia and facts related to all sorts of topics.

Intuiting

The ability to perform advanced skills can be limited by memorization since there is no context or connections for the mind processors to use. On the other hand, minds can have plenty of productive intuitive intrinsic memory – such as driving a car, riding a bike, adding and subtracting single digit numbers learned from math facts, sounding and even sight reading.

Inquiring

Inquiry-based learning, driven by asking deeper questions about a topic, also produces new idea structure. Inquiring is a natural process some minds are extremely well suited to perform. Essentially, it is the questions that drive the curiosity to learn (assemble/create) new ideas by asking questions that have to be assembled with other ideas to create new ideas. At each step, the ideas become deeper and richer as more questions are asked. The mind guides itself to learn and develop deeper understanding of topics, building both knowledge, network links, and thinking/inquiry skills. Inquiry is a natural process for some minds. The ultimate goal is to adopt new perspectives as the questions lead to ideas, thoughts, processes, and knowledge previously unknown to the mindspace. Successful inquiry leads the mindspace to change its structure.

Deciding
Some decisions are intuitive --- the issues are well understood and organized. In an intuitive streamlined decision process, the mind moves information in and out of its decision processor -- quickly eliminating poor choices and finding the optimal. Deeper decisions can take much more processing effort. An organized mind can keep information in a near priority order in a compact and patterned structure. Then the decision processor sorts through the preference-ordered list and weighs the attributes. Complex decision making can be much more involved in terms of accessing information from scattered locations throughout the mindspace. By its very nature, complex decision processing is more deliberate and extensive. More sophisticated reasoning (inductive—inference --- deductive) is used along with determining probabilities of outcomes. In this complex case, the decision process includes analysis of many diverse measures of costs and benefits and other considerations.

Creating
Some minds have a natural capacity to assemble ideas in new ways to invent or create entirely new ideas. The act of assembling and connecting ideas can be a result of inquiring, thinking, learning, or deciding or some combination of these processes being performed in an iterative and complex process.

Forgetting
One reason the mind has empty areas or isolate ideas is that it forgets many ideas and connections that were once important. An efficient mind allows unneeded clutter to disappear. It is for efficiency that the mind forgets some things that it will never need to use again. But still there are some unneeded, outdated things that will stay forever stored in the mindspace. .

Imaging
A significant mental function is the mind's ability to learn, think, create, decide, dream using graphic images and not word ideas. The mind is able to store versions of the graphic images. These mental images are compressed or possibly distorted images of what is actually seen, but once in the mind they are the mind's version of reality. Then mindspace processors are able to retrieve the images and use them to produce new thoughts through analysis of the stored image or to remember the situation that created the image. These images are essentially powerful ideas that can be used in many mind processes --- thinking, learning, deciding, inquiring, creating, hoping, and dreaming. The mind can store and retrieve dynamic images in enough detail to play back entire scenes --- like video replays or trailers of a movie. Imaging is an extremely powerful mind process for most people.

Communicating
While there are many models of communication and speech, the ones most compatible with our mindspace model are from Chomsky [6, 7] and Chafe [8]. The communicating aspect of our model was explained and highlighted in Arney [1]. As expected, the purpose of speech, whether to provide information, persuade, entertain, or express emotion, has significant effect on speech patterns and word choice. The intent of communication is to guide listeners to form an idea in their mind that would then lead them to the idea that the speaker wants them to have. The pathway from and to that idea is language.

7. MINDSPACE ENVIRONMENT

Like any biological process, the processes of the mind are affected by the mind's environmental situation and vise versa. Sometimes, the mind can be bogged down by the person's emotional and physical state. The reality is that the mind id always degraded. Extreme environmental conditions can adversely or positively affect mind processing. Sometimes, deliberate reasoning processes are shut down and the mind goes into an efficient, quick-reaction mode. Deep thought is less likely during a stressful situation since one of the most debilitating emotional conditions is stress. In general, the environment reflects situational awareness. The more the person feels she knows about her situation, the better her environment and vice versa.

8. CONCLUSIONS

Our model establishes a theoretical geometric framework for the network structure and knowledge processes of the virtual mindspace. At this juncture, low-scale, simple examples and notional frameworks are produced to enable simple forms of the model to be understood and visualized. Further development and testing of the model's framework and network measures are needed to validate the model.

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Conceptions and Context as a Fundament for the Representation of Knowledge Artifacts

Thomas KARBE
thomas.karbe@tu-berlin.de
FLP, TU Berlin
Berlin, 10587, Germany

ABSTRACT

It is a well-known fact that knowledge is often not objective and not context-independent. However, in many application systems knowledge is treated as objective and independent. In this paper it is argued that subject and context dependencies of knowledge need to be reflected in knowledge representation. Bernd Mahr's Model of Conception offers a fundament for new knowledge representation technologies which takes these properties of knowledge into account. Nevertheless, it is still possible to represent objectivity and context-independence in the model.

Davis, Shrobe and Szolovits [2] outlined five roles of knowledge representations. In this paper we will examine Bernd Mahr's Model of Conception in these five roles and argue for its usefulness in modelling information systems.

Keywords: subject-dependency, objectivity, context, conception, knowledge representation, modelling

1. INTRODUCTION

The need for interoperability and semantic integration in information systems shows that subject- and context-dependent actions and processing are almost everywhere present.

Bernd Mahr argues with the Model of Conception, that everything which is conceived of by some subject is conceived of as something influenced by a context. The context is not only influencing the conception, it even is the only source of meaning for the conceived object.

Context is not naturally existing but originates from subject's conceptions and actions of interpretation. It supports the subject in recognizing relevant information and using it in the process of reasoning.

In the following sections, we will first discuss how the notion of context was analyzed and used in literature. Then we introduce Bernd Mahr's Model of Conception, along with its views on subject– and context-dependency. Later we explain the five roles of knowledge representation according to Davis, Shrobe and Szolovits [2] and examine the Model of Conception in these roles. The envisaged scope of knowledge representation based on the Model of Conception includes agent systems, telecommunication, distributed AI-systems, context-aware systems, ambient intelligence systems and others. It also could be a step into the direction of generality in AI.

2. CONTEXT IN LITERATURE

There is lots of work related to context, e.g. in the fields of context-aware computing, ubiquitous computing, linguistics, artificial intelligence and many others, but there is only a small line of work, which particularly focuses on the concept of context itself.

The need for representing context was probably first stated by John McCarthy in [13]. He argued, that in order to reach the goal of generality in AI, the notion of context needs to be formalized. Then, in [14] and [15] he made a first approach, by adding abstract contexts to logical formulas.

Following the ideas of McCarthy, Ramanathan V. Guha developed a logic, based on first order predicate calculus, which handles contexts [5].

Based on the work of McCarthy and Guha, Doug Lenat built his common sense knowledge base *CYC* (see [1], [10]). The knowledge base is build as a lattice of contexts. Each context then consists of a set of assumptions and a set of content assertions, which hold under the assumptions.

Dourish analyzed in [4] how the notion of context is used in ubiquitous computing and on which principles it is based. He describes these principles as a *representational model* and argues for a new set of principles, which he calls an *interactional model*. One important change he introduces is that context is dynamic and not static.

Kokinov in [8] analyzed the notion of context from a cognitive point of view and found several properties that characterize the term. He also built a cognitive architecture called *DUAL*, which offers an implicit model of context. We'll come back to this model later.

Anind K. Dey [3] even offers a definition for context:

> Context is any information that can be used to characterize the situation of an entity. An entity is a person, place, or object that is considered relevant to the interaction between a user and an application, including the user and applications themselves.

The definition focuses on interactions between users and applications, but nevertheless, it captures a point that was also seen by Kokinov: Context is any information that is considered *relevant*.

Based on these insights into context, we provide a more detailed analysis of context-dependency in [6].

3. BERND MAHR'S MODEL OF CONCEPTION

The term *conception* is used in a wide variety: We say that *something is conceived of by somebody* and mean situations where somebody perceives something with his senses in a certain way; where somebody thinks of something somehow; where somebody wishes something to be; or where somebody understands that certain things are related to each other in a certain way.

Based on his work on "Object and Context"[1] [11] and on following studies on the notion of *context* Bernd Mahr developed his *Model of Conception*, which was published in [12]. It models conception by relating the term to the three other terms *subject*, *object*, *context*, and it derives from it the notion of the *content* of a conception.

None of these terms can be seen as being "more basic" than the others and each of the terms can only be understood in relation to the others. Thus, the Model of Conception can also be seen as a model of "object", of "context", or of "content".

Following the model, a subject conceives of an object in some context. The context is a complex which consists of relationships into which the conceived object is embedded. These relationships determine the content of the conception.

Clauses of the Model of Conception

Bernd Mahr's Model of Conception is given by thirteen clauses in natural language:

[1] translated from German "Gegenstand und Kontext"

Entity

1. An entity is something that is. Anything that is, is an entity.
2. An entity is the content of some conception.
3. Any two entities are different.

Both, the concepts of conception and content are explained in later clauses. However, they are entities themselves and so this clause results in a circular relation, which states that both, conceptions and contents are themselves a content of some conception.

Relationship

4. A relationship is an entity by which entities are related.
5. An entity belongs to a relationship, if it is one of the entities which are related by this relationship.

Complex

6. A complex is an entity by which entities belong to relationships.
7. A relationship belongs to a complex, if the entities which belong to this relationship belong to this relationship by this complex.
8. An entity belongs to a complex, if it belongs to a relationship which belongs to this context.

Conception

As the name states it, conceptions are central in the model of conception. They are, together with the content of a conception, described by the following two clauses:

9. A conception is a relationship by which an entity, identifiable as the subject of this conception, an entity, identifiable as the object (or subject matter) of this conception, and a complex, identifiable as the context of this conception, are related.
10. The content of a conception is a complex, to which exactly those relationships belong, which belong to the context of this conception, and to which the subject matter of this conception belongs.

Situation

11. A situation is a complex in which all entities which belong to this complex are conceptions.

Universe

12. A universe is a complex to which with every entity which belongs to it, also belongs a conception, whose content is this entity.

13. A universe is called reflexive, if it belongs to itself.

Example

The following example demonstrates an application of the Model of Conception:

A man and a woman are sitting in a restaurant and the man gives his credit card to the waiter to pay.

The whole event can be described as a *situation*, a *complex* which consists of many *conceptions*. In this case, there are conceptions where either the man, the woman, or the waiter are the *subject* of the conception.

One of these conceptions would describe that the man uses his credit card to pay. He would be the *subject* and the credit card would be the *object* of this particular conception.

The *context* of the conception would contain *relationships* that describe information about credit cards in general, about the role of a waiter in a restaurant, and that the waiter needs the card to process the payment.

The *content* of this conception would consist of all information in the context that relates to the credit card. This content would describe the actual meaning of the credit card in this particular context.

Viewing this situation as an entity in the Model of Conception shows how complex this seemingly simple example is.

Subjectivity vs Objectivity

By introducing the term "subject", the model, among other things, allows explicit description of communication situations between persons, between machines and between a person and a machine. Furthermore, subjects are not restricted to persons and computers. Every entity that can have a conception of something can be seen as a subject. Thus, also a whole nation, a book on art, or a scientific community could be the subject of a conception.

The first clause of the Model of Conception states that "Anything that is, is an entity" and thus, the model simply takes *everything* into account. One may assume, that therefore the Model of Conception itself is an ontology of everything, but in fact, it takes an opposite role.

Entities in ontologies are supposed to be objective in the sense that they are independent of a conceiving mind. By the second clause any entity is the content of some conception and therefore depending on a subject and a context. Consequently, the model itself and each ontology are entities and as such subject-dependent. According to [17] "the ontological status of objectivity can only be given within an ontology".

Because of the subject-dependency of Bernd Mahr's Model of Conception, it was originally coined *A* Model of Conception and not *The* Model of Conception. In this paper we often use the article *the*, referring to the model made by Bernd Mahr. We do not intend to see it as the only possible model. It is in the very nature of the model, that there are other models in other conceptions.

Context-Dependency

According to the second clause of the Model of Conception, every entity is the content of some conception. Therefore every entity must be a complex, which consists of relationships from the context of the conception. The content of the conception is the whole meaning of the entity and it is completely derived from the context of the conception. In other words, the content is a part of the context of a conception.

Following this idea, an entity alone has no meaning. The whole meaning of an entity is given by its relationships to other entities.

Consistency of the Model of Conception

For using the Model of Conception in calculations, it needs to be formalized somehow. This seems to be problematic because of the circular nature of the model: A conception is a relationship and thus an entity. Each entity is the content of some conception and thus each conception is the content of a conception.

In [17] Tina Wieczorek formalized the model by writing the logical reading of its clauses in first order logic notation, using appropriate function and predicate symbols. She gave two axiom systems for universes, and constructed for each of these systems a Tarski-style model.

Her model constructions do not only prove consistency of the Model of Conception, also in the case of reflexive universes, but they also show that the conventional set-theoretic universe and the ϵ-theoretical universe of ϵ-sets are both universes in the sense of the Model of Conception. In ϵ-theory it is possible to consistently represent reflexive and circular structures up to self-reference.

4. FIVE ROLES OF KNOWLEDGE REPRESENTATION

In [2] it is argued, that knowledge representation is best described in five roles: It states that a knowledge representation is

a surrogate Every reasoning process takes place in the mind of some reasoning entity. Thus, there must be a representation of everything the entity is reasoning about in its mind.

a set of ontological commitments The ontological commitments are "a strong pair of glasses that determine what we can see, bringing some part of the world into sharp focus at the expense of blurring other parts." [2]

a fragmentary theory of intelligent reasoning This theory usually describes three components of reasoning: a fundamental conception of intelligent inference, a set of inferences that the representation sanctions, and a set of inferences that the representation recommends.

a medium for efficient computation The knowledge representation must not only represent knowledge, but it must also allow for efficient usage of the knowledge in inference processes.

a medium of human expression A knowledge representation should allow humans to describe their knowledge in a natural way.

In [16] John F. Sowa argues that these five roles "can be used as a framework for discussing the issues of knowledge representation". Following this idea, we will examine the Model of Conception with respect to the five roles, to motivate its potential usefulness as a fundament for knowledge representation.

The Model of Conception as a Surrogate

The Model of Conception was largely inspired by cognitive science and thus, is based on the idea, that everything in our mind is a conceived thing. We can only think, talk and act on things which we have conceived before. The idea of conceptions is expressed by the sentence "There is nothing for us, which is not through us.[2]"

According to [2] everything that an intelligent entity is reasoning about is an internal representation of a real thing in the external world. As a result from this thought, the authors come up with two questions about surrogates: "What is it a surrogate for?" and "How close is the surrogate to the real thing?".

[2]This statement was made by the German philosopher Günther Figal.

The Model of Conception does not deal explicitly with the external world. It does not represent the "real thing" directly, but the conception of a thing, which is already internal. Still, such a conception is a real thing too, and so we have two levels of surrogates here: first, the conception and the content as a surrogate for the real thing and second, the Model of Conception as a surrogate for the conception.

For the first level, in the example given above, there is an entity which is a surrogate for the credit card and the content of the described conception is a surrogate for what the man considers relevant to the credit card in the context of a restaurant.

For the second level, the question "How close is the surrogate to the 'real' thing?" translates then to "How close is the Model of Conception to the 'real' conceptions?". Although the thirteen clauses of the model are carefully formulated, they are very abstract and thus, they leave room for interpretation. So the answer to this question depends on the way in which the Model of Conception is formalized.

Ontological Commitments in the Model of Conception

As we have argued before, the Model of Conception is not an ontology in the sense that it does not claim objectivity. Still, there is an ontological commitment to concepts like *entity*, *relationship*, *conception*, *subject*, and *context* and to the way they are related to each other. This kind of commitment is fairly minimal, like it is in the case of logic. Every model based on the Model of Conception would use these few concepts to represent others.

The amount of ontological commitment for a knowledge representation should depend on its purpose. For a tool that is specialized on a certain area the corresponding knowledge representation does only need to cover that area.

The Model of Conception was not designed for a specialized application, but for applications in many different fields. A human is not restricted to understand a limited set of concepts, and thus the Model of Conception should not be restricted in the same way. Every restriction in this sense would prevent realizing McCarthy's goal of generality in AI.

A Fragmentary Theory of Intelligent Reasoning based on the Model of Conception

The Model of Conception does not include a theory of reasoning and therefore it is no knowledge representation by itself. Nevertheless it can be seen as a fundament for a theory of reasoning and thus for a knowledge representation. Ideas for such a theory can be found in the models of cognitive science. One concept that is particularly interesting is described by Kokinov in his *DUAL*-architecture [7]. The architecture is a net of DUAL-agents, called nodes. Kokinov introduces the notion of *activation* which is a property of a node and which practically denotes how relevant this node is in a particular situation.

Interpreted in the Model of Conception it means, that the object of a conception serves as a source node which has a constant level of activation. It spreads a percentage of its activation to the entities which are related to it. These entities again spread a part of their activation and so the activation propagates through relationships. All entities have a certain threshold and when their activation is below the threshold, they are inactive and will not spread any activation.

By the concept of activation the concept of *relevancy* is modeled, which was seen as a important part of context by Kokinov and Dey.

Efficient Computation in the Model of Conception

In the Model of Conception, calculations would manipulate conceptions and contexts. Doug Lenat describes context in [9] as follows:

> We understand the potential usefulness and power of contexts, of being in and reasoning within a context:
>
> - Enabling us to ignore 99.999% of our knowledge so we can focus on the task at hand
> - Enabling us to be terse and sloppy in our communications and yet expect our readers/listeners to understand our intent
> - Enabling us to accommodate apparently contradictory information, by partitioning it out to different contexts

The first item in his list explains, why computations on contexts would be efficient. Sorting out irrelevant information provides a means to reason about things as it reduces the amount of information to a proper size which can be handled.

In the given example, only relationships are considered relevant, which on the one hand are related to the credit card, and which on the other hand are part of the restaurant context.

The Model of Conception as a Medium of Human Expression

There is no formal language defined for the Model of Conception. However, as we mentioned before, it is inspired by cognitive science and therefore by the human mind. Thus, a language based on the Model of Conception would allow for a very natural way of expressing knowledge in terms of relationships and complexes.

5. CONCLUSION

We discovered that the Model of Conception by itself is no knowledge representation, but that it is possible to create one on its basis. A first step towards it is to formalize the Model of Conception, which we are currently working on. The next step would be to develop a theory of reasoning on top of the model. The theory should formally define the notion of relevance and thereby allow for efficient computation. Further, we need to define a formal language that allows for a natural way of expressing knowledge.

Our examination of Bernd Mahr's Model of Conception with respect to the five roles of knowledge representation argues that it can serve as a fundament for knowledge representation. The model introduces the two central concepts of subject– and context-dependency, which offer a new perspective into representing knowledge. The idea to include these concepts into the model is inspired by cognitive science, and its goal is to improve the way that computers handle knowledge artifacts and make it more similar to the way humans do.

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How Is Interdisciplinary Research Performed in Korea?

Hye Na Kim
Department of Education, Pusan National University
Busan, South Korea

Ewha Kang
University of Göttingen
Göttingen, Germany

Dae Hyun Kim
Department of Education, Pusan National University
Busan, South Korea

ABSTRACT

The purpose of this study was to figure out how interdisciplinary research (IDR) is performed in South Korea, in terms of platforms, process, and outcome and evaluation. To achieve the purpose, this study employed semi-structured interview with researchers who had experiences of IDR. The results are as follows. First, regarding platform of IDR most informants conceptualized IDR in terms of multidisciplinarity and IDR was motivated by personal interests, interdisciplinary nature of home discipline, or external forces like research funds. Second, in the process, the informants perceived that their researches were largely implemented at multidisciplinary level and problems in communication and relationship between team members were raised as main challenges. Cultural aspect was revealed to affect interaction and relationship between team members. Finally, the informants mainly suggested tangible outcomes when asked about results of IDR and it was considered that such responses were influenced by meritocracy of evaluation system.

Keywords: interdisciplinary research (IDR), platform, process, outcome, evaluation

1. OBJECTIVES

Various fields in today's society are undergoing unprecedented changes in response to globalization, and academic realm is not an exception [1]. As needs of the society and characteristic of valued knowledge have been changed, academic researchers are given pressure and, at the same time, have motivation to effectively react to the change. One of the most recognizable changes in academe is observed in types of pursued research that is represented by shift from discipline-based research to interdisciplinary research (IDR).

IDR is considered to have several benefits over traditional disciplinary research. Research that does not solely based on single discipline (i.e. IDR) has been reported to be useful to solve complicated real-world problems and allow comprehensive understanding of phenomena [2] [3].

Recently, increased number of IDR and researchers who conduct IDR is obviously observed in Korea [4] [5]. To promote this change, Korean Research Foundation (KRF) has provided official fund for researchers to design and implement IDR by announcing "project of IDR support". The attention to and investment on IDR seems to emerge with multiple purposes, including to raise the nation's competitiveness in the globalized world, to solve real problems effectively, and to produce new knowledge.

There have been a lot of researches to understand and improve IDR. They could be categorized around three major themes including conceptualization of interdisciplinary approach [2] [6] [7] [8] [9] [10] [11], process and elements involved in IDR [12] [13] [14], outcomes and evaluation of IDR [15] [16] [17]. Results from these studies feed back to the practice of IDR, contributing to development of the area.

Although a lot of researches transgressing boundaries between disciplines have been produced in Korea, attempts to investigate IDR as an object of inquiry have not been given much attention. In other words, we have little to talk about reality of IDR done in Korea.

Regarding Korean studies on IDR most focused on suggesting needs or ideal status of IDR [4] [18] [19] [20] [21]. On the other hand, experiences researchers go through in IDR are relatively not well-known. Given the current movement toward IDR in Korea, however, it is considered to be necessary to identify how IDR is operated, in order for current researchers to understand their practice and achieve higher quality. In this respect, this study aimed to figure out how IDR is performed in Korea.

Toward this end, three research questions were identified.

1. With what platforms (i.e. background, concepts, and images of IDR) do the interdisciplinary researchers enter into the research process?
2. What happens in the process of IDR?
3. What are the outcomes of IDR and how are they evaluated?

The results of this study would contribute to understanding of Korean experience in terms of IDR. Not only that but it would facilitate discourses between researchers worldwide who are interested in the theme and help them to reflect on common factors and unique differences in IDR practice. It would lead to discuss about constructive future of IDR in this globalized world. In this respect, this study has implications for importance of intercultural understanding in research globalization.

2. THEORETICAL BACKGROUND

A lot of different terminologies were suggested by scholars to refer research which is not confined to a single discipline. As well as, the definition and typology of IDR varies according to scholars.

Definitions of interdisciplinarity during 1970s and 1980s distinguished multidisciplinarity and interdisciplinarity, focused on disciplinary integration [10] [22] [23]. Some of the typologies advocated transidisciplinarity as the most desirable form of interdisciplinary approaches. Klein (1990) indicated that to some extent, general consensus about distinction between multidisciplinarity, interdisciplinarity, and transdisciplinarity was achieved among scholars.

Multidisciplinary work juxtaposes disciplines without any integration and disciplinary elements retain their original identity [9]. However, interdisciplinarity integrates the elements of the involved disciplines. It is a process of addressing a problem that is too broad or complex to be solved by a single discipline [29]. Transdisciplinarity was defined as a comprehensive framework constructed through an overarching synthesis of disciplinary worldviews [9]. Klein (2005) suggested general systems, structuralism, Marxism, policy sciences, feminism, and sociobiology as leading examples of transdisciplinarity, which transcends the narrow scope of disciplinary views.

Some scholars who adopt rigorous and narrow definition of interdisciplinarity do not accept all kinds of interdisciplinarity stated above as IDR. This study, however, applied broader definition of IDR which involves all three types above regarding initiating stage of IDR in Korea and to make the results rich and comprehensive, and thus applicable to other contexts.

Researchers who were interested in how IDR was implemented have studied on motivations, needs and conceptualization that interdisciplinary researchers conceived about interdisciplinarity [2] [25]. Laberge, et al. (2009) investigated perspectives of interdisciplinary researchers on value of interdisciplinary health research. The respondents expressed wide variety of views. Lattuca (2001) explored various backgrounds from which informants in her study became interdisciplinary and revealed intellectual and personal influences on their commitments to IDR throughout their lives.

In this study, we categorized these elements into “platform” recognizing that researchers start their interdisciplinary work from and with the elements. The concept of platform owed to Walker (1971) who used the term to refer concepts, theories, aims, images, and procedures that curriculum developers carry with them to deliberation where experts in various fields participate.

A lot of literature on the process of IDR has been cumulated, focusing on interaction, collaboration, and dynamics in team-based work [14] [27] [28] [29]. Oughton and Bracken (2009) found that explicit negotiation is prominent feature in IDR process. Repko (2009) suggested a set of steps in IDR process, including using disciplinary insights and dealing with conflicts between relevant disciplines. Nair, Dolovich, Brazil and Raina (2008) revealed that relationship and power distribution between participants played central role in the IDR, which could encourage or discourage the research process. Based on the literature review, this study identified its second question to figure out what happens in the middle of IDR process.

There are some research conducted on outcome and evaluation of IDR [2] [15] [16] [30] [31]. Lattuca (2001) found that conference presentations and papers, journal articles, monographs, books, promotion, tenure, learning from others could be outcomes of interdisciplinarity. In her comprehensive review of literature on interdisciplinary and transdisciplinary research evaluation, Klein (2008) suggested a framework consisted of seven principles: (1) variability of goals; (2) variability of criteria and indicators; (3) leveraging of integration; (4) interaction of social and cognitive factors in collaboration; (5) management, leadership, and coaching; (6) iteration in a comprehensive and transparent system; and (7) effectiveness and impact. The third research question was drawn by these literatures.

3. METHODS

This study employed semi-structured interview to achieve the purpose. 25 informants who had experiences(s) conducting funded interdisciplinary project were subject to the interview.

Participants

The sample was selected based on convenient sampling and snowball sampling methods in which informants introduced interviewers someone they know who would provide relevant information for the research. The sample population included 25 informants in 4 universities. Their majors represented variety of academic perspectives, including architecture, English novel, control system engineering, science philosophy, mechanical engineering, and etc.

Data Collection

The interviews were conducted face-to-face and individually to acquire specific information about their research practice. Two researchers did their interviews respectively. To improve reliability of data collection process, the interviews were based on same interview protocol, but not restricted to the questions in the protocol. In addition, they had several times of pilot interviews.

The interview protocol developed by the researchers of this study consisted of grand tour questions about platforms, process, and outcome of IDR and probing questions asking specific examples of their answers. Each interview lasted for about 30 to 40 minutes. All interviews were digital-recorded and transcribed using pseudonym and the informants were rewarded with honorarium for their participation.

Figure 3.2 Interview Questions

Categories	Questions
Platform	How do you define “interdisciplinary”? What’s your motivation for interdisciplinary research?
Process	How was your research implemented in terms of types of interdisciplinarity? How was communication between team members? If the communication was not facilitated, what do you think the reason was? Was role division between the members clear and reasonable? How did role division influence the research process?
Outcome	What were the outcomes of your project?

and Evaluation	How were the research and its outcome evaluated?

Data Analysis
Transcriptions and field notes of the interviews were analyzed according to general analysis procedure of qualitative research. We conducted iterative and recurring process of categorizing words and main ideas from transcriptions. The process was made by tracking the ideas and memos the researchers wrote down while reading the transcriptions using Nvivo program. Then emerging variables were classified into the themes, and examined in terms of interrelationships. The process was continuously repeated and reviewed through categorization and re-categorization to establish valid and reliable themes and it included experts in higher education and qualitative research.
To improve validity and reliability of the study, triangulation and member check was employed [32] [33]. Transcriptions were compared to field notes that were written during the interviewes and validity of categorization was reviewed by different researchers. As well as, we reported the results of this study to the informants and accepted their opinions to avoid distortion of results by researchers.

4. RESULTS

Platform
Many informants interviewed conceptualized IDR as “doing research with researchers in different disciplines, while firmly having their own disciplinary boundaries, toward shared purpose”. It means that the informants considered IDR team as “temporary, experimental, and virtual one”.

> “Interdisciplinary” means cooperative work with different disciplinary majors from one’s own traditional discipline. [E]

> It is a process in which each discipline maintains its own features, but through listening to opinions from different disciplines, involved disciplines create common results that emanate synergy effects. [L]

> “Interdisciplinary” means virtual team in which more than two disciplines are associated to solve complicated problems. It has a meaning as “field of experiment” where researchers with sufficient basis of independent disciplines meet each other temporarily. [M]

Regarding motivation of IDR, some informants reported that they naturally initiated IDR realizing characteristic of their home disciplines that was related to other disciplines or with personal interests. Others were motivated by external forces like research fund or proposal from colleagues to join the project. Among them, some underwent gradual commodification in their motivations to make economic profits or large number of articles.

> My undergraduate major, control system engineering, taught me skills of indispensable to be interdisciplinary. As I look back on the past, my major was inevitably interdisciplinary that needed integration. [C]

> I got interested in interdisciplinary research when I was in master’s program. I was attracted in developing medicine that considered relationship between relevant organs, not focusing only on target organ. However, traditional disciplinary framework was not useful to achieve the purpose. Hence, I tried to see holistic picture. [G]

> I think interdisciplinary research should be application-oriented rather than pure disciplinary one. And after all, it should produce journal articles and, in my major, outcomes such as patent. [I]

Process
In the same line of their conceptualization of IDR, the participants were likely to implement their research usually at multidisciplinary level, which meant teamwork with different disciplines keeping their own disciplinary boundaries, not in a form of high level of integration that transgresses existing disciplinary barriers. Some informants suggested that “expert mentality” could discourage IDR process.

> In fact, many interdisciplinary researches being done in Korea remain at multidisciplinary level, not trans- or interdisciplinary. [S]

> Even though we did “interdisciplinary research”, the expert mentality proud of disciplinary knowledge led the research not to go beyond “physical integration”. [C]

An informant mentioned that predominance of multidisciplinary research might be related to the fact that we were in “0.5 generation of interdisciplinarity” and he believed that after the efforts would have been cumulated, they would create “first generation of interdisplinarity”.
Challenges in research process commonly mentioned among the informants were communication between participants resulted from differences of disciplines in epistemological paradigm or technical terms. The difficulty in communication required additional efforts and energy. An informant affiliated to architecture department participated in an interdisciplinary project with researchers in physics and English literature and remembered his experience as following:

> Whereas it was familiar for me to collaborate with English literature, differences in epistemological paradigm with physics was one of the most challenges in the research process. That is, physics has strong tradition based on reductionism and positivism while English literature and architecture stand on the opposite point from physics. It led to difficulties in mutual understanding and integration. It required more efforts than needed for obtained benefits. [L]

> Time consuming is caused by challenges in communication which is rooted in differences in terms, concepts, and perspectives between disciplines. That’s one of the biggest problems. [G]

As well as, pervasive culture of Korean society and preference of researchers with “pure strain” in their academic career was considered to discourage IDR process.

> The most important is discussion, but usually that’s not the case…… Confucian culture embedded in Korea makes certain situation where junior faculties do all the things in the team made up of senior and junior professors…… Age serves as one of the disturbing

factors for discussion. [S]

Scholars trained from single discipline are still preferred in Korean universities and research project. But on this starting point of interdisciplinary research, we should train and employ young scholars who have interdisciplinary experiences and are not limited in disciplinary paradigms. [K]

Outcome and Evaluation

Majority of the informants thought tangible outcomes, such as journal articles or project reports, are central outcome of IDR.

Usually the outcomes are research reports. [C]

In this case, we have produced one English article and two Korean articles so far. [P]

Their views of outcome of IDR were likely to be affected by evaluation standards of funding organization, which will be discussed later.

As well as, some informants suggested discovery of researchers who shared interests with them, personal relationships with researchers in different disciplines, and training students as professionals in IDR.

Additional outcomes include training students to work on their theses and dissertations related to the project theme…… I felt that we have significant potential to construct a team on the topic in my local area. [P]

However, these invisible outcomes could not be effectively assessed by current evaluation system of IDR. The informants' emphasis on publishing articles as outcome of IDR seems related to evaluation standards of funding organization. Some of them felt pressure for producing quantitative results, which discouraged high quality of IDR and led resistance of scholars to meritocracy.

It's a problem that funding organizations require researchers to make visible and quantitative outcomes. It would render interdisciplinary research superficial and impede interdisciplinarity. [Y]

The informants suggested that evaluation on the process of research would be needed to facilitate and ensure IDR with high quality.

For valid evaluation to be enacted, evaluation on the research process, not on the outputs, should be made. [S]

There appeared marginalization of interdisciplinary researchers in evaluation process by privileged academic societies (i.e., association of traditional disciplines), which was often seen in reviews on interdisciplinary papers.

Interdisciplinary research is excluded by the scholars who have prestige in existing disciplines. Figuratively, doing interdisciplinary research is like "becoming a bat" in academe. [K]

On the other hand, an informant perceived interdisciplinary feature of his research would be an advantageous point in paper publication and acceptance of research fund.

No, I think interdisciplinary research has advantages in research funding and paper publication in academic journals. [J].

5. DISCUSSION

Based on the results, following conclusions could be made.

First of all, we explored how the informants conceptualized IDR and what makes them pursue it.

The result indicated that most informants defined IDR in terms of multidisciplinarity. Given that informants in the previous studies defined interdisciplinarity from multidisciplinary, interdisciplinary and/or transdisciplinary point of view [2] [25], the informants of this study seemed to have relatively narrow view of interdisciplinarity, represented by multidisciplinary perspective. Their conceptualization of IDR seemed to influence subsequent practice, resulting in multidisciplinary level of research.

As well as, it was found that IDR was begun from personal interests, interdisciplinary nature of home discipline, or external forces like research funds. The last type of motivation has recently given attention by some researches [34] [35]. They would be useful to understand how commodification of knowledge affects research practice.

Second, the informants perceived that their researches were largely implemented at multidisciplinary level. It would be understandable regarding relatively short history of IDR in Korea.

Issues including communication and relationship between team members were raised as main challenges amid IDR process. Large number of previous studies that focused on these issues [14] [27] [28] [29] indicates importance of interaction and relationship in IDR.

One of the interesting results was that cultural aspects had significant effects on relationship between members. In this study, Confucian culture in Korea was considered to create age-based hierarchical relationship that discouraged interaction in research team. In this case, clear and reasonable role division becomes more important and needs to be made at the planning stage of research for equal distribution of power among team members. Based on the results, suggestions for further studies that would examine relationship between cultural aspects and interaction in IDR process could be made.

Finally, the fact that the informants mainly regarded tangible outcomes as representative results of IDR indicated that they were influenced by meritocracy of evaluation system. The results suggested alternative form of evaluation that values research process, complementing weaknesses and side effects of evaluation of, mostly countable, research outputs. Establishment of qualitative standards for evaluation like Klein (2008) suggested is prerequisite conditions for interdisciplinary researchers to produce creative outcomes and improve quality of their research.

Although outcomes of IDR were not different from disciplinary research as Lattuca (2001) found, what interdisciplinary researchers experience in evaluation process was different from that of disciplinary researchers. One of the interesting results was that there exist discrepancies in perception of their status among interdisciplinary researchers. Further studies on what makes differences in their perception would be needed.

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Relational Deployments Towards Cognitive Global Frames

Rinaldo C. MICHELINI
DIMEC, University of Genova, Via Opera Pia 15/A
Genova, 16145, Italy

and

Roberto P. RAZZOLI
DIMEC, University of Genova, Via Opera Pia 15/A
Genova, 16145, Italy

ABSTRACT

Nowadays, the globalisation complex and confused scenarios show that the *industrialism* cycle has arrived to an impasse; sustainable and long-lasting progress requests strong changeovers. The technology challenge needs solving the over-pollution and over-consumption figures of the current industrialism: to that purpose the world ought to radically modify the political set-up moving to global village sustainable growth, ruled by ‹the force of the law› and turning to ‹hyper-democracy›, to assuring balanced citizen/authority interplay.

Keywords: Social-Ecology-Economy-Cognitive Global Views, Economic Globalisation, Hyper-Democracy, Knowledge Society.

1. INTRODUCTION

The XX century leaves, after the short ‹global assent› illusion, under the US leadership, the all world with stability prospects. The crisis of the XXI century beginning shows that the economic globalisation cannot work [30, 31], with, perhaps, military dominance, but manufacture and trade supremacy moved to new sub-continent size countries [4, 10, 19, 22]. The soothing through financial tricks hides, for a while, the situation seriousness, delaying the time of the truth [5, 6, 9].

The current analyses show that the formerly successful European ‹nation-states› do not have any more cost-effective dimension [7]. The EU formation leads to clustering sovereign countries, adding a steering Commission, with duplicated functions and peripheral subsidiarity. The market widening does not match up politico-economic integration, shown by the growth differential trends of unlike efficiency partners.

The balance, between the efficiency provided by suited political cohesion and the fees due to the governmental duties, becomes severe handicap in these nation-states, worsened by the solidarity bill that most governments rule, by local macro-economic measures. In this frame, the ecology damages and pollution further modify the supply chain course, requiring apt reclamation targets. The paper presents an overview of the topics, illustrating the impending threats of the ecologic globalisation, and prospecting a futuristic changeover, embedding the economic globalisation inconsistencies.

2. POLITICAL COHESION PARABLE

The mankind quality of life increases, due to spendable riches' bigger availability. The progress depends on the country effectiveness, and this trait occurs to be winning along with industrialism, creating a divide between, at first, the UK, later, other European countries, and the other regions of the world. The modern history has well assessed upshot, roughly explained, by the higher efficiency of given ‹nation-states›, compared with others. The differential selection mechanism operates at the ‹collective› range, so that the process is described as ‹social Darwinism› [20], leading to the ‹utility› of the entire leading country, compared with the inefficiency of the other ones [21].

The mechanism, as a matter of facts, is well acknowledged. Before even agricultural revolution, the ‹group selection› originates the ‹social breakthrough›, leading the men to assemble in organised communities, with job allocation and ruling leaders [13]. In historic times, the differential efficiency is apparent in the progress of peoples ordered into legality frames, opposite to barbarous folk. Surely, the costs of the constituent legality need to be absorbed by the governmental competence; otherwise the built ‹empire› vanishes.

The modern industrial revolution enhances the ‹social Darwinism› differential efficiency, since the staples move from foodstuffs (mostly perishables, with transport limits), to manufactured goods (durables, with mass-handling chances). Hence, the fast grown gap in the world affluence. But the rest on one's laurels is fruitless. The economic globalisation shuffles the cards. The communication means change the trade dimension profitability. The charges of the constituent legality in progress marginalise the European ‹nation-states›. The UE Commission, up now, is essential but inadequate expedient.

3. COMPETITION OF COLLECTIVE ORDERS

The ‹social Darwinism› is the theory applying gene evolutionism to legally unified bodies, as the personal ‹utility› is best promoted by the constitutional lawfulness. The idea to distinguish the fellow citizen from the foreigner dates back from the civilisation very beginning. The division is merely legal, not ethnic. This is evident in the Persian empire, with citizens of various Semitic and Indo-European origins. It repeats in the Roman empire, in which ‹the force of the law› appears in its formal wherewithal, basically, assuming the transcendental derivation of the ‹law› [38].

The ‹kings by the grace of God› are rejected by the Enlightenment rationalism, and the notion of ethnic nations is XIX invention, based on scientific philology proofs. This brings to ‹nation-states›, strongly valuing the differential competition, with racial allegations. The line is, above all, suspect, after the human genome project results, but it was used as proof to extend the gene evolutionism at the political cohesion range.

Today, the approach turns to mainly ‹cultural› motivation, to foster the ‹civilisation struggle›. In view of the economic deployments, ‹global assent› orders are doubtful without stout leadership; the idea that cross-border corporation effectiveness might work in lieu of government inadequacy, leads to the ‹hyper-market› order. The hyper-market efficiency rejects all clerical overseeing. The switch, from public functions, to private services, grants savings. The hyper-market new incomes need to create self-ruling orders. The issue leads to the self-supervision and to the hyper-watch schemes. The hyper-market is hypothetical issue. The company risk, in the scenery, faces twin economic-and-political haziness. The challenge is to perform the business project, and, in like time, to re-shape the public contexts, along with the market efficiency principles.

4. AUTARCHY OF CONFINED SELFISHNESS

The opposition to the economic globalisation follows twin paths: of the ‹no-global› movements; of the multi-pole (or archipelago) headship. The former prices the safeguard through circumscribed selfishness orders, exploring the ‹precaution principle›; it promotes ‹autarchy›, to local support and parsimony mind. The latter aims at split management of clustered countries, inspired to the EU, in view of the adequate politico-economic dimension. The competition through collective orders takes now account of the eco-safeguard, at least, with preliminary goals about the climate changes.

The economic globalisation is, basically, stopped, with the ideology positions of the ‹autarchy›, or the factual acknowledgment of the ‹archipelago›, not the differential selection mechanism of the resource hoarding, in conflict with rivals. The ecologic globalisation, thus, is experienced as if the problems might be solved, creating locations, where to castle, leaving the outside populations with little or no shelter. Consciously or unconsciously, it is preferred to think the ecologic globalisation as somebody else affair, perhaps, if our ‹castle› becomes unsafe, as yet-to-be generation matter.

The ‹social Darwinism› is so misleading, at this point, that the gene evolutionism competition means hampering or annihilating the mankind survival. The collective selfishness (of the group or the nation) does not look providing ways out, if the solutions are just moved at different differential range compared by the gene selfishness. The economic globalisation might be tackled with resort to ‹the law of the force›. The ecologic globalisation, most surely, requires totally different path.

5. ALTRUISM OF CO-OPERATING ORDERS

The yet-to-be cognitive revolution (if occurring) deals with political cohesion targets, based on ‹social awareness› [14, 15, 35, 36, 41]. The earth discontinuities, life and intelligence, are followed by complementary evolutions: biology trends and knowledge trends [12]. The former shows gene selfishness and selective proliferation of species. The latter proves meme altruism and mind simulation/emulation faculties. The meme evolutionism value-added is the civilisation driver [2]. It generates ‹culture›: the ‹cognitive› progression, piling up intangible value-added; the upgrading mechanisms, through ‹empathy and rationality› issues [25, 32, 34].

Rather than ‹social Darwinism›, progress requests culture and ethics conscious issues: science and liability; i.e.: the making of ‹artificial transformation› know-how; the ‹free will› doing, for a responsible planning of the future. The collective orders, replacing the individual (and the gene), are outcome of cultural thresholds: below given limits the progress cannot stabilise and propagate. The meme evolution does not provide for selfishness, but requires altruism.

The political cohesion, started by group selection, moves to ‹nation-state›, always keeping the size above the necessary thresholds. The co-operation set-ups are, any time, adapted to the outer driving situations. Not only the economic globalisation shuffles the cards. Presently, the ecologic globalisation totally modifies the governmental musts, to make the political settlements fit for the mankind survival. For sure, this is necessary, not sufficient condition. The ‹cognitive revolution›, moreover, is needed, with the related ‹robot age› technologies.

6. CONCLUSION

The conclusion might discuss in contrast the scenarios to come: the gene evolutionism, i.e., competition up to annihilation of the rival punters; against: the meme evolutionism, i.e., legal rationality balancing of the earth stock allocation.

In the first case, the economic pulling biases are: management of the scarcity, by hoarding the residual resources [18]; permanent mixing of chattels, to even the score not to starving. The world will possibly continue along the known trends, towards ‹continental powers›, with highly disruptive deterrent power [16, 17]. The progression will take course by worldwide survival wars, according to ‹the law of the force›.

The other way, the ecologic driving frames hope in: the ‹cognitive revolution› by artificial intelligence/life procedures; the resource provisioning, by robot-safe ‹to rematerialise› processes [1, 8, 11, 27, 29]. The technology challenge needs solving the over-pollution and over-consumption figures of the current industrialism [3, 39]. But, to that purpose the world ought to radically modify the political set-up: on the legal tenet, moving to global village sustainable growth [23, 26, 28, 33], ruled by ‹the force of the law›; and on the cohesion views, turning to ‹hyper-democracy›, assuring balanced citizen/authority interplay.

All these ideas are not often discussed in the developed countries, where business uncontrollable growth is a new religion and globalization is the best that would have happened for them: this is contrary to empirical evidence, for example often seen in the declining jobs pool [24, 37, 40].

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Mobile Newspapers in Social Studies Education

Young C. Park

Div. of Information and Communication Engineering
Baekseok University
Cheonan 330-704, Korea

ABSTRACT

Recent advances in mobile and wireless technology could be used to enhance the learning and teaching in the class. In this study we evaluated mobile newspapers articles to take full advantage of them for social studies education of high schools in Korea. The results show that the mobile newspaper articles are good media for motivating students to be interested in the subject and provided up-to-date information on diverse aspects of social studies.

Keywords: mobile device, newspaper in education, tablet PC and social studies.

I. Introduction

The world is changing rapidly, and the definition of what makes a complete education must change with it. 21st century subjects are the disciplines that teach students how to be part of an increasingly interconnected planet. Thus, recent education system is heading toward fulfilling the needs of students and the needs of the globalizing pedagogies in the information age. Technologies provide rich and flexible media for representing what students know and what they are learning. By the end of 2012, South Korea intends to connect every home in the country to the Internet at one gigabit per second. That would be a tenfold increase from the already blazing national standard and more than 200 times as fast as the average household setup in the United States. A pilot gigabit project initiated by the government is under way, with 1,500 households in five South Korean cities wired. Each customer pays less than $27 [1]. The newspaper is a source of up-to-date and compelling information that teachers can use to teach current events in the school. Newspapers supplement the traditional text book, serving as “living textbooks” from which students can learn the “concepts and generalizations underlying the social studies program” [2-4]. Today’s students use the Internet to track down information and share their research with students across the world via blogs and wikis. At home, students use the Internet to find information and communicate with friends. A 2007 National School Boards Association study found that 96 percent of students who have access to the Internet have used social networking (blogging, instant messaging, and online communities) [5]. The Korea government invests $36 billion to spread Newspaper in Education (NIE) from 2011 to 2013 [6].

The growing popularity of smart phones is proving a double-edged sword for newspaper publishers, with the number of consumers reading more content online almost exactly counterbalanced by a decline in those buying print products, according to a report from Orange [7]. Tablet PCs are considered to be strongly recognized by the education community as a powerful tool. News Corp is taking the iPad very seriously as a new way to distribute the news. Amazon launched a new, more affordable Kindle in July and, in September, 2010, Samsung announced its new Galaxy tablet based on Google’s Android operating system, and LG announced Optimus PAD recently. The media giant is taking it so seriously that it is developing a new publication called the *Daily* which will only be available on the iPad (no print edition, no Website). Tablet PC offers 3G internet connections, or Wi-Fi which is a high-speed wireless networking connection, can be found in your office, home, and coffee shops and restaurants.

In this study we evaluated mobile newspapers articles to take full advantage of them for social studies education of high schools in Korea.

II. Mobile newspaper and Education

One of the biggest challenges the newspaper companies face is on delivering information to readers who are using different mobile devices in the mobile Internet environment. Users usually access mobile Newspaper by using mobile devices like mobile phone and tablet PC. With increased access to more advanced technologies, schools now can expand their learning environments to include databases, information-retrieval systems, and other library and museum resources throughout the world. Through mobile newspapers, electronic study groups, and international education networks, teachers can plan class-to-class long-distance learning activities. Students retrieve, process, and organize information gathered from newspapers, libraries, cultural institutions, museums, archives, and government document repositories. PressReader is the software application that allows us read a growing list of over 1,800 full-content newspapers from 94 countries in 49 languages available through the world's largest online newspaper and magazine kiosk. With one software download we can access many publications on our computer; we do not need to download software for each publication as we do with other news readers [8].

Street [9] reported that newspapers supplement the traditional textbook, serving as living textbooks from which students can learn the concepts and generalizations under-lying the social studies program. Street also reported that reading newspapers helps students develop reading, critical thinking and problem-solving skills.

The NIE program, operated through major news companies, allows students to debate current events and understand how the world works in everyday life at home and abroad. Students in general gravitate to activities involving touch and manipulation. Reproduction of historical newspapers provided an added advantage to educators, since they are considered primary sources for both national and state teaching standards. So, if you are administratively required to provide lesson plan inclusion of primary sources consider era newspapers as the most interesting, multi-purpose, and inexpensive option [10].

Web-based mobile tablet PCs have three perceived usability problems: they are screen size, navigation and site structure, and input methods. While screen size is the major concern, some researchers indicate that small displays of devices that could only show a few lines would not badly affect users' ability to read and understand the information [11].

III. Social studies education with tablet PC

Social studies education is defined as the integrated study of the social sciences and humanities to promote civic competence by National Council for the Social Studies (NCSS) in 1992. The primary purpose of social studies is to help young people make informed and reasoned decisions for the public good as citizens of a culturally diverse, democratic society in an interdependent world. Students represent what they learn in products that demonstrate their ability to use information accurately, and that reflect the thinking and research skills acquired in the process of learning. Students should learn both to conceive and implement self-directed projects and to participate in group projects.

To investigate the potential impact of tablet PC usages in high school, we conducted the survey for high school students between September 1 and December 15, 2010. Table 1 shows top uses of table PCs in Cheonan Foreign Language High School in Korea. Total sample size is 150 respondents and respondents were asked to check all that applied. The survey results are accurate within a range of plus or minus 2.5 percentage points at the 90 percent confidence level.

Table 1. Top uses of Tablet PCs

(Total Sample (N): 150 Respondents)

Activities	Respondents
Send/receive text messages	141
Play games	133
Send/receive e-mails	117
e-book reading	111
Listen to music	106
Browse the Web	102
Watch videos	99
Get news	93
Download music	87
Map directions/Global Positioning System (GPS)	80
Get other information	77

Table 2 shows the effectiveness of mobile tablet PCs. Total sample size is 150 respondents. With the scalar-styled questions, students were asked to judge a specific question on a numeric scale. The numeric scales of 1 (Strongly Disagree) to 5 (Strongly Agree) effectively correspond to a measure of agreement or disagreement with the questions. “Agree” as shown on table includes both “Agree” and “Strongly Agree” options in the questionnaire. From the result, we can see that 90% of students found that the format of mobile tablet PC was easy to use, and they also like the way the information was presented in the short story format. And it is seen that the mobile tablet PCs are effective tools of gathering useful information and they are easy to use.

Table 2. Effectiveness of mobile tablet PCs

(Total Sample (N): 150 Respondents, Respondents were asked to judge a specific question on 5 numeric scales)

Questions about the format of mobile newspaper	Agree	Neutral	Disagree
Is the format easy to use	135	7	8
Do users like the short story format of news?	123	10	17
Is the classifieds section useful for mobile users?	110	24	16
Is it easy to personalize the content?	102	27	21
Is Personalization useful?	132	9	9
Is the targeted ad useful?	112	26	12

Table 3 shows recall types of newspaper usage in Cheonan Foreign Language High School. The majority (91%) of students attended in high school are talking about newspaper articles in class. Among those who used newspapers in high school, 86% recall reading a newspaper for social studies or civics in class.

Table 3. Recall types of newspaper usage

(Base: attended High School)

Recall types of newspaper usage	Yes	No	Not sure
Talking about newspaper articles in class	91%	8%	1%
Have a class where a teacher referred to newspaper articles	89	9	2
Reading a newspaper for social studies or civics	86	11	3
Cutting out articles or stories and bringing them to school	83	13	4
Completing a school project that involved using a newspaper	80	16	4
Having a class where using the a news-paper was integrated into the curriculum as part of social studies, reading, math or another subject	75	22	3
Having a class where newspapers were distributed to the students	43	53	4

The results show that the mobile newspaper articles are good media for motivating students to be interested in the subject and provided up-to-date information on diverse aspects of social studies. When students can't take a real field trip to get experience, they can get useful information by utilizing electronic field trips, and virtual tours provided by mobile newspapers. And mobile newspapers give students enchanted learning with motivation and critical thinking, and students become more aware of the world around them and more capable of making important decisions.

It is seen that Information Technology such as tablet PCs can be used to enhance school education and it can complement the conventional manner of classroom teaching in social studies effectively.

To explore the effectiveness of social studies education by utilizing mobile newspapers, another survey was conducted. Students were informed that this survey was not for a grade, but rather an opportunity for them to provide valuable feedback regarding how they like to learn in the social studies classroom. Students were encouraged to have multiple responses to two questions when applicable: Question 1- *Which methods do you like to learn social studies?* Question 2- *What do you like about social studies topics by using mobile newspapers?* Of the 150 (N) students in the high school, a total of 141 (n) responses were collected in this study. The results of the open-ended survey questions are as follows.

Question 1 – Which methods do you like to learn social studies?: Using mobile newspapers 82%, Field Trips 78%, Cooperative Learning Activities 70% , Study guides, reviews, and review games to help prepare for exams and tests 65 %, Hands-on/Active Learning 61%, Class Discussions 57%, Student Presentations 49%.

Question 2 – What do you like about social studies topics by using mobile newspapers?:

Global Connections 76%, Culture and Cultural Diversity 69%, People, Places, and Environments 63%, Civic and economic life 60%, Individual Development and Identity 57%, Democratic politics and civic participation 74%.

It is clear from the responses to the first question that students do like to learn social studies with mobile newspapers. From the second question, we see that individuals with high exposure to mobile newspapers as students are more likely to be interested in global connections and culture diversity of social studies topics.

IV. Conclusions

In these days the world wide web, globalization of education, u-school, distance learning and mobile newspapers, the potential application of hypermedia in education is tremendous. Mobile connectivity is now a powerful differentiator among technology users.

In a new report projecting the growth trends of the various computing platforms, the market research firm predicts the tablet PCs to outnumber netbooks by 2012 and desktops by 2015 and the estimates point out to a sale of close to $8.17 billion by 2015 [12].

The PEW Internet & American Life Project found that 93 percent of teens between the age of 12 and 17 are online, and 89 percent of teens say that technology (the Internet, tablet PC, etc) makes their lives easier [13]. Mobile newspaper offers seamless connection for students at school or at home.

In this study we studied mobile newspaper by using mobile devices like mobile phone and tablet PC and evaluated mobile newspapers articles to take full advantage of them for social studies education of high schools in Korea. Youth are moving to a mobile device such as a tablet PC for their learning and communication needs. The results show that the mobile newspaper articles are good media for motivating students to be interested in the subject and provided up-to-date information on diverse aspects of social studies. And the results provide insight into the importance of dynamic social studies instruction in high school.

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Differences in Creativity Performance and Environment Support between Education and Art students

Sy-Chyi Kiky Wang
Dept. of E-learning Design and Management, National Chiayi University,
Chiayi, Taiwan

Chia-Wen Chen
Dept. of E-learning Design and Management, National Chiayi University,
Chiayi, Taiwan

Jin-Yuan Chern
Dept. of Health Care Administration, Chang Jung University,
Tainan, Taiwan

ABSTRACT

This study examines the differences among students in the education and art fields, regarding their creativity performance and environment support for creativity. One hundred and twenty-eight college students were recruited for the study. The TTCT (Test of Torrance Creative Thinking) was adopted for the assessment of creativity performance. The KEYS Scales developed by Teresa Amabile were used to assess the stimulants to creativity in the work environment. The results show that on average the art students obtained a higher score for creativity performance than the education students. A significant difference in originality ($p=0.003$) was found between the two fields. As for the environment support, education students feel more supported by peers ($p=0.04$), while art students feel having more freedom ($p=0.003$) and more sufficient resources ($p=0.00$) in the context. More efforts on fostering creativity in education field are suggested at the end.

Keywords: Creativity, TTCT, Innovative environment, Education change, Domain differences

1. INTRODUCTION

Along with the progress of technology evolving, there is no doubt that the world is changing faster than ever. The fast changing world constantly creates new and unexpected problems, which obviously demands more creative solutions. In recent years, governments and policymakers claim that creativity really matters in this globalization world and urge young generations to challenge barriers to existing knowledge and technology with creative production and innovation. Richard Florida [1] even stated in his book, The Rise of the Creative Class, that “human creativity is the ultimate economic resource.” However, although most educators reach consensus that creativity should be rooted in education and become part of the educational agenda, the stereotyped view of current education as stagnant, obsessed with testing and destructive of creativity is still being framed. Ken Robinson [2] even said that schools kill creativity in his famous talk and stated in his book.

Creativity

Many efforts have been dedicated to defining creativity. However, we have to admit that there is still a continuing confusion about its definition as well as a debate about the ability to think creatively. Some people view it as a gift from God, an unconscious phenomenon of nature without control; some people think it is a controlled process and stress the importance of knowledge and the ability of conscious analogical reasoning on creativity. Some people consider creativity as a decision; some people see it as a mental process. One of the most well-known examinations of creativity was made by Rhodes [3], which defined creativity in four dimensions— person (i.e. personality, or behavior), process (i.e. cognitive process), product (i.e. innovation), and place (i.e. press, or environment).

In creative thinking domain, the word “creative” is frequently entangled with “gifted”. While most of people may “agree” that creativity is the natural propensity of human being-ness [4], they still subconsciously overlook their potential of being creative. The deep-rooted impression of that being creative is something you may “meet” but not what you can “ask,” often stifles the development of potential creativity in educational environment. Currently, except for some specific fields (e.g., business, art and design), creative thinking curricula seldom have their opportunity to be disseminated outside the fields.

This study is interested in exploring how education people perform creativity as opposed to those in the creativity highly rated fields? And, is the environment created in education field really less supportive for creativity, comparing to those in the creativity highly related fields?

Creativity performance

Can creativity be measured? Theoretically, the answer is “yes.” Although there are still a lot of questions and arguments about the reliability and validity of the assessment of creativity performance, many researchers look at the positive aspects of creativity measurement and suggest that creativity tests are worth using [5, 6]. As demonstrated in the literature, among the various creativity assessment instruments, the Torrance Tests of Creative Thinking (TTCT) [7] are the more famous and frequently used tests [6, 8]. Based on Guilford’s measurement factors of divergent thinking, the TTCT verbal form is scored on three characteristics: fluency (the quantity of responses to stimuli), flexibility (the quantity of different categories of responses to stimuli), and originality (the uniqueness of the responses which are statistically infrequent). On the other hand, the TTCT figural form yields scores on five characteristics: fluency, originality, elaboration, abstractness of titles, and resistance to premature closure [5]. Ever since its initial publication in 1966, the Torrance Tests have been intensively reviewed many times, and have been translated into many languages [6].

Creativity Environment

While creativity seems to be “personal,” a large body of research on creativity argues that a supportive and meaningful environment can be helpful for fostering creative potential [9] [10]. In other words, the social environment can influence the development of creativity. Therefore, in addition to the traditional approach focusing on the characteristics of creative persons, in recent years, many efforts have been devoted to develop contextual theories and models, which try to identify dimensions of work environment in related to creativity and innovation [11]. One of the highly valued tools is KEYS to Creativity and Innovation [12].

The KEYS focused on factors that drive the development of creativity and interested in understanding contextual influences on creative behavior in workplace [13]. The instrument comprises stimulant scales (e.g., Freedom, Challenging Work, Managerial Encouragement, Work Group Supports, Organizational Encouragement, and Sufficient Resources) and obstacle scales (e.g., Lack of Organizational Impediments and Realistic Workload Pressures) [14].

In the field of education, although the literatures claim that many school students easily lose their creative potential due to the lack of a supportive environment for creativity, and sometimes the suppression of creative expression, in most existing educational settings [15, 16], there are not many researches found, which focus on the assessment of creative environment in education domain.

Purpose of the study

This study tries to examine the differences among students in education field and art field, regarding their creativity performance (fluency, flexibility and originality) and environment support (stimulants scales) for creativity.

2. METHOD AND PROCESS

The Participants and Sampling

Through a purposeful sampling approach, the freshman-level and junior-level college students at the department of Education and department of Art and Design at Chiayi University were the targeted population for this study. One hundred and twenty-eight college students were recruited for the study. Most of the participants aged about 18-22, with 65 from education field (16 males and 49 females) and 63 from art and design field (12 males and 51 females).

Data collection

Two major instruments were used to collect data for this study: two idea generation tasks adopted from the TTCT (Test of Torrance Creative Thinking) verbal tests, and the questionnaire adopted from the KEYS Scales.

The TTCT was adopted for the evaluation for creativity performance. The participant’s performance on fluency (reflecting the ability to produce a large number of ideas), flexibility (quantifying the ability to produce a variety of kinds of ideas, to shift from one approach to another, or to use a variety of strategies), and originality (representing the ability to produce ideas that are not obvious, commonplace, banal, or established), of creativity, respectively, was evaluated and scored with the aid of the TTCT scoring guide (Torrance, 1974). The KEYS Scales developed by Teresa Amabile were used to assess the stimulants to creativity in work environment, which comprise organizational and supervisory encouragement, work group supports, freedom, sufficient resources, and challenging work. The participant’s responses to the KEYS Scales questions were measured and scored on a Likert five-point scale with “strongly disagree” scored for 1 and “strongly agree” for 5.

Process

This study used only required courses to conduct research activities to ensure that as many students as possible in the two programs, and to avoid the bias resulting from students’ distinctive interest in elective courses. For each discipline, a research-conducting plan was scheduled in advance during the first week of the semester. The major concern was to lessen interference with regular class activities as much as possible. A specific scheduling plan was prepared for both class levels (i.e., sophomore and junior) in the two departments, respectively. The researchers then obtained from the instructors the permission to access their class students.

After sufficient numbers of participants were recruited in each class, they were provided with important information regarding research ethics and the necessity of obtaining a signed consent form. The researchers then distributed the questionnaires and the idea generation tasks tests to those participants who signed the consent forms in the class. Research activities lasted about 20-30 minutes for each level’s classes at the two departments.

3. RESULTS

The results show that overall the art students demonstrated a better creativity performance with higher TTCT scores than the education students (Table 1). A significant difference in originality (3.58 vs. 2.16; p=0.003) was found between the two fields, but not in fluency and flexibility.

Table 1. Creativity Scores Between Education and Art/Design Students From Different Perspectives

	Education		Art/Design			
	Mean	S.D.	Mean	S.D.	t	p
Fluency	46.0	6.92	48.4	7.94	-1.75	.08
Flexibility	45.6	5.42	47.5	6.51	-1.72	.09
Originality	47.9	8.46	51.7	9.76	-2.25	.03*

* $p< 0.05$

As for the assessment of organization's support for creativity in the environment, significant differences were found in "work group support," "freedom," and "sufficient resources" (Table 2). In brief, education students feel more supported by peers (3.86 vs. 3.64; p=0.04), while art students feel having more sufficient resources (3.28 vs. 2.78; p=0.000) and more freedom (3.45 vs. 3.18; p=0.003) in the context.

Table 2. Scores of Creative Environment Scales between Education and Art/Design Students

	Education		Art/Design			
	Mean	S.D.	Mean	S.D.	t	p
Organizational/ supervisory encouragement	3.28	.57	3.42	.49	-1.47	.14
Work group support	3.86	.62	3.64	.53	2.11	.04*
Sufficient resource	2.78	.66	3.26	.58	-4.57	.000***
Freedom	3.18	.50	3.45	.50	-3.02	.003**
Challenging work	3.33	.60	3.51	.47	-1.86	.07

* $p< 0.05$, ** $p< 0.01$, *** $p< 0.001$

4. CONCLUSION AND SUGGESTION

This study showed that education students perform less in creativity-related activities than art students, especially for originality. By looking at some of the common definitions of creativity, such as "create something new" or "think outside the box," it is not overstated that originality is the most essential component of creativity. The relatively low scores on originality seem to suggest more efforts on fostering creativity in education field. Including creativity-related courses in the curriculum or providing creativity workshops may be part of the solutions to begin with.

The results also showed that the education field seems to have stronger environment support for creativity on peer support but much weaker on freedom atmosphere and sufficient resources. Respecting individual difference and having more tolerance for creative behaviors are suggested for developing a more supportive environment for creativity in education field. Better arrangement of school resources is recommended for the education field as well.

Overall, this study calls attention to the development of creativity in education field, particularly for creating a creativity-friendly, meaningful, imagination-fostering, and rich environment in school for young generations.

A further study on investigating the perceptions of faculty and staff may give a more holistic view of the research issues. A qualitative research approach would also be necessary for future research.

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ACADEMIC GLOBALIZATION AND ICE: CROSS-CULTURAL RESEARCH AND TRANSNATIONAL EDUCATION

Marta Szabo WHITE
Department of Managerial Sciences,
Georgia State University
Atlanta, Georgia 30303, USA

ABSTRACT

As the Lion said to the Man, "There are many statues of men slaying lions, but if only the lions were sculptors there might be quite a different set of statues."

- Aesop

Commensurate with Aesop's message of the sculptor matters, so does the communicator, the language and surprisingly, business context.

The evolution from the experientially-based Cultureactive to the theoretically-based ICE, from first-generation to second-generation, this paper underscores the marriage of cross-cultural research and transnational education. Both Cultureactive and ICE serve at the pleasure of Globalization, and more importantly, Academic Globalization and Transnational Education. The impetus for this paper derives from two pivotal questions: Does one's professional lens create similarities more dominant than culture; and does English evoke responses significantly different from those of one's native language.

ICE emerged from Cultureactive when validity and reliability research issues became noteworthy. Known as the ABC research team, Adair, Buchan and Chen [1] & [2] capitalized upon both Hall's low context/high context communication tool and Triandis' model of subjective culture to result in the theoretical underpinnings for ICE. This conceptual reconfiguration is also grounded in the works of Trompenaars, Holtgraves, Hampden-Turner, Thomas and Kilman, Yamagishi, and Bearden, Money and Nevins [3], [11], [20], [22] & [24]. ICE implementation strategies include the employment of Myers Briggs typologies.

The contribution of this paper is the celebration of the first year of ICE [InterCultural Edge], and its far-reaching ramifications. Previous research streams have underscored global similarities and differences among cultures, and a previous paper [23] established that cross-professional rather than cross-cultural differences are more paramount in assessing communication differences. This study employs Cultureactive and the LMR model, noting that business versus non-business context results in a more dominant impact on LMR profile than does nationality. Regardless of culture, persons involved in business are characterized primarily by linear-active modes of communication, and persons involved in non-business activities typically employ more multi-active/hybrid and less linear modes of communication. The pivotal question for academic globalization remains: Given ICE, are we in a better position to assess and predict leadership, negotiating styles, and communication behaviors, all of which are central to transnational education and cultivating global business leaders.

Keywords: International Business, Culture, Strategic Management, Communication, Leadership, Decision-making

TRANSNATIONAL EDUCATION

The explosion of the Internet has fueled learning in different time zones and business transactions across borders. Culture itself remains the final barrier. While immersed in a Great Britain Study Abroad Program [1999], the author discovered and purchased a fundamental, cross-cultural learning tool and precursor to Cultureactive, called *Gulliver* [8]. Upon sharing this find with the Duke CIBER, Arie Lewin and Jeff Russell began collaborating with Richard Lewis Communications to initiate the evolution from Lewis' Cultureactive to ICE [InterCultural Edge].

ICE is a collaborative initiative between the Fuqua School of Business, Duke CIBER, Richard Lewis Communications, and Cultureactive.com. Cultureactive and ICE are web-based products that teach cross-cultural awareness in business settings by focusing on individual cultural profiles which are then compared to national profiles using the Linear-active, Multi-active, and Reactive [LMR] constructs. Participants analyze personal assessments with both team results and national cultural profiles. Experiments with ICE have been conducted at Fuqua (Duke University), Robinson (Georgia State) and globally to provide a broad research base in fulfillment of rigorous research standards for ICE validation.

LMR FRAMEWORK

From his forty-plus years of cross-cultural consulting, Richard Lewis authored *When Cultures Collide* [14] and *The Cultural Imperative* [16], in an effort to explain national, international and transnational business cultures. Poignantly, he also conceived of the LMR [Linear-active, Multi-active, and Reactive] framework [15], which gave birth to Cultureactive, a cross-cultural assessment tool. The strength of this model, as is its successor's, ICE, is that it transcends previous works by focusing on the individual, rather than the nation-state as the unit of analysis. As such, there is no assumption of within-nation homogeneity.

LMR PROVENANCE: RICHARD LEWIS

The provenance of Cultureactive and ICE is grounded in the LMR framework and briefly chronicled here. The 1980s propelled an acute demand for cross-cultural instruction, and Richard Lewis, the consultant, was approached repeatedly by multi-national clients for a new and practical cultural/national classification system. For years, cross-culturalists had grappled with the problem of summarizing or simplifying national characteristics. Hofstede chose four dimensions- power distance, collectivism versus individualism, femininity versus masculinity and uncertainty avoidance. In response to considerable criticism, he later added long-term versus short-term orientation. Edward Hall classified groups as monochronic or polychronic, high or low context and past- or future-oriented. The Kluckhohn-Strodtbeck [10] framework examined cultural differences along six dimensions: Control, Focus, Trust, Quantity versus Quality, Responsibility, Private versus Public (Activities largely conducted in private or public). Trompenaars and Hampden-Turner [22] identified seven fundamental dimensions of culture: Universalist versus Particularist, Individualist versus Collectivist, Neutral versus Emotional (Affective), Specific versus Diffuse, Achievement versus Ascription, Attitude regarding Time (Past versus future), Motion of Time (Monochronic versus Polychronic). The GLOBE research [13] cites differences among several cultural dimensions, such as Assertiveness, Future Orientation, Gender Differentiation, Uncertainty Avoidance, Power Distance, Institutional Collectivism, In-Group Collectivism, Performance Orientation and Human Orientation.

Lewis notes that such categorization attempts were very different from each other and often proved challenging to translate when assessing the culture capital among employees.
A succinct, complete, and understandable categorization system was sought. Lewis

did not find that the previous models had met the practical criteria sought. In Lewis' assessment, Hall was sound and succinct, but did not focus on solutions. Hofstede's idea of judging people by their uncertainty avoidance and reaction to power distance, was novel, but only partly descriptive of character, and few people knew what he meant by masculinity and femininity. Trompenaars, pre-empted by Hofstede and Hall, compensated with more dimensions, which did little to provide distinction or value.

Richard Lewis pondered whether employees are affective, ascriptive, neutral, particularist, or diffuse, and if so, how should they be managed? Thus, he proposed that cultures could be classified more comprehensively according to the three categories, comprising the LMR framework [14], [15] & [16].

Linear-actives
Cultures which are task-oriented, plan, organize, schedule and pursue one thing at a time (e.g. Germans, Swiss).
Multi-actives
Cultures which are lively, loquacious, multitask, prioritize according to the importance or thrill of the event (e.g. Italians, Latin Americans, and Arabs).
Reactives
Cultures that prioritize courtesy and respect, listen quietly, and react carefully to proposals (e.g. Chinese, Japanese and Finns).

Lewis argued that *linear-active* and *multi-active* are better terms than *monochronic* and *polychronic* in that they are not restricted to the use of time. A new dimension was the *reactive* category, characteristic of the behavior of most Asians, but overlooked by previous categorizations. The focus of the Lewis model is communication, which is often the impediment between and among cultures, and commensurately a key consideration in transnational education and academic globalization.

CROSS-CULTURAL RESEARCH AND TRANSNATIONAL EDUCATION

The contribution of this paper is the leap from Cultureactive to the dissemination of ICE, the next generation. Commensurate with exploring, expanding and energizing the field of transnational education, these cross-cultural assessment instruments are cross-cultural, cross-disciplinary and cross-epistemological as they equip academicians and practitioners with multi-cultural leadership and communication tools for the next generation of global leaders.

Earlier theoretical frameworks for studying cultural differences include Kluckhohn-Strodtbeck, Trompenaars and Hampden-Turner, and most notably, Hofstede [4], [10], [19] & [22]. More recently, the Global Leadership and Organizational Behavior Effectiveness group [GLOBE] [13] analyzed data for 18,000 managers in 62 countries. Like Hofstede, Trompenaars, Hampden-Turner and Kluckhohn-Strodtbeck, the GLOBE results also established cross-cultural differences among countries. While these important works are familiar to most, the Lewis model is less widely cited, perhaps because it is grounded in experience rather than research. However, this author argues that not only does the LMR framework transcend previous models by placing the individual, rather than the nation-state at center stage, its delivery through ICE rather than Cultureactive solidifies its theoretical and practical milestone.

Research consortia are finalizing the requisite validity and reliability measures for ICE, and commensurate ICE teaching consortia will soon develop a certified teaching network.

UNIVERSALITY

The cross-continent implementation of Cultureactive initially elicited the following fundamental question: Whether one's business affinity or cultural mindset has a more dominant effect on individual LMR profiles and leadership/ communication/ cultural styles. The second salient question to emerge is whether *English* makes a difference. Are participants primed differently when they are surveyed in English vs. their native language? Cross-national studies propose to examine the following two variables and four conditions for cross-cultural similarities and differences:

Business Context

Survey Language	Yes	No
English		
Native Language		

Source: InterCultural Edge (ICE) Research Progress Report
http://faculty.fuqua.duke.edu/ciber/ice/about.html. Accessed February 6, 2011

The above chart illustrates the fundamental question of whether one's business affinity or cultural mindset has a more direct effect on individual LMR profiles and leadership/communication/cultural styles. Moreover, survey language most likely impacts individual positioning along the LMR framework, but this remains to be substantiated. Capitalizing on the LMR framework, and focusing on Business Context, samples were collected from multi-cultural sources: European Fulbright students, Sub-Saharan African entrepreneurs, Duke and Georgia State University MBA and undergraduate business students. It was demonstrated that business vs. non-business proclivity across cultures and disciplines, is a more powerful indicator of work habits, negotiating styles, cognitive processes, etc., than is cultural orientation. Regardless of national culture, persons with a predisposition for business were characterized primarily by linear-active modes of leadership/ communication/ cultural mindsets, and persons with a non-business tendency typically employed less linear-active and more hybrid or linear/ multi-active modes of leadership/ communication/cultural mindsets.

CONCLUSION

Having established the dominant within-professional similarities and few cross-cultural differences, the non-business model resulted in a different yet equally powerful leadership/communication/cultural framework. These distinct paradigms for business vs. non-business models are further substantiated by trends emerging in other works. Thus business or non-business predisposition has a more direct impact on one's individual cultural profile than does nationality, and yet both are important in a world where culture remains the final barrier.

The poignant questions posed in this paper are whether the universality of cross-cultural research and transnational education, as substantiated by the Cultureactive tool, are also corroborated by the now completed transition to ICE? What has the first year demonstrated? Will the evolving paradigms continue to be universal demonstrating within-professional similarities dominating cross-cultural differences? Moreover, does

Survey Language matter? Are leadership/communication/cultural frameworks different for participants primed in English versus. their native language? Such answers remain to be established.

Richard Lewis' contributions were made through the lens of practitioner and teacher of cross-cultural communication. Lewis spent much of his life learning languages and observing communication styles. Intuitively, his model has a practical validity to it. CIBER at Duke University was inspired by this experiential model, and has transformed it into the theoretically-grounded InterCultural Edge (ICE). The ICE research project led by Duke University has invoked a more rigorous methodology, grounded in strong psychometric and theoretical properties, yielding a more powerful tool for practitioners and academicians.

This paper transcends previous works along four salient dimensions:
1] Invoking the individual as the unit of analysis;
2] Establishing that a professional mindset is a stronger influence on communication style than is culture alone;
3] Introducing the next-generation cross-cultural assessment tool, i.e. ICE.
4] Finally, can ICE catapult cross-cultural literacy to the next level of robustness?

In previous samples, business orientation played a major role in unifying groups across the globe in terms of underscoring a strong linear-active commonality amongst business professionals. The cross-disciplinary sample substantiated that both business and non-business orientations demonstrate profound distinctions.
With a more sophisticated, robust and rigorously-validated ICE tool, will the fundamental question of whether one's business affinity has a more direct effect on individual LMR profiles and leadership/ communication/cultural styles, remain?

Commensurate with discovering and disseminating the field of international business, cross-cultural and cross-disciplinary assessment tools equip academicians and practitioners for transnational education. The universality of LMR constructs across cultures and within disciplines is pivotal, profound and poignant. In the evolution of academic globalization, ICE is the sculptor that cultivates transnational education, culture capital and cultural literacy.

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SOME CRITICAL REFLECTIONS TO PEER REVIEW SYSTEM IN ARABIC

Prof. Dr. Luisa María ARVIDE CAMBRA
lmarvide@ual.es
Department of Philology, University of Almería
04120- Almería. Spain

ABSTRACT

Peer reviewing is the common way used for validating writings and requests of financing in order to measure and to test their property, possibility and strictness, etcetera; and, in spite of its failures, faults and mistakes, it seems the best way to get quality assurance for scientific publishing.
Nevertheless, there are many people who are in disagreement with this methodology and criticize it from different points of view.
This paper refers to some critical reflections about peer reviewing system and includes three conclusions. It has been possible thanks to the finance of the Spanish Ministry of Science and Innovation (MICINN).

Keyword: Peer review system

PRELIMINARY NOTES

As we know, into academic world peer review also known as *refereeing* is the process of subjecting scholarly works, research or ideas to the scrutiny of others who are experts in the same field, usually two or three persons. Peer reviewers are knowledgeable scientists who are not directly involved with the research being evaluated, but who are familiar with the field [1].
Peer reviewing is the common way used in every scientific field, including of course Arabic Studies field, for validating writings and requests of financing in order to measure and to test their property, possibility and strictness, etcetera; and, in spite of its failures, faults and mistakes, it seems the best way to get quality assurance for scientific publishing, although some important scientific works were not reviewed [2].
The first recorded editorial prepublication peer review process was at The Royal Society in 1665 by the founding editor of Philosophical Transactions of the Royal Society, Henry Oldenburg. In the 20th century peer-review became common for science funding allocations. This process appears to have developed independently from the editorial peer review. Peer review has been a modern scientific method only since the middle of the 20th century, except in the field of medicine. Before then its application was optional according to each scientific field [3].
Anonymous peer review, also called blind review, is a system of prepublication peer review of scientific articles or papers for journals or academic conferences by reviewers who are known to the journal editor or conference organizer but whose names are not given to the article's author. The reviewers or referees do not know the author's identity, as any identifying information is stripped from the document before review. This system is intended to reduce or eliminate bias, although this has been challenged and today there are many people who advocate for an open peer review where reviewers' names are given to the article's author. In other hand, there is the non-blind review, where the reviewers' names are proposed by the article's author himself, and in my opinion is the best way because they usually belong to the same field of knowledge than the article's author and, so, they are experts in the same subject, as in other types of peer review is possible that it is not so, over all in Arabic, a very specialized field of knowledge [4].

To preserve the integrity of the peer review process, submitting authors may not be informed of who reviews their papers; sometimes, they might not even know the identity of the associate editor who is responsible for the paper. In many cases, alternatively called masked or double-masked review (or, like I have said, blind or double-blind review), the identity of the authors is concealed from the reviewers, lest the knowledge of authorship bias their review; in such cases, however, the associate editor responsible for the paper does know who the author is. Sometimes the scenario where the reviewers do know who the authors are is called single-blinded to distinguish it from the double-blinded process. In double-blind review, the authors are required to remove any reference that may point to them as the authors of the paper [5].

Traditionally, the reviewers would remain anonymous to the authors, but this standard is slowly changing. In some academic fields, most journals now offer the reviewer the option of remaining anonymous or not, or a referee may opt to sign a review, thereby relinquishing anonymity. Published papers sometimes contain, in the acknowledgments section, thanks to anonymous or named referees who helped improve the paper.

During the peer review process, the role of the referees is advisory, and the editor is typically under no formal obligation to accept the opinions of the referees. Furthermore, in scientific publication, the referees do not act as a group, do not communicate with each other, and typically are not aware of each other identities or evaluations. There is usually no requirement that the referees achieve consensus.

Reviewers' power is considerable, but anyway, the decision whether or not to publish a scientific article or what should be modified before publication, lies with the editor to which the work has been submitted.

CRITICAL REFLECTIONS

In spite of the peer review system seems to be the best way of refereeing for evaluating the scientific works, there are many people who are in disagreement with this methodology and criticize it from different points of view [6].

This paper refers to this subject and indicates some critical reflections about the process with some of which I am not in agreement of all [7]:

1) The slowness of the process: certainly, in some journals, it passes a long time since the article is received until it is accepted or refused for publishing. In fact, one of the most common complaints about the peer review system is that it is slow and that it typically takes several months or even sometimes several years in some fields for a submitted work to appear in print.

2) All publishers might have the same discernments without bearing in mind their academic interests and their field of knowledge in such a way that the authors were not damaged.

3) There are who say that the identity of the authors might be always unknown by the reviewers in order to avoid possible reprisals. And so, and in order to keep the integrity of peer review system, this methodology is used by some journals.

4) The reviewers usually are very critical with the conclusions which are contradictory to their scientific interests, ideas or points of view, as well as very indulgent with those who are in agreement about them.

5) There are who think that, under no circumstances, the identity of the reviewer must keep in anonymity because, so, the authors stay helpless with regard to a possible unfairness and iniquity as a result of hypothetical academic and scientific interests.

6) There are who speak about the inefficiency of this process, as some notable works never were reviewed, like for example the article from Watson and Crik's on the structure of DNA which was published in 1951 in *Nature* without reviewing [8].

7) There are who believe that this process is not independent at all and speak about a complex system of scientific interests.

8) There are who think that this process is not clear at all and speak about a complex system of academic reprisals and bias [9].

9) Within Internet era, there are who question if the social networking can replace the traditional

process of peer review carried out by scientific journals to decide whether a job should be posted and if the researchers are prepared for criticism and exposure of their research online.

CONCLUSIONS

1) Although the peer review system has got defaults and failures as well as it can be improved without any doubt, and despite the critics received from many authors and researchers, the process in its different modalities is at the moment the best way, or the least bad, for validating the scientific quality of every work and the approval from the editors.

2) Under all circumstances, the referees or reviewers might belong to the same field of knowledge than the work to be evaluated belongs to, but it not always happens. Moreover, they would not know author's name in order to prevent possible reprisal and bias as well as conflicts of interests. This mark is more obvious in certain small scientific fields, like for example Arabic Studies.

3) The suitability or no suitability of keeping referees' anonymity depends on several circumstances; and, in my opinion, it is more advisable in some specific small fields of knowledge, like for example Arabic Studies, than it is in other biggest ones. Bearing in mind that, the more appropriate system seems to be the mixed system, I mean the peer review based on anonymous referees and on reviewers proposed by work's author to be evaluated, reducing or avoiding thus possible conflicts between reviewers and authors whose work has been refused.

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Free Web-Based Tools with Which to Detect Plagiarism

José L. BERNAL-AGUSTÍN, Rodolfo DUFO-LÓPEZ
Department of Electrical Engineering, Zaragoza University, Zaragoza, Aragón, 50018, Spain

ABSTRACT

Due to the expansion of the Internet and the large number of search engines, it has become extremely easy to copy works and ideas from other authors. Consequently, cases of plagiarism have, unfortunately, become more and more frequent.

This paper evaluates the various free web-based tools that reviewers of scientific papers can utilize in order to detect this type of fraud. These tools can be quite useful in the task of reviewing papers. This work comments on the main characteristics and capabilities of a number of different revised tools and attempts to determine those that are most suitable to reviewers of scientific journals.

Keywords: Plagiarism, Free tools, Detection.

1. INTRODUCTION

Plagiarism involves using phrases or ideas without indicating who the original author is. Other useful definitions can be found in [1]. In research papers, plagiarism is considered a crime [2].

The Internet enables us to gain access to a large number of information, but it has also increased the use of the copy and paste function [3].

Reviewers of papers would do well to utilize some of the available tools in order to avoid publishing research papers that have been plagiarized. Several tools, both free and commercial, exist that may be useful to reviewers in detecting possible plagiarism. In this work, various free tools that are currently available [4-13] are reviewed.

We have only considered free tools, as reviewers are not remunerated for reviewing papers; therefore, it would not be logical for them to be required to invest money in order to successfully conduct their reviews. Moreover, only Web-based tools have been considered, as they are easier to use and do not necessitate software installation.

In order to evaluate the tools, a simple test was conducted. First of all, the abstract of the paper [14] was used in order to determine whether or not the tools are able to localize the source. In addition, a short portion of text extracted from the same paper was used so as to verify whether or not the tools are capable of detecting possible plagiarism. As the abstract is available from the journal Web page, the tools should easily be able to locate it. The other text is generally not accessible without a subscription to the particular journal in which the paper in question was published. Thus, if a tool is unable to locate the abstract, the other text is not checked.

2. FREE WEB-BASED TOOLS

In this section, the main characteristics of the tools that have been examined are described, as well as the test results.

Two tests were conducted. “Test 1” entailed a search for possible plagiarism of the abstract extracted from the paper [14] used to evaluate the tools. “Test 2” encompassed a search for possible plagiarism of a text extracted from the same paper.

SeeSources

SeeSources [4] provides the option of uploading files (MS Word, HTML, or text document) and pasting a text. Fig. 1 depicts the main screen.

Test 1: Upon conducting this test, two results were obtained. The first result was a paper that did not prove to be an instance of plagiarism, as it only contained certain words coincident with the abstract. The second result was a Doctoral Thesis, in which the abstract was mentioned in the bibliographical revision.

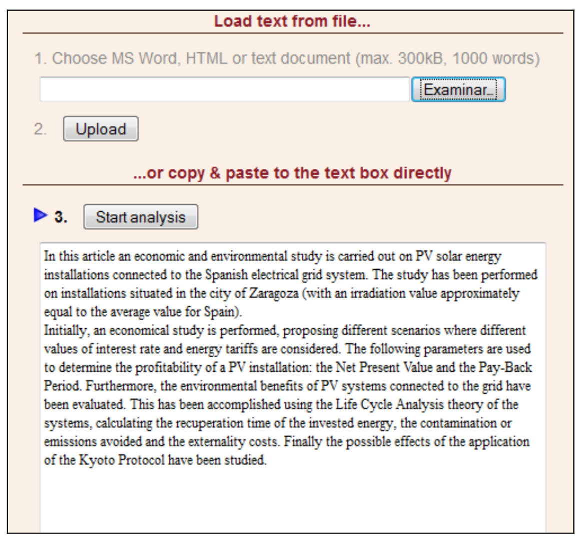


Fig. 1. Main screen of SeeSource

Test 2: Thereafter, the second text was conducted and the following result was obtained: “No strongly similar text sources found on the Internet.” Therefore, this tool has not satisfactorily passed the test. A paid version of this tool exists; perhaps, improved results would be obtained if that version were utilized.

Plagium

Next, we tested Plagium [5], a screen shot of which is shown in Fig. 2, utilizing the "Deep Search" option. It is necessary to register in order to use this option. Registration is free, but a valid e-mail address is required.

Test 1: The results of this test were as follows: "Plagium did not find documents making use of the text that you entered." Therefore, this tool has not passed the test.

Test 2: "Test 2" was not conducted, as this tool failed to pass "Test 1."

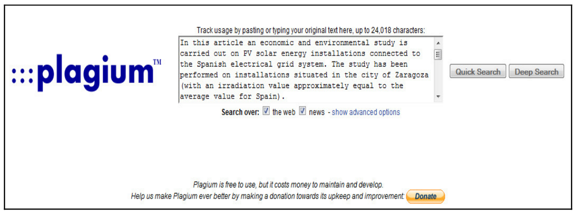


Fig. 2. Main screen of Plagium

eTBLAST

This tool [6] specifically focuses on texts related to medicine (Fig 3). It offers several different search options (various databases can be selected).

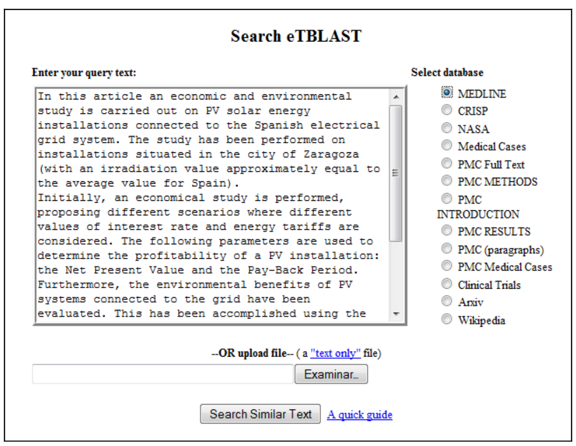


Fig. 3. Main screen of eTBLAST

Test 1: After testing all of the search options, the tool generated a considerable number of results, but it was unable to locate the original paper. Among the results obtained, only a few words coincided, but no instances of plagiarism were found to exist.

Test 2: This test generated several results similar to those obtained in "Test 1."

A new test was conducted with a text extract from an article in a medical journal, and in this case, good results were obtained.

Chimpsky

In order to utilize this tool [7], a screen shot of which is shown in Fig. 4, it is necessary to register as a user. The process is free and does not require an e-mail address. The text file to be analyzed must be uploaded, and the tool does not allow text to be pasted.

Test 1: The tool did not obtain any results.

Test 2: As the tool failed "Test 1," "Test 2" was not conducted.

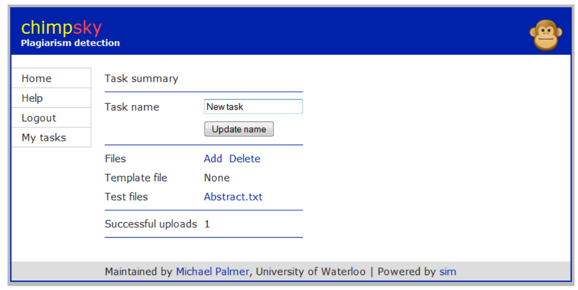


Fig. 4. Main screen of Chimpsky

DOC Cop

In order to use DOC Cop [8], it is necessary to use a valid e-mail address to become a registered user.

The search results are sent to the e-mail address that was entered upon registering.

Test 1: A slightly confusing report was obtained, as the tool located the original paper, but not on the journal Web page.

Test 2: The results obtained were similar to those of "Test 1."

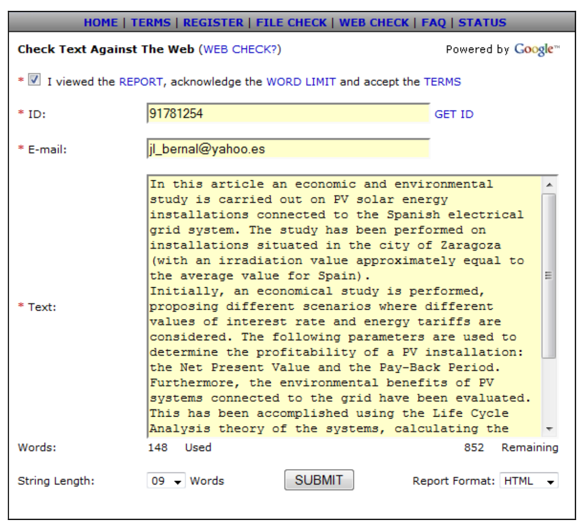


Fig. 5. Main screen of DOC Cop

The Plagiarism Checker

This tool [9] allows an MS Word document to be uploaded or the text to be pasted for analysis (Fig. 6).

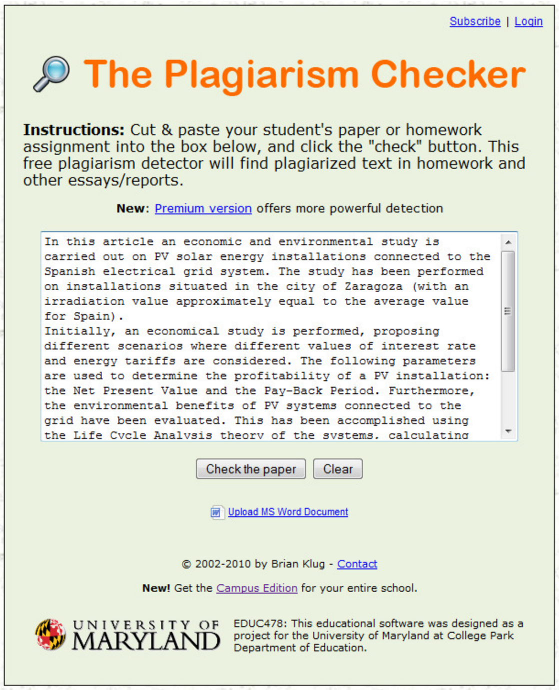
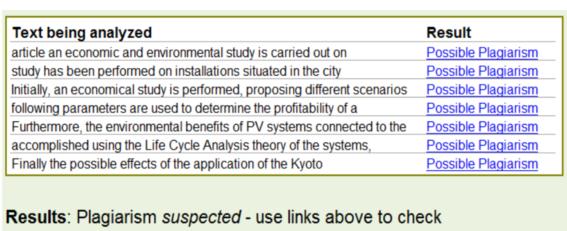


Fig. 6. Main screen of The Plagiarism Checker

Test 1: After analyzing the abstract, good results were obtained, as demonstrated in Fig. 7. The tool located the original paper on several different Web sites and databases.

Test 2: In this case, the tool was able to locate the original paper.



Text being analyzed	Result
article an economic and environmental study is carried out on	Possible Plagiarism
study has been performed on installations situated in the city	Possible Plagiarism
Initially, an economical study is performed, proposing different scenarios	Possible Plagiarism
following parameters are used to determine the profitability of a	Possible Plagiarism
Furthermore, the environmental benefits of PV systems connected to the	Possible Plagiarism
accomplished using the Life Cycle Analysis theory of the systems,	Possible Plagiarism
Finally the possible effects of the application of the Kyoto	Possible Plagiarism

Results: Plagiarism *suspected* - use links above to check

Fig. 7. Results reached using The Plagiarism Checker

Duplichecker

Duplichecker [10] allows the text to be analyzed to be pasted or a file of the text to be uploaded (Fig. 8). Furthermore, it allows a particular search engine to be selected (Google, Yahoo, or msn).

Test 1: Using Google, this tool located the original paper on several different Web pages, including that of the journal, while "The Plagiarism Checker" only located the paper on Web sites that were not directly related to the journal. Using Yahoo, the tool only located the paper on one Web site. Using msn, it did not locate the original paper.

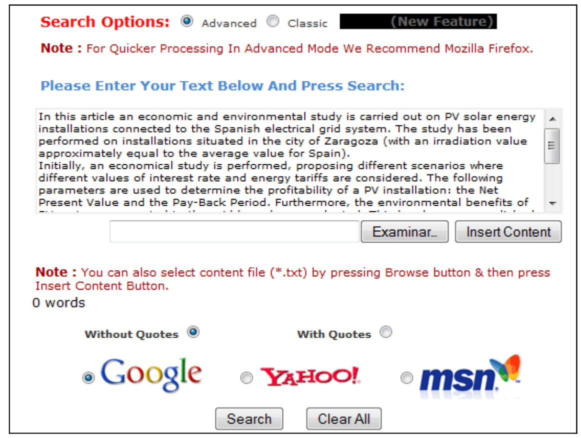


Fig. 8. Main screen of Duplichecker

Test 2: Using Google, very good results were obtained, as two instances of plagiarism of the article in question were detected. The first instance involved a paper published for a congress, containing an entirely different abstract, in which the tool detected a large number of phrases copied from our paper. The second case involved a book chapter, in which several phrases from the paper in question had been included.

Articlechecker

Articlechecker [11], Fig. 9, is similar to Duplichecker. It uses Google and obtained the same results as Duplichecker, albeit in a less compact and tidy form. It only allows the text to be analyzed to be pasted.

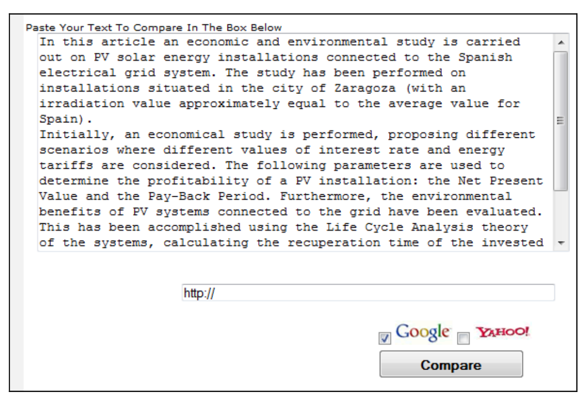


Fig. 9. Main screen of Articlechecker

Google Scholar

Google Scholar [12], a screen shot of which is depicted in Fig. 10, found the original paper, but obtained fewer, less detailed results than Duplichecker.

Fig. 10. Main screen of Google Scholar

Google

Using Google [13], very good results were obtained, similar to those of Duplichecker.

3. CONCLUSIONS

Plagiarism checker, Duplichecker, Articlechecker, and DOC Cop comprise the tools with which the best results were obtained. Furthermore, simply using Google generated good results. Nevertheless, if the format in which the results are presented is taken into account, as well as the option that allows for a text file to be uploaded, Duplichecker is the best tool, followed by Plagiarism checker, Articlechecker, and DOC Cop.

Thus, reviewers have several free tools available to them with which to detect possible instances of plagiarism Surprisingly, in the tests conducted, in which two text extracts from a paper written by the authors of this work were analyzed, only two instances of plagiarism of that particular paper were located. One of these contained a high percentage of the original work, and the other included several phrases and expressions that had been copied and pasted.

Therefore, we believe that it would be of considerable value for journal publishers to recommend the use of these or similar tools. Although, perhaps, the publishers should be the ones who conduct such text searches in order to avoid publishing papers that have been plagiarized.

4. ACKNOWLEDGMENTS

This work was supported by the “Departamento de Ciencia, Tecnología y Universidad del Gobierno de Aragón” and by the “Fondo Social Europeo” of the European Union.

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Relevance of First Tier, Peer Reviewed Journals in the Tenure and Promotion Process at Non-Doctoral Granting Engineering Institutions

Amanda S. FLORIO
Valparaiso University
Valparaiso, Indiana, 36383, USA

and

Mark M. BUDNIK
Valparaiso University
Valparaiso, Indiana, 36383, USA

ABSTRACT

The IEEE (formerly the Institute of Electrical and Electronics Engineers) is the world's largest professional society dedicated to the advancement of technology. While it is indeed growing into multiple technology areas, the IEEE is still first an organization of electrical, electronics, and computer engineering professionals. It has over 400,000 members and publishes nearly 100, first tier, peer-reviewed journals. As such a large purveyor of scholarly works, engineering faculty at almost all academic institutions (doctoral granting and non-doctoral granting) are familiar with the IEEE. For this reason, the IEEE makes an excellent case study for the relevance of first-tier, peer-reviewed journals in the tenure and promotion process at non-doctoral granting engineering institutions. In our work, we surveyed editors of the 97 IEEE journals. 93% of respondents indicated that 10% or less of their submissions were from non-academic institutions. None (0%) of the respondents believed that the number of non-doctoral granting institution submissions would be increasing over the next three years. In fact, a majority of the respondents (55%) see the number of non-doctoral granting institution submissions decreasing in the same time frame. To correlate this data, we examined a sample of 2,099 articles published in the first issue of each IEEE journal in 2009. 357 (17%) of these 2,099 articles were authored by individuals from academic institutions in the United States. Of the 357, only 35 were published by individuals from non-doctoral granting institutions (1.7%), with only 8 (0.38%) from institutions where a bachelor degree is the highest the offer.

Keywords: Engineering, Journals, Peer-Review, Tenure, Promotion.

1. INTRODUCTION

The IEEE (formerly known as the Institute of Electrical and Electronics Engineers) promotes itself as the world's largest professional society dedicated to the advancement of technology [1]. Its 2009 annual revenue (the latest year data is presently available) was over $389,000,000 (United States Dollars) [2]. The IEEE is comprised of over 400,000 [3] members with approximately 24% of its population in academia [2]. It publishes 97 separate scholarly, peer reviewed journals with additional journals being added almost every year [4]. It is the leading publisher of scholarly work related to the electrical and computer engineering disciplines in the world. Most (if not all) of the IEEE's publications are considered to be of a "first tier" status in the specific electrical and computer engineering disciplines [2]. As such, the number of publications a professor has in IEEE peer reviewed journals is often used as a factor in his/her tenure and promotion decision process by the professoriate in electrical and engineering departments and schools.

However, there is a growing concern about the accessibility of IEEE peer reviewed publications by non-doctoral granting institution prospective authors. Therefore, we have undertaken a 24 month study to the opportunity for non-doctoral granting prospective authors in IEEE journals today and determine the importance of IEEE peer reviewed publications at non-doctoral granting institutions in the tenure and promotion process, and how the two are intertwined.

2. PROCEDURE

Contact Information

This project included multiple steps of research and analysis. First, we narrowed the scope of our investigation to the 97 actively publishing IEEE Transaction, Journals, and Letters. Five publications were not current, thus lowering the number from the original 102 to 97. We then collected the contact information for every Editor in Chief. When available we also included the contact information for any Assistant or Manager listed.

Survey

We then designed a survey to send to the Editors. We began writing the survey with a few general questions in mind. What do the Editors believe is the breakdown between international and domestic corporations, international and domestic schools, and doctoral, masters, or bachelor programs? Can the Editors predict an increasing or decreasing frequency in publications from any of these institutions? What are the expectations that Editors have for the quality of work they publish? The final draft of the survey is shown in Appendix 1. Only ten questions long, we hoped it would be simple and straightforward for busy Editors to fill out quickly. We designed the survey online at zoomerang.com [5], which enabled us to create a professional looking survey, send it out in mass, and receive the data processed by the website.

Cover Letters

Before sending out the survey, we sent each Editor a personalized email explaining our purpose and explaining that a mass email with the survey link would follow. We hoped that these men and women would appreciate the time and effort we put forth by including their names and titles, and the title of the publication that they worked for at the top of the email. A day or two after the more personal cover letters went out we revamped the letter to be more concise and to include the survey link. Two weeks after we sent out the survey we revised and sent again the mass email and link—we had only received seventeen responses.

Collecting and Analyzing Data

While we waited for the Editors to fill out the survey, we researched each of the 97 IEEE publications first issues of 2009 [6]. We used the IEEE Xplore Digital Library to view all 2,099 abstracts. These abstracts provide the authors name and the institution from which they work. Using this information we then created an Excel file entitled *IEEE Transactions, Journals, and Letters Author Information 2* (see example in Appendix 2). This file contains a worksheet for each of the publications. Each worksheet contains the same header including the publications title, its volume and issue number, and its frequency of publication (how many times a year it is published); the next four columns are entitled Unidentified, Domestic/International Corporations, Domestic Schools, and International Schools. We collected our data from the first issue of every publication in 2009 to provide a sort of consistency amongst our samples. Placing the article title, author, and location into the spreadsheet, and then categorizing each entry according to the aforementioned four columns the data was calculated quickly using the AutoSum formula. In total, the 929 page document provided the raw data for much of our work.

We created a second spreadsheet in Excel called *Totals*, which summarizes the data we collected in *IEEE Transactions, Journals, and Letters Author Information 2*. The *Totals* spreadsheet contains the breakdown for each publication. It is easy to see in this spreadsheet how many articles from each publication were unidentified (could not be categorized because of lack of information), domestic and international corporations, domestic schools, and international schools. The significance of this spreadsheet though comes at the bottom where we found the totals for each of these categories for all of the publications. These final totals are very important because they provide a basis for comparison:

- Total Articles 2,099

- Corporations 467
- Domestic Universities 357
- International Universities 1,140

Our next step was to isolate and research the articles written at the domestic schools to determine what the highest degree offered at each institution. The 357 articles were submitted by authors with 146 different affiliations. By consulting their institution websites, we were able to record which schools were doctoral granting institutions, which schools had masters programs, and which were bachelor or associate programs.

3. ANALYSIS

There were pros and cons to working with the IEEE webpage. In the first week of compiling the Editor's information, we realized that the website had two lists of publications, though seemingly the same, one turned out to be far more extensive than the other was. Collecting the contact information from the publications individual links was a problem only when the IEEE had not kept the information updated. We received several emails in response to the personalized cover letter informing us that new Editors had taken over the position. Updating the contact list was a constant process because of this and a few incorrect email addresses; we also received emails from some Editors writing back asking to be taken off the correspondence list.

There were a few issues with the survey. Five Editors did not receive surveys, four of them did not provide email address on the IEEE website, and one address repeatedly sent back an error. Respondents of the survey brought forth issues with the survey that had escaped us initially. As hard as we tried to cater to the convenience and perspective of the Editors, we did not have a true grasp on what their job really entailed. We received comments such as, "I don't have data for questions 6-10 so please disregard my answers" and "I'm just guessing at the percentages. I don't have statistics compiled on this information" and "Some of these questions can be interpreted in a couple ways".

A few Editors emailed back directly, they suggested we look at their instructions for authors. These documents simply provided insight to the strict particularities that authors must pay attention to before submitting a paper. One Editor introduced us to the company that facilitates the peer editing process that makes these journals so prestigious. We also asked questions that authors themselves might be more able to answer than the Editors might. Questions concerning the length of time between submission review and resubmission, as one respondent pointed out, "depend on how long authors take to revise. Sometimes they take a long time". We acknowledged initially that many factors interplay here, but in writing the survey, we attempted to generalize the role of the authors, the Editor and the peer review process too much.

We asked Editors to what percentage of submitted articles staff at non-educational institutions were writing, respondents reported from 2% to 50%. We asked the same question in regards to doctoral granting institutions, and respondents reported from 20% to 100%. Their responses to this question regarding non-doctoral granting institutions fell between 1% and 50%. In short, Editors believe that most of their articles are coming primarily from doctoral granting institutions, then from non-educational institutions, and the smallest margin from non-doctoral granting institutions (see Figure 1).

The data we collected from the IEEE publications corresponds with the estimates from the Editors. Our findings revealed that of the 357 domestic schools published in and IEEE transaction, journal or letter 322 were doctoral granting institutions, 25 were masters level, 8 were bachelor, and 2 were associate.

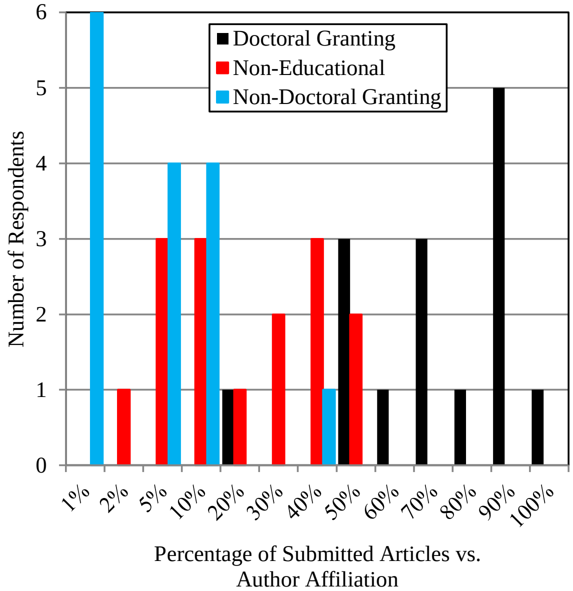

Figure 1. Editor survey responses of author affiliation.

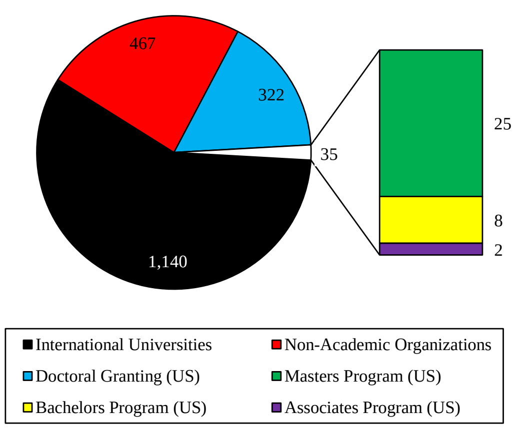

Figure 2. Author affiliation for 2,099 sample IEEE journal articles.

The survey asked Editors which sector of the industry they believed would increase articles submitted in the next three years, 79% said doctoral granting institutions. Similarly, we asked which sector would be decreasing in the next three years, 55% said non-doctoral granting institutions. This leads us to believe that the disparity that we see now, 322 doctoral granting schools to 35 non-doctoral granting schools, is only going to increase.

We believe that one of the strongest reasons for this discrepancy is the amount of time required for prospective authors to pursue their research and prepare their manuscript. The Editors were questions about the number of months authors should dedicate to their work before submitting their work for review. More than 53% of the respondents said that prospective authors should dedicate 12 months or more to their research before submission (see Figure 3.) Most non-doctoral granting engineering institutions emphasize engineering education over research. Therefore, it is rather difficult for the faculty members of non-doctoral institutions to find the pre-requisite time to compete with authors from corporations, government organizations, and doctoral granting institutions for the limited amount of papers accepted by the IEEE.

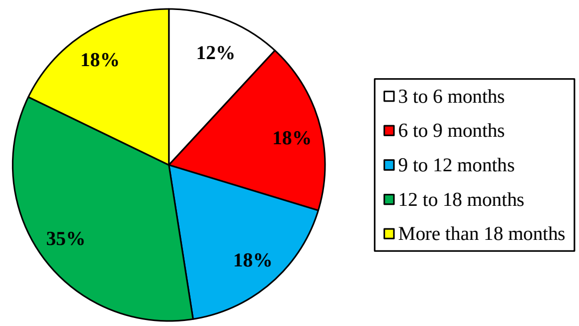

Figure 3. Editors' expected amount of time dedicated by authors prior to journal submission.

4. CONCLUSIONS

Editors of 97 IEEE journals were surveyed. 93% of respondents indicated that 10% or less of their submissions were from non-academic institutions. To correlate this data, we examined a sample of over 2,000 IEEE journal articles. 357 of the articles were authored by individuals from academic institutions in the United States. Of the 357, 35 were authored by individuals from non-doctoral granting institutions (1.7%), with only 8 (0.38%) from institutions where a bachelor degree is the highest degree offered. Based upon these data points, it is our conclusion that the authorship of first-tier, peer-reviewed journals should be not be heavily emphasized in the tenure and promotion process at non-doctoral granting engineering institutions.

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Appendix 1. Survey for IEEE Transaction, Journals, and Letters Editors.

Thank you for taking the time to participate in this survey. I have designed it with you, the Editors in Chief of IEEE Publications in mind. I hope that your answers will grant me insight into your submission and review processes, as well as to your expectations when reviewing a submission. Please take a few minutes to answer these 10 questions as accurately as possible.

Instructions
Please complete the following survey

1) Please check the option that best describes your regular employer.
__________a non-educational institution such as a corporation or government laboratory
__________a doctoral granting institution
__________a non-doctoral granting institution

2) How long have you served as an IEEE journal editor? Please check the most appropriate option.
__________Less than 6 months
__________6 to 12 months
__________12 to 24 months
__________More than 24 months
__________I am not currently an IEEE journal editor

3) Throughout the course of the research, writing, and submission process, how many months do you expect a typical submission's author(s) to invest on the project? P lease check the most appropriate option.
__________Less than 3 months
__________3 to 6 months
__________6 to 9 months
__________9 to 12 months
__________12 to 18 months
__________More than 18 months

4) What is the typical amount of time elapsed between the submission of an article and its outright acceptance? Please check the most appropriate option.
__________Less than 3 months
__________3 to 6 months
__________6 to 9 months
__________9 to 12 months
__________12 to 18 months
__________More than 18 months

5) Throughout the submission process, typically, how often do you return an article to its author for revision before you accept it outright? Please check the most appropriate option.
__________0
__________1
__________2
__________3 to 4
__________More than 4

6) In 2008, approximately what percentage of submitted articles was written by staff at non-educational institutions (corporations or government laboratories)? Please select the most accurate percentage.
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

7) In 2008, approximately what percentage of submitted articles was written by faculty at doctoral granting institutions? Please select the most accurate percentage.
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

8) In 2008, approximately what percentage of submitted articles was written by faculty at non-doctoral granting institutions? Please select the most accurate percentage.
10% 20% 30% 40% 50% 60% 70% 80% 90% 100%

9) Which do you perceive to be increasing in numbers of submissions over the next three years? Check all that apply.
__________Non-educational (corporations or government laboratories/institutions)
__________Doctoral granting institutions
__________Non-doctoral granting institutions

10) Which do you perceive to be decreasing in numbers of submissions over the next three years? Check all that apply.
__________Non-educational (corporations or government laboratories/institutions)
__________Doctoral granting institutions
__________Non-doctoral granting institutions

Thank you for taking the time to complete this survey. Your answers will be a great contribution to our research.

Appendix 2. Example of IEEE Journal Table of Contents with Author Affiliations (1 of 97).

IEEE Transactions on Very Large Scale Integration (VLSI) Systems Vol. 17, No. 1, Published 12 times/year	No ID	Domestic or International Corporation	Domestic School	International School	Total Articles
	0	5	5	5	15
Wire Topology Optimization for Low Power CMOS Zuber, P. Bahlous, O. Ilnseher, T. Ritter, M. Stechele, W. Technol. Aware Design, Interuniversity Microelectron. Center, Lowen;		1			
Low-Power, High-Speed Transceivers for Network-on-Chip Communication Schinkel, D. Mensink, E. Klumperink, E. van Tuijl, E. Nauta, B. Axiom-IC B.V, Enschede;		1			
Maximizing the Lifetime of Embedded Systems Powered by Fuel Cell-Battery Hybrids Jianli Zhuo Chakrabarti, C. Kyungsoo Lee Naehyuck Chang Vrudhula, S. Synopsis Inc., Mountain View, CA;		1			
Ultra Low-Power Clocking Scheme Using Energy Recovery and Clock Gating Mahmoodi, H. Tirumalashetty, V. Cooke, M. Roy, K. Dept. of Electr. & Comput. Eng., San Francisco State Univ., San Francisco, CA;			1		
Random Test Generation With Input Cube Avoidance Pomeranz, I. Reddy, S.M. Sch. of Electr. & Comput. Eng., Purdue Univ., West Lafayette, IN;			1		
Probabilistic Error Modeling for Nano-Domain Logic Circuits Rejimon, T. Lingasubramanian, K. Bhanja, S. Dept. of Electr. Eng., Univ. of South Florida, Tampa, FL;			1		
High Performance, Energy Efficiency, and Scalability With GALS Chip Multiprocessors Zhiyi Yu Baas, B.M. Dept. of Microelectron., Fudan Univ., Shanghai;				1	
Fast Configurable-Cache Tuning With a Unified Second-Level Cache Gordon-Ross, A. Vahid, F. Dutt, N.D. Dept. of Electr. & Comput. Eng., Univ. of Florida, Gainesville, FL;			1		
From Parallelism Levels to a Multi-ASIP Architecture for Turbo Decoding Muller, O. Baghdadi, A. Jezequel, M. Electron. Dept., TELECOM Bre- tagne, Brest;		1			
Hierarchical Segmentation for Hardware Function Evaluation Dong-U Lee Cheung, R.C.C. Luk, W. Villasenor, J.D. Mojix, Inc., Los Angeles, CA;		1			
Design and Synthesis of Pareto Buffers Offering Large Range Runtime Energy/Delay Tradeoffs Via Combined Buffer Size and Supply Voltage Tuning Hua Wang Miranda, M. Dehaene, W. Catthoor, F. IMEC, Katholieke Univ. Leuven, Leuven;				1	
Modeling, Analysis, and Application of Leakage Induced Damping Effect for Power Supply Integrity Jie Gu Keane, J. Kim, C.H. Res. Center for Adv. Sci. & Technol., Univ. of Tokyo, Tokyo;				1	
Performance-Oriented Parameter Dimension Reduction of VLSI Circuits Zhuo Feng Peng Li Dept. of Electr. & Comput. Eng., Texas A&M Univ., College Station, TX;			1		
Interconnect Exploration for Energy Versus Performance Tradeoffs for Coarse Grained Reconfigurable Architectures Lambrechts, A. Raghavan, P. Jayapala, M. Bingfeng Mei Catthoor, F. Verkest, D. IMEC vzw & Katholieke Univ. Leuven, Leuven;				1	
Decoding the Golden Code: A VLSI Design Cerato, B. Masera, G. Viterbo, E. Univ. della Calabria, Calabria;				1	

Review-by-Few or Review-by-Many?

Peter M. Maurer
Dept. of Computer Science, Baylor University
Waco, TX 76798, USA

ABSTRACT

It's clear that traditional forms of academic publication are rapidly becoming obsolete. It's also clear that peer review is a seriously flawed process that could be much improved upon by modern methods of communication. The primary flaw in the peer review process is that it gathers the opinions of a small group (two-to-four) of individuals, and attempts to make a decision based on that sample. It is my contention, that, except in rare cases, this decision is based on too small a sample to be valid. In this opinion piece, I suggest a method for gathering reviews from a wider group of people with the aim of improving the decision-making process.

INTRODUCTION

As academics, we find ourselves at a strange point in history. We have dedicated ourselves to learning, teaching, and to accumulating and disseminating knowledge. Yet, it seems that the very tools that we have used, seemingly for ages, are disappearing before our eyes. In many fields conference publications have supplanted journal publications as the primary means of professional communications. The best conference publications sometimes are published in archival journals, but more often, the conference paper is the final form of the paper. Conference proceedings that used to be published as semi-archival volumes are now published on CD ROM or electronically. Indeed, in many fields, electronic preprints have supplanted conference publications as the primary means of professional communication.

And what of the book? Books were once the mainstay of literacy, the cornerstone of modern civilization. When was the last time you read a book for information? Who needs an encyclopedia when you have Wikipedia? Who needs a cook book when you've got recipies.com? Who needs a math reference when you've got MathWorld or integral-table.com? Virtually anything you want to know is available on the World Wide Web, and you can find what you want in mere seconds without searching through stacks of journals, books, and other printed media. Of course, some of the information you obtain from the web is not particularly reliable, but if you're a sensible person you can usually filter out the fact from the fiction.

To be sure, this is no tragedy. Fast, reliable communications, vast repositories of information and instantaneous searches are a researcher's dream come true. Nevertheless, the one thing that gets lost in all of this is peer review. As academics, we have a need to prove that our work is worthwhile. At the very least, we need to get tenure and we need to get promoted. Our annual reviews are based on the number and quality of our peer-reviewed publications. Peer review is (or is supposed to be) the stamp-of-approval that certifies that a work is original and not a copy or trivial extension of some other work, that it is correct – that we didn't add two plus two and get seven, and that it is somehow a worthwhile addition to the body of human knowledge.

Unfortunately, the ideal of peer review is far from the reality. Rather than being the last bastion of truth that separates good science and nonsense, it is a veritable lunatic asylum and the lunatics are definitely in charge. Let me cite a few examples. I have published many peer reviewed papers, and I have served as both a reviewer and as an editor so I am intimately familiar with the peer review process. To be sure, there are instances where it works well, but these tend to be the exception rather than the rule. Here are a few of the types of individuals I have encountered both as an author and as an editor. These are examples taken from real life with the names changed to protect the guilty. Despite the ironic way I tell these stories, each one is taken from a *real review*.

Before I proceed, let me point out that my opinions are not unique. They are shared, at least to some degree by many others. See [1] for example. Another interesting read is [2], which shows how peer review failed to detect one of the largest scientific frauds in history.

A FEW BAD REVIEWS (AND REVIEWERS)

The Rubber Stamp.

The Rubber Stamp is an agreeable person who responds positively to every request for a review. Unfortunately, he really doesn't like reading papers, so he puts it off as long as possible. When the review is finally due he either scans the paper lightly, reads only the abstract, or doesn't bother to read the paper at all. Of course he's an agreeable person who would never consider recommending rejection. He writes a bland review containing generic statements like "Excellent paper, I really enjoyed it," and recommends acceptance. The paper, unfortunately, was written by a lunatic who believes that all Science Fiction is real. The references include citations from several Star Trek episodes, a couple passages from the Encyclopedia Galactica, and a few papers that exist only in the author's imagination.

The other reviewers don't bother to send in their reviews, so the editor must make a decision based on a single review. Of course the editor is much too busy to actually look at the paper so he passes it along to the EIC with a recommendation for acceptance. The EIC is also too busy to look at the paper, so it appears in print with everyone looking like an idiot.

The Detective

The detective believes that all authors have a hidden agenda and that it is his sworn duty to expose the author's chicanery. Of course, he is much cleverer than any mere author, so he quickly spots the odd turn of phrase and the hidden misdirection that conceal the author's true intent. He triumphantly recommends rejection of the first real solution to the P=NP problem.

King for a Day

If you knew this guy you'd wonder why anyone would ask his opinion about anything. The chance of him ever writing anything for publication is nil. He knows that nobody respects him, but somehow he was asked to review a paper. Now is his chance to show the world that he's smarter than those bozos who write papers. He points out the mathematical error on page 5 (2+2=4? I don't think so!) He notes that only an idiot would use a variable name like X when Z is so much more appropriate. He gleefully recommends rejection of the first valid unified field theory paper.

The Curmudgeon

The Curmudgeon has written only one good paper in his life. It really is a good paper. In fact it's considered to be one of the key papers in the field and any new paper in the field really ought to reference it. The editor, seeing the reference, sends the new paper to the Curmudgeon who never turns down a review. His reviews are all the same, "Why would anyone be so stupid as to try to publish *this*? 'The Curmudgeon' (using his own name, but speaking in the third person) solved this problem years ago." He viciously recommends rejection.

All progress in the Curmudgeon's field has come to a halt, even though there are many interesting and useful problems to be solved.

The Turf Warrior

The Turf Warrior is a cousin to the Curmudgeon. He doesn't like people horning in on his field, so he routinely recommends rejection of any paper that is even close to his field of expertise. He's not a bad man, he just believes, in his heart of hearts, that nobody can do the job as well as he can. Progress in his field is slow or non-existent.

The Club President

The Club President works in a research area that is "out of the main stream." When he receives a paper for review, he first looks at the author's name and checks to see if it is on his personal list of "acceptable authors." If not, he writes his standard rejection, which reads in part, "While we truly appreciate Dr. Bullfrog letting us know what he's been up to, …"

Because of The Club President's attitude, nobody knows, *or cares* what's going on in his field.

The Clairvoyant

The Clairvoyant is well-meaning individual, but he truly believes that the Berzwack algorithm is optimal for problem Q. He sees no point in exploring other approaches. If an author suggests a new solution to problem Q using anything other than the Berzwack algorithm he will recommend rejection of the paper. The Clairvoyant does not believe in looking at experimental results.

Because of him, no new solution to problem Q has appeared in decades, even though all known solutions are far from optimal.

The Drowning Victim

Professor Jaundice has just received a paper to review. The paper is quite challenging and would be a difficult read even for the top experts in the field. Professor Jaundice, however, does not like reviewing papers. Nevertheless, he believes he *should* review papers, so, he accepts the review, and passes it along to one of his graduate students. The student (i.e. the Drowning Victim) has just obtained his BS degree and cannot make head or tail of the paper. Even though he is a well-meaning individual, he is also human. It is human nature to say, "If I can't understand this, it must be nonsense." Most people never question their ability to understand *anything*. He recommends rejection of the paper. Professor Jaundice passes the review along to the editor without further comment.

The Reference Collector

At many of the more prestigious institutions, mere publication is not enough for promotion and tenure. It's also necessary that your publications be referenced. The more references the better. When the Reference Collector gets a paper for review, he immediately turns to the reference section looking for his name. If he sees it, he recommends acceptance. If he doesn't see his name, he adds one of his papers as a required reference, and recommends acceptance with mandatory changes. He doesn't bother to read the paper.

Mr. Cut-Off-Your-Nose-To-Spite-Your-Face

The Reference Collector has a cousin called Mr. Cut-Off-Your-Nose-To-Spite-Your-Face. He also consults only the reference section. If he doesn't see his name, he feels that he's been slighted and angrily recommends rejection. It never occurs to him to recommend adding his paper as a reference, even when such a recommendation is legitimate.

The Savant

The Savant believes that all new knowledge comes to us from Bunwucky State University, where he is employed. He has received two papers for review one from Bunwucky State entitled "Exciting New Variable Names for the Quicksort Algorithm" and one from some other place containing a legitimate three-line proof of Fermat's Last Theorem. He enthusiastically recommends acceptance of the Bunwucky State paper, and recommends rejection of the other paper with a review that reads "Fermat's Last Theorem is a difficult problem that is best left to the experts. We recommend that you redirect your efforts toward problems more suited to your level of intelligence."

Etc.

I could go on, (and on and on) but you get my point.

REVIEW-BY-FEW OR REVIEW-BY-MANY?

Speaking as a former editor, I can say that obtaining good reviews is an excruciatingly difficult problem. The top people in most fields routinely reject all review requests saying that they are too busy. Those who do accept the reviews often pass them along to unqualified students. Few reviews are done by the author's peers. They are done either by unqualified students or by people whose main qualification is that they agreed to do the review after the first twelve people refused. Even when the reviews are good, the process is still chancy. In one case I received two excellent reviews for a paper and was about to recommend acceptance to the EIC when the third review arrived. The third review consisted of a single reference to an identical paper that the authors had published elsewhere. If I hadn't been lucky enough to select a reviewer who had actually read the other paper the authors would have gotten away with a duplicate publication.

In too many cases, individuals who promise to do reviews don't do them. I call this type of reviewer "The Black Hole." Once the paper has been sent to him, no further communication is ever received. He not only won't send you the review, he will also refuse to communicate with you in any way shape or form. When this happens, your decision on the paper is bound to be based on insufficient information.

Finding reviewers in new fields is agonizing. Very often there are no peers, so you try and find people in related fields. All too often the reviews you get are "Drowning Victim" type reviews which are of no help.

One of the primary problems with peer review is that papers are reviewed by a select group of people chosen by an editor. There is no guarantee that this select group of individuals will give you a reasonable set of opinions on the paper. Although it seems good in theory, it doesn't work in practice.

But the biggest problem with the peer-review system is that there almost always no appeal. I have editors explain to me, very kindly and carefully, that even though I raised objections to every one of the reviewers' negative comments, it couldn't possibly change the fact that my paper was rejected. Even if you are lucky enough to have an understanding editor, the best he can do is send the paper out for another set of reviews. He's probably pretty far down the list of acceptable reviewers already, so the new reviews will usually be even worse than the first ones.

So how do we fix the system? We don't. We get rid of it. I believe that all papers should be published electronically with *no initial review*. Once the paper is published we should then collect comments from anyone who wants to submit them. The author should be able to respond to negative comments and should be able to revise the paper to correct deficiencies. Reviewers should be able to revise or withdraw their comments. And most importantly, reviewers should be able to comment on each other's reviews. I once reviewed an excellent paper for a well-known journal and enthusiastically recommended acceptance. I was stunned when the editor rejected the paper based on another review. After reading the other review, I realized it was seriously flawed and wrote a letter to the editor detailing the errors. The editor's response was: "Dear Dr. Maurer. I understand that you are upset that your paper was rejected, but I assure you it was reviewed with the utmost scientific accuracy … ." Meanwhile, back on *this* planet …

I don't believe in anonymous reviews. People ought to stand behind their remarks take responsibility for what they say. All too often, reviewers treat the cloak of anonymity as a license to be nasty. Nevertheless I acknowledge that some form of anonymity might be needed to protect reviewers from behind-the-scenes personal attacks. The simplest solution to this is to require all reviewers to have a single on-line "handle." This would make it possible for everyone to identify individuals who continually make inaccurate and unfair comments, and distinguish them from people who are generally fair.

Of course, reviews written by anyone and everyone could be fragmentary, and potentially wildly inaccurate. Despite this, I believe that it would be relatively easy to distinguish the good reviews from the bad and assign a rating to the paper based on them. The reviews could be as long or as short as the reviewer wished them to be, with no deadlines and no pressure to complete them. This is a *review-by-many* paradigm which I believe cannot help but be a major improvement over the current *review-by-few* model.

WHY PUBLISH AT ALL?

But perhaps the very idea of publishing is an anachronism. Perhaps a better paradigm would be for scientists and other researchers to communicate by E-Mail and abandon formal communications entirely.

I don't believe that this is a good idea. Preparing documents for formal release demands a level of care that is absent in informal communications. You can't just say that you believe something is true, you must formulate your thoughts as a series of lemmas and theorems and provide proofs for each one. Going through this process forces you to work out the bugs and clear up any errors or glaring omissions.

By the same token, preparing experimental data to prove your hypotheses, or to demonstrate that your algorithms are better than others, forces you to demonstrate the correctness of your ideas. Without the concept of formal publication there would be little incentive to prove anything. Errors would accumulate and scientific progress would be severely impeded.

But is there any reason to publish anything anywhere than on my own website? I think the answer to this is also, "yes." I need to know that my work is of value, and some kind of formal feedback is the only way I'm going to be certain that this is true. Furthermore, I want electronic search engines to put my papers on page one, or at least somewhere the first three pages. If the paper is on my own website, the chance of this happening is less than if the paper resided in some formal archive. Furthermore, a publication in a prestigious electronic archive is more likely to impress my dean when he is thinking about tenure, promotion or annual raise.

ELECTRONIC ARCHIVES

I believe that there should be electronic archives that essentially replace journals, conference proceedings and other forms of formal publication. Furthermore, I believe that these electronic archives should accept *everything* that is submitted to them, as long as the subject of the paper is appropriate to the mission of the archive. The mission of these archives should be much broader than that of a typical scientific journal. I would imagine an electronic archive that would comprise all of the publications of a professional society rather than a collection of papers on a narrow topic. The archive would, of course, be subdivided into subsections of papers on specific topics. There is no reason why the subdivisions should be at the level of current journals, but this would probably be a good starting place. It should also be possible for authors to create new subdivisions (subject to editorial review) giving an instant venue for publication of results in new fields.

Papers should be given a quality score based on the number of times they have been accessed, the number of times they have been downloaded, a voluntary score (+3 to -3) assigned by readers, and voluntary reviews done by individuals with author responses. Authors could continually revise their papers to respond to reviewer comments and improve their scores. Inappropriate papers could be voted out of the archive by a sufficient number of votes, but perhaps kept in a "slush" archive for a time just in case the vote was incorrect.

This model would allow papers to be reviewed by many individuals, and confine reviews to those people who genuinely wish to write them. Papers would move up in the archive based on the quality of their reviews, and the responsiveness of the author to suggestions for improvement.

CONCLUSION

It's time to apply modern methods of communication to the peer review process. As time progresses, traditional journals are becoming less and less a means of professional communication or for archiving significant scientific results, and more a mechanism for obtaining promotion and tenure by academic researchers. I don't believe that tenure and promotion is a sufficient *raison d'être* for the continued existence of journals. I believe that there are better mechanisms for distinguishing good papers from bad, and that these mechanisms can serve as a filter for electronic archives and as a substitute for peer review in promotion and tenure decisions.

The ideas presented here are the product of long discussions with many other people over many years. I thank all of these individuals for sharing their ideas with me. However, the views expressed here are purely my opinions. The blame for any exaggerations, inaccuracies or downright errors lies entirely with me. You may direct your comments to the following E-mail address. (Peter_Maurer@Baylor.edu).

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Actionable Ethnography in Participatory Innovation: A Case Study

Svenja JAFFARI[1], Laurens BOER[2] and Jacob BUUR[3]

Spire Research Center, Mads Clausen Institute,
University of Southern Denmark
Sønderborg, 6400, Denmark

" ! **svenja@mci.sdu.dk, tlf.: +45 6550 1697, [2] laurens@mci.sdu.dk, tlf.: +45 6550 1276,**
! **buur@mci.sdu.dk, tlf.: +45 6550 1661**

ABSTRACT

In this paper we describe how ongoing work with ethnographic material in a participatory innovation sets the scene for innovation to happen. We elaborate on how actionable formats of ethnographic material have been mediated to industrial partners with a stake in an innovation project. We illustrate how the stakeholders engaged in activities such as sense-making, co-analysis, and cross-comparison of the ethnographic materials, and the specification and mapping of innovation opportunities. We argue that these activities served to establish a shared understanding and ownership of the participatory research, design material.

Keywords: Ethnography, Design Methods, Participatory Innovation, Stakeholder Involvement, Workshop Facilitation

TOWARDS PARTICIPATORY INNOVATION

Within the field of design research, there has been a long-standing focus on how to relate to and empower the user of a certain product or service. Especially in fields such as Human Computer Interaction [28], Computer Supported Cooperative Work (CSCW) [13] and User Centered Design (UCD) [2, 21], there have been multiple research and design projects to study the context of use and to ask for feedback from the user in the design process. This relatively passive role of the user has been turned into a more active one since then, and users have been directly involved in the research and design process to make findings from the context of use more realistic and actionable. One quite influential approach to this is Participatory Design, which has been practiced at universities and research and design institutes particularly in the Scandinavian countries [16, 25, 26, 30]. In a participatory design process, design researchers often stage an iterative design process, which, amongst other activities, consists of field visits, workshops and design sessions. During this process, the ethnographical material and in-situ design experiments undergo a form of collaborative analysis, ideally leading to a shared understanding and ownership of design materials between designers and users (as co-designers [11]).

Besides the field of design research, there has been a similar but 'slower' development in innovation research. Leonard & Rayport [19] engage in the discussion about probable limitations of traditional User Centred Design, and they advocate enriching the innovation process with empathic design methods. Empathic Design mainly focuses on observing the user in his/ her own environment, e.g. the interaction with and modification of a product and the tacit needs of the user. Leonard & Rayport [19] suggest a five-step process for Empathic Design, consisting of observation, data collection, reflection and analysis, brainstorming, and prototype development. The basic preamble of such a process does hardly compare to the co-design perspective of participatory design.

Despite the agendas of Participatory Design and Empathic Design to involve the user, Buur & Matthews [5] have criticized that these approaches might nevertheless fail to take the 'business perspective' (e.g. a company's business model and its values, visions) into account. This is crucial for bringing the user centered designed products into the market. In a similar vein, newer innovation literature has explored methods that enhance the product or service design process not only in terms of observing and co-creating with the user, but also with regards to involving and co-designing with all the different stakeholders [3, 4, 22, 27]. Here, stakeholders include any person who have a 'stake' in the planning, designing, launching and using of a certain product or service, e.g. the 'ordinary' consumer, designer, system developer, sales or marketing personnel, project manager, distributor etc. Buur & Matthews [5] propose the new field of Participatory Innovation in order to meet the challenge of involving many different stakeholders and letting a shared understanding of and ownership over the design process evolve.

Participatory Innovation borrows from three relatively independent approaches to user driven innovation, namely participatory design, design anthropology and the lead user approach (figure 1).

Figure 1. Participatory Innovation as a merger of three approaches to user driven innovation [5].

Within user driven innovation, Participatory Design offers a range of practical methods to involve the users and project team in the design process, whereas Design Anthropology helps to bring deeply ingrained product use and user knowledge to the surface. The Lead User approach suggests an early collaboration of innovation companies with a small group of users that lead future trends of the market [31]. A participatory innovation process has a twofold aim, which is to generate knowledge, i.e. study use practices to trigger an innovative reframing of company identity, and to generate business opportunities in terms of new products, services and visions.

SHARED ETHNOGRAPHIC ACCOUNTS IN PARTICIPATORY INNOVATION

Ethnography in design research and practice

The reason why ethnographic field research, in its less exotic form [9], has been conducted within the area of design is often described as "…understanding the particulars of daily life in such a way as to increase the success probability of a new product or service or, more appropriately, to reduce the probability of failure specifically due to a lack of understanding of the basic behaviors and frameworks of consumers" [23]. In the field of Human Computer Interaction, Suchman [28] borrowed tools and techniques from ethnography to study the interaction between human beings and technology in workplace settings. Other scholars have followed to look at the details of interaction by visiting, observing and recording highly complex and often routinized workplaces such as airplane cockpits [14], underground control rooms [12], medical practices. Some of them have critically looked at how and with what type of ethnographic data (e.g. notes, audio, video) a researcher can contribute to systems design and development [1, 29]. Sometimes termed as 'design ethnography' or 'design anthropology', it has been practiced in User Centered and Participatory Design projects to understand and build sensitivity toward user experience and user values. It has become common to use video supplemented by notes and drawings to document field visits, thus allowing for the detailed analysis of interactions. Often the "ethnographic camera" is fed back by presenting user portraits or using drama [2] to make both users and designers reflect on their practices and promote shared understandings [32]. In some projects, users have been asked beforehand to record their everyday life by using cultural or technology probes [10, 15]. In many cases, interaction design researchers and practitioners in design companies translate and present these ethnographic accounts in the forms of storyboards, scenarios and personas.

Ethnography in the landscape of participatory innovation

Despite twenty-five years of adaptation and exploration of ethnographic techniques in design practice and research, there has been less attention paid to how to mediate and co-analyze the actual raw material with business people and companies with a stake in a particular innovation project. From a participatory innovation perspective, these non-designers and non-users often have a critical say in the design process. They are also a considerable, strong link to making innovation happen.

With regard to this, both designers and practitioners in participatory innovation come to realize more and more that it is important to develop a language that enables the multidisciplinary project team to innovate together, related to Buur & Larsen's [7] 'quality of conversation' and Sanders & Stappers' [24] 'co-design language'. A facilitator has to adjust his/ her tools and techniques as well as his/ her role to enable such a process. In Sanders' & Stappers' [24] "new landscape of design", both the nature of the design researcher's and designer's role change. In their example [24], the design researcher does not just translate a user study but rather facilitates (e.g. guides, provides scaffolds for) the process of building shared ownership and creative expression at all levels (user, researcher, company people). The designer, on the other hand, focuses on using his skills and knowledge (in e.g. interaction design, industrial design, interior design) to support the complexity and scope of arising problems. Designers are often asked to develop tools, similar to what Sanders & Stappers [24] call 'generative design tools', to encourage non-designers to participate and express themselves in workshops. Besides this new landscape of changing roles and tools and techniques of facilitation, the process of co-analyzing the user study (in the form of ethnographic material) together with the stakeholders in user driven design and innovation projects might bring about shared ownership and understanding that grows a co-design language and spurs innovation.

In the following, we describe a participatory innovation project and especially the phase during which ethnographic material was prepared and mediated in different formats to the industrial stakeholders, non-designers and non-users. We will claim that this helped to create a common language in the project. This paper contributes to design research and practice in innovation by stressing the need for an active integration and co-analysis of ethnographic material with industrial stakeholders, as opposed to a passive presentation in forms of e.g. portraits or personas.

CASE STUDY

Project Overview

In the participatory innovation project entitled 'Indoor Climate and Quality of Life', researchers from the Sønderborg Participatory Innovation Research (SPIRE) Center and from the Center for Indoor Environment and Energy at the Technical University of Denmark (DTU) together with five industrial partners, developing indoor climate products and systems, are looking into the potential for user driven innovation for the indoor climate context. The three-year design research project (2008-2011) aims at developing new knowledge about people's experience of comfort in homes, offices and institutions in order to demonstrate innovative indoor climate solutions to the industry that can enhance people's quality of life in terms of health, well-being and economy. The design process is split up into five phases, that are 1) literature screening of the concept of 'comfort' within different disciplines, 2) field studies of five Danish families (in homes, offices, kindergartens), 3) development of 'comfort themes', 4) innovation projects for new indoor climate solutions/ concepts and 5) mediation to the industry. Currently, the project team has reached the fourth phase, innovation projects.

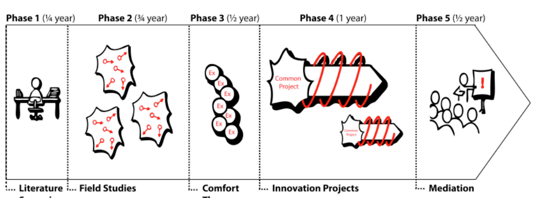

Figure 2. Process Overview of the Indoor Climate project.

Following a participatory innovation process, this project has been organized to encourage the meeting between researchers and practitioners with different professional backgrounds and research traditions (quantitative and qualitative). Together, this multidisciplinary team conducted expert interviews, field studies (both participant observations/ interviews and measurements of indoor climate parameters), and workshops in order to permit for an exchange of viewpoints, sharing of expertise and understanding between the disciplines [18], and thus let a common co-design language evolve and innovation happen. Relatively raw ethnographic material was continuously mediated and shared in different, actionable formats during the workshops with the researchers and practitioners from indoor climate product development.

In the following, we will describe in greater detail how the sensemaking and co-analysis of the field material (user studies) was facilitated and how it helped to co-ideate concepts and find innovation potential. Due to the focus being on facilitation and results of the actual process, we will not go into depth with the content and meaning of themes developed during the workshops.

Stakeholder Workshops

Within phase 3 of the project (figure 2), the SPIRE Center facilitated three workshops where ethnographic material from the private homes, offices, and kindergartens was co-analyzed in order to identify directions for innovation. Facilitation of the workshops ran according to the idea that "researchers reflect on the basis of their own participation" [7], where the facilitator participated and shifted between stepping fully in and then out to reflect.

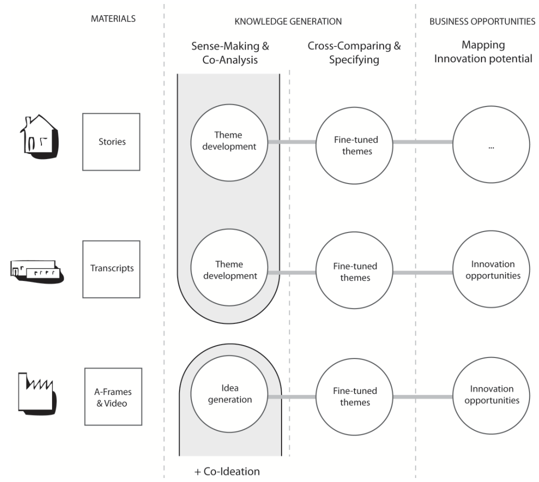

Figure 3. Overview of the three workshops (horizontal) with their corresponding ethnographic materials and collaborative activities (vertical).

The Home Context

The first workshop (figure 3, first row) dealt with the ethnographic material of the five private homes. Beforehand, researchers from SPIRE, who had also conducted the field studies, selected a range of interesting indoor climate scenes and situations that could represent the whole of the field material, while being sensitive to one's own social categories [9].

The multidisciplinary project team was split into groups of three, each of whom obtained seven to eight A4 sheets of paper with a story, quotes and a situational picture describing indoor climate related actions and motivations at a particular home (figure 4).

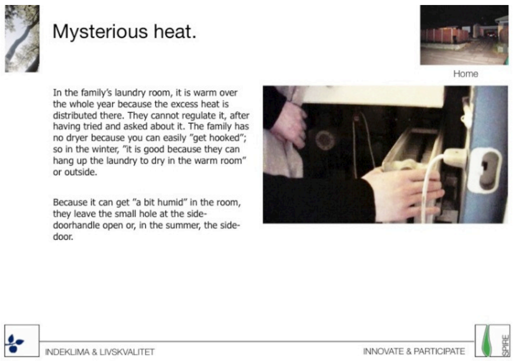

Figure 4. Material from the workshop on homes: a story card

Then, the groups were asked to map out interesting comments with post-it notes on another A3 sheet of paper, which were presented to the other groups afterwards. From these comments, the facilitator (SPIRE Center) together with the project team clustered and fine-tuned indoor climate themes across the different homes.

During the workshop, the industrial project partners in the groups were particularly surprised about how unsustainable and atypical the home owner/ the user often acts. One of them, a development manager from a Danish production company of insulation materials, helped to pinpoint the theme *"an expert you trust"* with regard to dealing with one's indoor climate. She concludes that in many of the home settings, which were visited, *"people are often trusting their neighbors and friends more than an expert. They don't want an expert to tell them what to do."* Many of the dilemmas and situations presented in the story cards (figure 4) were rather mundane and familiar at first sight, but during the reflective workshop session they became strange and were suspiciously looked upon. What the researchers from SPIRE aimed for was that especially the industrial partners being experts in providing an indoor climate product and/ or system for optimal comfort would slowly recognize everyone is a novice in experiencing indoor climate systems and comfort in real life. Furthermore, the whole project team would come to gain a shared understanding, let new knowledge evolve and concepts of indoor climate and comfort be reviewed. From the results of the first workshop, it seemed promising, in that it could also trigger a discussion about the industrial partners' own experiences, interests and possible future directions for innovation, but challenging as well to wanting to do this with the help of simple observations from the ethnographic material.

The Kindergarten Context

In the second workshop (figure 3, second row), the ethnographic material of the kindergarten setting was presented for co-analysis. Here, the multidisciplinary groups of three to four people received an A4 sheet of paper with transcripts and corresponding pictures of kindergarten personnel dealing with everyday indoor climate related situations. They were asked to read through, discuss and comment with post-it notes on another A3 sheet of paper in order to present 'their kindergarten' situations to the rest of the team. Afterwards, the facilitator tried to pinpoint some indoor climate themes (figure 5) across the different kindergartens, and then moved on to collaboratively transfer them to an x-y coordinate system to frame innovation potential of these themes. Themes were found to be strong and worthwhile to be explored further when high innovation potential (x-axis) was met with the project partners' strong belief (y-axis) (figure 9).

Figure 5. Cross comparing the themes and kindergartens in the workshop on kindergartens.

When one of the groups presented comments about the material from the kindergarten that they had co-analyzed, one of the industrial partners, a development engineer from a Danish company producing controlled window openings for buildings with natural ventilation, listens carefully and finds a commonality to 'their' kindergarten case (figure 6). *"That's kind of interesting because we had kind of a similar problem [refers to his transcript]. She [one of the pedagogues] wouldn't air out because she was afraid that other people would hear what they were talking about… Tavshedspligt [duty of confidentiality]. [..] That they [pedagogues] go here [kindergarten office] and were talking about some children. So they find an excuse not to air out."* With his reaction, the engineer shows his ability and willingness to make a fine-grained observation, comparison and to draw a conclusion from it.

Figure 6. Development engineer (left) refers to one of the group's transcripts.

In another instance (figure 7), he discusses with the project team the fact that *"it is weird that our user is talking a lot about this responsibility they have to take. […] And she's [points at his transcript] talking about getting away from structure, and yours [points at other group] is talking about having structure. […] But she's-she says [reads off transcript] "we should not have a procedure for when we open the window. […] She [the pedagogue] was totally opposite."*

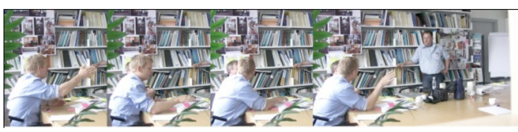

Figure 7. Development engineer (left) discusses by pointing at ethnographic material.

From these and other interactions during the second stakeholder workshop about ethnographic material from kindergartens, the project team moved towards owning the material and reaching a shared understanding in the participatory process of innovation. They seemed to loose their initial hesitance, to directly refer to the material, compare and analyze it, to show empathy with "their user", to tell about "their experiences", and to see the challenge that e.g. existing routines in kindergartens present if one wants to keep optimal indoor climate conditions ("not airing out"). The facilitators were confident in challenging perspectives for another time.

The Office Context

The third workshop would concern the ethnographic material about indoor climate and comfort issues in five offices. Prior to this, there had been an internal workshop with researchers from the SPIRE Center where the project was recapitulated and indoor climate themes across the offices were prepared. The internal workshop served as a way to rehearse and to share different viewpoints of the material. In the beginning of the workshop, the groups of researchers were handed ethnographic material of the different offices in forms of six to seven A-frames [8]. A-frames were developed as a performative tool for co-analysis, consisting of an A4 sheet of paper with a transcript, a picture and some space for comments, folded to a standing A5-sized prop. Besides the A-frames, the groups also received the corresponding video clips (approx. one minute long). Their task was to read through the transcript, see the video clip, and then annotate on and give a title to the A-frame. Afterwards, the group should collaboratively collect some of the A-frames each under one theme, which they had to present to the other teams. After the group presentation, the facilitator tried to summarize five indoor climate themes, by also taking the themes from the workshops about homes and kindergartens into account.

Following the internal workshop, the project team conducted the stakeholder workshop with the companies and DTU (figure 3, third row). Here, the groups of three picked each an indoor climate theme they wanted to work with. They were asked to familiarize themselves with the A-frames and video clips, and possibly add some comments. Then, the groups began to generate design ideas for indoor climate solutions based on their theme and field material (figure 8). These ideas were presented and discussed with the rest of the workshop participants afterwards. In the end, the facilitators and the project team tried to fine-tune and discuss innovation potential of the indoor climate themes, by assigning them a place in the same x-y coordinate system (figure 9).

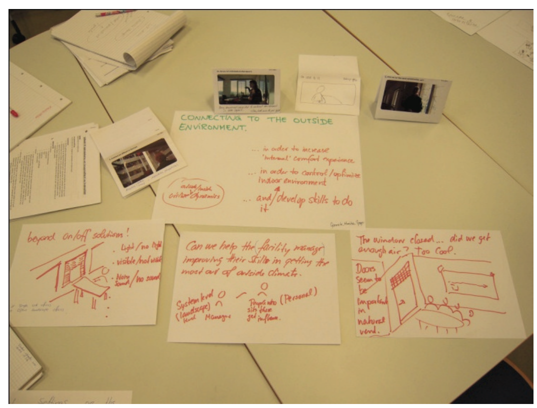

Figure 8. Co-ideation in the workshop on offices: A-frames and concepts.

Figure 9. Mapping innovation potential of the indoor climate themes in the workshop on offices.

The third stakeholder workshop meant another stepping-stone for the industrial partners, the Technical University (DTU) and the Participatory Research Center (SPIRE) to share perspectives and understanding with the help of observations from and the co-analysis of raw ethnographic material. When discussing his group's design ideas with the rest of the project team, an engineer from the standardization and product regulation department of a Danish manufacturer of daylight and sun lighting systems, gives a detailed account of one of the A-frames: *"In one of the offices [points at A-frames], they solved the problem of shading with posters. But they didn't think about moving their workplace. […] So having [an] allowance to discuss in the room [office] different situations and solutions should be encouraged, because their [workers] awareness leads to responsibility which was one of our subthemes in this [points at A-frame grouping]."* (figure 10).

Figure 10. Engineer (right) discusses by pointing at A-frames grouping.

This comment guided the discussion towards possible solutions to raise awareness, e.g. using one's mobile phone to measure light, heat and noise. Often, the industrial partners related with utterances such as *"if we had to see it from the users' point of view", "in these/ our cases", "people do…"* to the ethnographic material in order to support and to make their claims relevant. They also seem to have an account of what has happened during the project so far. *"We could relate them [the indoor climate themes] to the study [literature study/ expert interviews] that we did in the start where we asked different types of people what they are thinking about indoor comfort. I think it was very interesting to see that every science and art actually does have this theme in a way"*, as two of the participants proposed.

From the three workshops, the project team could see the merits of making ethnographic material actionable to practice sense-making, co-analysis and cross-comparison together with stakeholders early in the design process. It could produce not only shared ownership and understanding of the design material but also participants having to negotiate their stakes and interests in the innovation process. The indoor climate themes that emerged during the workshops served further as user driven design directions in the innovation projects (figure 2).

CONCLUSION

Within a participatory innovation project or any innovation project, we see it as important to nurture the meeting of different perspectives and disciplines in the development process because it "create[s] a complexity that none of us can foresee" [7]. In agreement with Buur & Larsen [7] we see such a complexity as a resource for innovation. One of the ways for how to take up this challenge could be to mediate and analyze field data in forms of ethnographic material together with the different stakeholders in a participatory innovation project. This certainly asks for new formats and approaches compared to existing design research and practice.

During our project 'Indoor Climate and Quality of Life', we engaged the entire project team in the work with well-crafted, actionable ethnographic material and staged activities such as sense-making, co-analysis and cross-comparison. This helped create a shared language and ownership of the project. The workshop participants could see the value of the ethnographic material in terms of innovation directions and often returned to it in their discussions and reflections. We also saw it as important to address the companies' stakes and interests throughout the workshops in a language that they can easily relate to. During the process of engagement, especially the industrial partners came to actively reflect over the users' and their own practice and also readjust their stakes to let innovative ideas emerge.

Acknowledgements
We thank all the participants of the 'Indoor Climate & Quality of Life' project who took part in the workshops and helped us to establish the material for this paper.

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Involvement of Student Teachers and Pupils in Designing and Manipulating Virtual Learning Environments Impacts Reading Achievements

A Successful Attempt at Teaching Novice computer Users

Esther ZARETSKY

Giv'at Washington Academic College of Education

D.N. Evtah, 79239, Israel

ABSTRACT

The research is aimed at investigating the involvement of student teachers and pupils in designing and manipulating virtual learning environment and its impact on reading achievements through action research.
In order to understand the connection between the real and virtual worlds, the design of such simulations is based on applying the virtual environment to the real world as much as possible. The objects were taken from the pupils' everyday environment and unique motivation. The researcher taught the method to 30 student teachers. Such procedures were held among different populations.
The findings showed that as the student teachers practiced the simulation design through the PowerPoint Software, it became clear to them how the computer can be implemented in their practical work. Consequently, their presentations became highly animated, and applied to the pupils' natural environment. The student teachers used their presentations in their practical work and reported their pupils' improvement in reading skills.
The student teachers could integrate theory and practice in their teaching and improved their level of academic writing. The motivation of the student teachers and their pupils to design and manipulate virtual environments was also enhanced.

Keywords: Action research, Application, Design, Manipulation, Simulations, Technology, Learning Environments, Reading skills, Simulations, Virtual Reality.

1. INTRODUCTION

Most Teachers in academic colleges of education teach basic computer courses without requiring its application, neither through action research. Besides, most special education teachers and student teachers are not aware of the pupils' capability to design and manipulate virtual simulations on their own. It is usually done by computer designers. According to Piaget & Inhelder's theory (1), reativity leads to a significant construction of knowledge. Developing control over the reality and compatibility with the natural environment occurred while creating virtual simulations.

2. THEORETICAL REVIEW

For better understanding of virtual design and the contribution of manipulations to the advancement of pupils with special needs, we will explain the main concepts such as computer simulations and virtual reality.
Computer Simulations are computer-generated versions of real world objects. They may be presented in two dimensional, text-driven formats, or increasingly, three dimensional multimedia formats. Computer simulations can take many different forms ranging from computer renderings of 2-D geometric shapes to highly interactive 3-dimentional multimedia environments (2).
Virtual Reality learning environments allow entirely new capabilities and experiences. The users have unique capabilities, such as the ability to fly through the virtual world, to occupy any object as a virtual body. Observing the environment from many perspectives is both a conceptual and social skills: enabling pupils to practice this skill in ways we cannot achieve in the physical world may be an especially valuable attribute of virtual reality. Dynamic programming software enables the addition of viewpoint control, command structures, object behaviors (3).

Situations which are complicated to perceive in usual learning environment can be presented and viewed in many different perspectives in a virtual environment (4) (5).

The Usual use of Virtual Reality in Special Education
Most virtual reality research and software programs for special education ad hoc have been developing for physically handicapped populations (6) (7), where the pupils participate as observers only. Inman & Loge (8) have created virtual reality programs for helping physically disabled children to operate motorized wheelchairs successfully. Virtual Reality researchers have pioneered the use of VR (Virtual Reality) technology to help training orthopedically impaired and sight-impaired children.

Writing as a preceding stage of Reading trough Computers
According to Goodman & Goodman (9) and Smith (10), the writer serves as a reader and not only for editing and revising the text. The use of computers enables us to exemplify the writing and thinking processes of the reader–writer.
The use of the word processor for writing instructions results in adopting writing strategies of expert writers (11) (12). Bereiter & Scardamalia (13) focused on building complex representation of writing tasks, planning and revisia of programs, comparing results to objectives and considering varied information kinds, enabling to check the spelling for improving the writing process. These options will be checked in further expansions of the methods suggested in the present research such as writing the relevant words in the PowerPoint presentations and typing it in the Internet search website for finding appropriate images and/or written information.

The findings of Zaretsky's research (14) showed an improvement of a learning disabled and mentally retarded pupil in reading thanks to her creating multimedia presentations on her own during the meetings. A transfer to the reading level in the classroom without using computers was also observed. Then the pupil could be included in the regular reading lessons in the classroom and understood the texts being read. It seems that utilizing the pupil's unique motivation by fitting the contents to her fields of interest enhanced her improvement in writing and reading in the class, either with or without vowels

.

Reading by Using Computers

Applying software to pupils' needs serves as a basic condition of integrating computers into teaching pupils with special needs (15). The multimedia might compensate for auditory or visual deficits according to the kind of exceptionality (16). Images focus the attention of the reader and motivate him to read the text (17). Success was observed in using drawings (18), motion (19) (20), textual and graphic information (21), and asking questions related to the text (22).

Like the computerized live books in multimedia environments, the computer user is exposed to enormous amount of varied stimuli in real time and rapid effective functioning. Therefore, a computer user is required to simultaneously manage all the stimuli. He also needs orthographic perception (23).

Thus, the characteristics of 3-D interactive environments, namely virtual reality, are closely aligned with those of an optimal learning environment. The perceived advantages of the virtual environment as an instructional tool include, among others, multi-perceptual engagement (24), the opportunity to change perspectives at will (25) and abstract concept representation (26) (27).

Designing and Manipulating Virtual Dynamic Learning Environment through Action Research

Student teachers' educational programs are being called on to provide models of authentic teaching, and to help teachers to develop their knowledge of the content, discourse, and content-specific pedagogy. They also must provide multiple perspectives on K-12 student teachers as learners, and offer meaningful opportunities for teachers to develop skills in using the technology (International Society for Technology in Education, (28)). It is essential that all K-12 teachers will be able to demonstrate an ability to use technology tools in their standards-based curriculum in order to promote student learning, improve student achievement, and provide student teachers with the skills they need in their future education and/or workplace careers. In 1999, the U.S. Department of Education established the Preparing Tomorrow's Teachers to use technology programs in order to support organizational change in teacher education so that future teachers will be able to use interactive information and communication technologies for improving learning and achievement (29).

Learners actively construct concepts through the process of mediated actions (Vigotsky (30)). According to the notion of mediated actions, human beings use cultural tools (such as language as well as tangible features of the environment) which fundamentally change the structure of the cognitive functioning and activity (31) (32). Beaufort (33) and Kezar (34) believe that the faculty instructors can be affected by changes such as integrating technology in their teaching program if only they are actively engaged in creating the change that is taking place.

Zaretsky & Bar's research (5) proved that carrying out action research by virtual reality significantly affected the academic achievements of special education pupils regarding their spatial perception, measured by their ability to solve the Standard Progressive Matrices of Raven (35). These pupils' abilities to read, write and compute was also improved. Computer-simulated environments are becoming more and more realistic, offering a real-world experience. The computer-generated environment simulates a busy street much as in a computer game, and through virtual reality technology, the child has the experience of driving the wheelchair (36).

This research is aimed at preparing student teachers to design virtual environment and apply it for improving their pupils' reading skills and writing academic reports.

The examples of works presented in this paper are based on the theory of preceding the writing to reading (37).

3. RESEARCH PRESENTATION

Procedure

The research group was composed of 30 student teachers majoring in special education. The tests were conducted for 2 meetings per a pupil, a total of 25 minutes per a pupil before and after the intervention program, which lasted six weeks, 12 meetings, and twice a week. This is a pilot research.

The Research Method

The student teachers planned their study and reported on each stage they completed. The method of training focused on the simulations of the objects on the computer screen relating to the real world. The objects were taken from the pupils' everyday environment.

The Stages of Designing the Virtual Environments and its Applications

The research design focused on the mode of a longitudinal qualitative research (38) during one semester (3 months) and included four stages:

Stage 1: Learning the basics of designing PowerPoint presentations

Stage 2: Planning a research:

- Choosing a pupil with special needs,
- Testing the achievements in the examined skills.
- Creating professional simulations through PowerPoint presentations in the relevant domain.

Stage 3: Using the presentations in the practical work,

Then the pupil adds his/her own simulations.

Stage 4: Writing the research report

The student teacher writes his/her analysis through PowerPoint presentation, and relates the practice to the theory.

Research Tools

Reading Tests

Reading Comprehension tests for the 4th grade (39)

Reading Comprehension tests for the 5th grade (40)

Readiness for Reading test (41)

Media

The PowerPoint Software was used for designing virtual simulations, training the pupils with special needs and writing the research report.

Case Presentations (Pre-intervention)

Case No. 1

Gam's project (42) was aimed at investigating the reading ability of a 13 year old autistic pupil with a medium-to-low educational, social and emotional functioning. After he had already learned in the past some of the Hebrew vowel symbols and he had just begun to recognize the rest of them, he became confused. Therefore the student teacher was not aware of the pupil's ability to read and write more than a few words with the vowels *patach* and *kamatz* (a) only.

The main objectives of the project were learning various Hebrew vowel symbols, reading words and even sentences. The secondary objective was enhancing concentration skills and motivation for learning.
The student teacher chose the subject "animals" for the PowerPoint presentation since this was the pupil's unique motivation. He got therapy in the zoo and enjoyed it very much. In order to motivate the pupil and reinforce what he had learned, the student teacher added the pupil's photo image and an animated butterfly's image that flies over the computer screen background which is composed of a field and sky.

The stages:

1. Choosing the appropriate word (among four words) for a specific image which appears in the center of the slide.
2. Selecting the image which matches the written word, in this case: animals like dog, cat etc.
3. Typing the same word by copying it.
4. Typing words according to the student teacher's words.
5. Connecting between animal images in the center of a sheet of paper to the appropriate word that appears at one of the corners around the image (choosing among four words).

Case No. 2 (Pre-intervention)
Ovadia's project (43) was aimed at investigating reading ability of a pupil 9.6 years old learning in a regular 5th grade class.
The pupil made spelling mistakes in some words and did not understand the meaning of certain words in the texts. He also was not interested in reading the texts and answering questions, especially when he was required to correct mistakes.

The main objectives of the project were to diagnose and increase the reading comprehension level of a text passage and correcting spelling mistakes. The secondary objectives were to enhance the motivation for reading, writing and designing computer simulations.
The application was based on recording the pupil's reading and adding effects of sounds and animation of objects over the computer screen. Consequently, the pupil created slides on his own. The pupil became actively involved in the performance of the activity.

The stages of training are the following:

- The student teacher and the pupil typed the text and copied the images from the Internet to the PowerPoint slides.
- The pupil recorded himself reading the text. He knew all the recording process, created animations on his own and enjoyed seeing the results of his activities

The intervention computer program included three meetings. The training method was based on presenting the word, globally; then, correctly analyzing the word (phonetically) either in written or oral form.

Case No. 3 (Pre-intervention)
Hageage's project (44) was aimed at investigating the reading skills of a learning disabled pupil 10.6 years old. The student teacher was not aware of the pupil's ability to read sentences and do home assignments. The pupil could not exactly read the text with vowelization. He also read words without Hebrew vowel symbols slowly. He used to guess the words he knew. In addition, he made spelling mistakes.

The stages of learning:
The student teacher varied the computer learning activities.
For example a quiz, focusing on animals and gathering information from the Internet, "cloze" (completing sentences), memory games, etc.

Evaluation
Evaluations were made on comparing the level of:

- The student teachers' writing of the action research and designing the computer simulations
- The pupils' achievements before and after the training.

4. FINDINGS

It was found that the computer-based intervention program affected the achievements in the examined skills as following:
The student teachers became aware of the relationships between the pedagogic-didactic achievements and the theoretical scientific approaches they used as the basis of their studies. The student teachers' reports became then clearer and more detailed as well (See table no. 1). Furthermore, the motivation and self-confidence of the student teachers and pupils were enhanced.

Table No. 1: Example of Differences between the Level of Research Performance of the student teachers at the Beginning and End of the Course

Starting Course	**Ending Course**
Focus exclusively on theory.	Apply the theory to the practical work.
Edit the research, in general, without using authentic examples.	Edit the research according to the standards.
Write long complex sentences.	Write brief sentences.
Copy the articles' text.	Write the text in their own words.
Focus on some objectives. Have difficulty differentiating between main and sub objectives. Have difficulty formulating the assumptions.	Focus on the main objective/s and assumptions.
Mix results and discussion.	Differentiate between results and discussion, Summarize briefly each table showing the results. Then concentrate on the discussion, Analyze the results according to the theory.

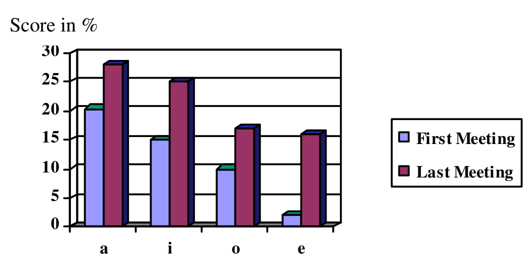
All the student teachers succeeded in their studies, while their pupils achieved high scores in the post-intervention tests, relatively to those in the pre-intervention tests. This improvement was clearly observed in the pupils' class scores.

The student teachers' reports relating their pupils' improvement strengthen the three cases exemplified in this paper.
We may highlight the progress noted among the student teachers by demonstrating each one of the projects that they performed.

Case Presentations (Post-intervention)

Case No. 1
The pupil improved his capability to read vowelized words with the help of vowel symbols patach (a), kamatz (a), hirik (i) and learned the vowel symbols full holam (o), tzerei and segol (e).
The student teacher hypothesized that "at the beginning I thought the pupil would improve his reading ability only, and merely in the vowel symbols patach (a), kamatz (a), hirik (i), Since he confused these three symbols, I did not figure I would succeed to teach him more Hebrew vowel symbols and surely I would not succeed to teach him writing".
But the results revealed that "the pupil improved his reading skills. Unexpectedly, the pupil made a deliberate choice to continue working. Even before this project, I had repeatedly worked with this pupil. I always believed he would advance, but I did not figure he would type words on the computer on his own. I also did not figure he would ask to continue working".
The student teacher summarized:
"I did not believe he would be so interested to learn and perform reading and writing activities. I figured he would like to finish his work quickly and pass to other activities which are more interesting for him. The learning became a **pleasant experience**". (See diagram no. 1).

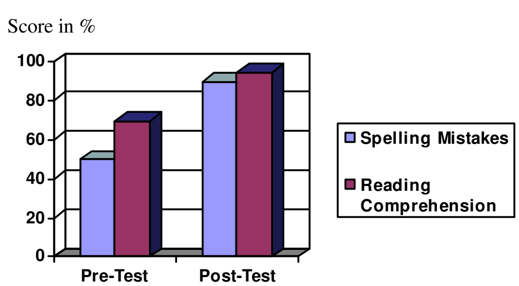
Diagram no. 1:



The data displayed in diagram no. 1 show an improvement in all the vowel signs. The improvement prominents in the tzerei (e) and segol (e) vowel signs.

Case no. 2 (Post-intervention)
Unexpectedly, the pupil succeeded in reading and understanding most words and had only a few spelling mistakes in his writing (See diagram no. 2).

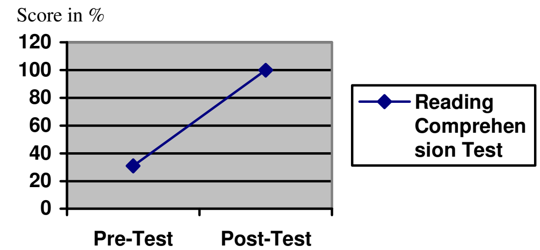
Diagram no. 2:



The data displayed in diagram no. 2 show that the pupil's achievements increased from 50% before the training to 90% after the training.

Case No. 3 (Post-intervention)
The pupil could read without vowelization (See graph no. 3).
Besides, his motivation for learning was enhanced. The pupil asked to continue working even at late hours at night. Consequently, he improved his performance in additional disciplines. Then, the pupil's mother worked with him according to the same method and he continued to improve his achievements. Also the teacher indicated that he advanced in his regular studies at school too.

Graph no. 3:



The data displayed in diagram no. 3 show an improvement from 31% before the training to 100% after the training.

Changes in the Teaching Staff

- The action research developed the student teachers' awareness of the pupils' capability to improve their computer and reading skills.
- The student teachers learned to diagnose the pupils objectively.
- Student teachers' self-confidence in using the computer, designing and manipulating simulations was enhanced.
- The student teachers improved their academic writing.

The Progress of the Pupils in their Learning Process

- The pupils learned to create virtual simulations on their own.
- The use of computers changed the learning gradually from mechanical to meaningful and relevant to the pupils' everyday environments. The reading achievements were improved.

5. DISCUSSION

The question raised in this research is whether the involvement of student teachers and pupils in designing and manipulating virtual learning environments impacts reading achievements.
In spite of the short time of training as novice computer users, before the training, the design and manipulation of virtual environments and an improvement in reading skills was recorded, as a result of the different non- routine mode of training.

Virtual Reality and Active Learning
According to Bagley and Hunter (45), students become empowered and spend more time in active construction of knowledge when using technology. Since our knowledge is constantly increasing, and there is now too much information to memorize, students should learn how to access information.

The investigation method of Mintz & Nachmias (46) was based on active learning. According to such a kind of learning, the learning is directly involved in the environment through natural direct experience and planned experiments in the laboratory. The Internet enables high accessibility to information in any area from any place in the world. Information and data achieved in real time through the net constitute a rich environment, where the learner explores gathering information.

The Role of Technological Manipulations in Learning and Thinking

Strommen & Lincoln (47) stress the importance of the way in which the technology is used. Computers and other technology should be viewed as tools which are an integral part of a child's learning experience. Manipulations must be used in the context of educational tasks to actively engage pupils' thinking with teacher guidance (48).

Educators can enhance the use of the technology of designing and manipulating virtual learning environments, and may affect the educational change by participating in the development of virtual reality.

Computer assisted design and manipulations guide student teachers to alter and reflect upon their actions, always predicting and explaining. The virtual reality environment is unique in its dynamic representation. Success in building and designing simulations of the real world has its motivating effect on the participants and thus enhances the effect of the training. In this research, the impact of the computer simulations on reading achievements and concentration skills was shown.

The findings indicated that the student teachers could integrate theory and practice in their teaching. Such a research work enables the student teachers to:

- Translate theoretical concepts into practical language,
- Apply them during the practical experience in a variety of educational contexts, and
- Interpret the results of the experiences by looking at them through the perspective of the theoretical approaches he/she has applied. Such courses usually focus on the basics of the use of computers only.

6. SUMMARY AND CONCLUSIONS

The scientific importance of the research lies in the student teachers' increased ability to carry out action research and write high level theoretical report (49) (50). The contribution of the research is also observed by their awareness of their ability to advance their pupils' reading and concentration skills by designing and manipulating virtual learning environments. In a technology-rich environment, technologies are merely tools/ or vehicles for delivering instruction (51).

The present study showed that this technology enhanced the theoretical and practical work of 30 student teachers majored in teaching pupils with special needs. The design of computer simulations and their manipulation showed the student teachers, that it serves as a mediator for developing academic skills, such as reading skills etc. While designing virtual instructional simulations, it became clear to the student teachers how they should read and which methods they should use for improving the planning and designing curriculum units. As the student teachers became more experienced in planning and designing virtual learning environments, they became more convinced regarding its impact on special education programs for their pupils in their practical work. Consequently, the pupils showed improvement in the trained skill.

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Embracing Web 2.0 and Starting E-Leader to form a Global Professional Network

Donald K. Hsu

Dominican College of Blauvelt

Division of Business Administration

Orangeburg, New York, USA

and

President, Chinese American Scholars Association

New York, New York, USA

Abstract

Internet III, Twitter and Web 2.0 (ITW) are the new fads. Students used ITW non-stop, in the classroom. Strategies to compete with ITW to recruit women and MSIM students were discussed in two papers at this conference. Web 2.0 social network sites such as Facebook, Twitter, YouTube generated 650 million followers. Should the business embrace them? In November 2009, this author employed the Linkedin as a tool to connect with professionals. Organizing eleven E-Leader conferences at Asia and Europe proved to be a social entrepreneurship for academic globalization. Results: 2,500+ professionals were linked and 127 board members joined from 31 countries.

Keywords: Internet III, Twitter, Web 2.0, Linkedin, CASA, E-Leader, Zoominfo

EISTA conferences have existed for many years. Most professional conferences tend to repeat themselves. Engineering professors will attend engineering conferences and social science professors will attend conferences on social issues. As a result, they never meet each other. Large conferences got 300 to 1000 attendees with 5 to 10 parallel sessions. Speakers presented their papers for 20 minutes and left. There was little interaction among individual at large conferences.

Since 1989, this author attended many foreign conferences. The Russia conference had 100 attendees, but only 15 speakers were outside of Russia. Everyone was in the same room. Professor would cover topics in social science, engineering, history, finance, etc. It was interesting to learn areas outside of one's discipline. As a result, there was much more exchanges among the small group.

Chinese American Scholars Association

Chinese American Scholars Association (CASA), was founded for academics, managers, professionals and others who shared and supported the concerns of the Chinese American issues. CASA was registered with the State of New York and Internal Revenue Service (IRS code Section 501 C-3) as a not-for-profit tax-exempt organization in 1989. CASA ran many workshops and conferences in the New York area with daily attendance 30 to 450 people. In 2004, emerging markets such as Brazil, Russia, India and China moved to the global stage. Electronic technology, Internet, robotics, virtualization provided new and innovative way to learning. This author was voted as the CASA President in 2005.

While attending a conference in Istanbul, Turkey, this author met Diana Silonova. Diana was a vice president of Vase Management in Connecticut. Vase is a company that does event planning. After meeting with Vase CEO Vee Adusei and obtained the approval of CASA board, a joint venture was formed to start E-Leader, which is to run international conferences in Asia and Europe to address these global issues.

Setting up a website

Vase Management employed experts to set up a simple website, so it can be used to disseminate information. The setup is not difficult, but was continually updated [1].

Accounting, Marketing and Operation

To keep the cost down, CASA employed staff in Eastern Europe. They are down to earth and professional. Yet the cost is much lower. To do marketing, CASA placed ad with Chronicle Higher Education four times, with limited success. This author got much information on speakers from past international and domestic conferences. CASA put together an email list of these speakers and continually generated new ones. Marketing is done by emails and follow-ups.

E-Leader is a low-cost operation. There was no physical office, no utilities (electricity, gas, water), no rent, and no salary. The cost is to maintain the website and email operations. The major cost for this author, is to travel to the different cities to run the conference. Since the University did not cover these expenses, the cost is treated as a tax deduction.

Location, Location, and Location

To make any conference a success, location is the key. CASA board decided to run two conferences per year, one in Europe and one in Asia. In June, the temperature ranged 60 to 75 degrees in Europe. It is ideal for a summer conference because American professors have summer off while European universities still have class in June. In January, the temperature was 75 to 90 degrees for Southeast Asia. This was perfect for a winter conference because most places in USA or Europe are cold in winter. Two choices of the conference location are: a hotel or a local University. The cost of hotel is prohibitive. With the good contacts from universities, CASA decided to employ Universities as the local hosts. This worked out well.

Registration and Payment

CEO, managers, professors, researchers participated as speakers. CASA charges the speakers only. Speakers are CASA customers. Local attendance, not presenting a paper, is free. CASA does this to encourage local participation.

CASA has a small staff. To collect fees in a foreign country is a major challenge. At one point, CASA set up a credit-card online payment. It turned out it worked for US credit cards, but not for foreign credit cards. After many trials and errors, the best practice is to get bank check or certified check from American speakers. For non-US speakers, they can pay by bank check, money order or Western Union. Another choice is wire transfer. For the repeat speakers (customers), wire transfer is the best way.

Benefits for Attending E-Leader

Speaker gets to visit a city in Europe or Asia and to publish his/her paper for possible promotion or tenure. For professors, this is a great incentive. Publication is not important for CEO or manager. But traveling to a new city to share success story is very compelling. Registration fee paid to CASA is fully deductible because CASA is a non-profit firm, registered with US government. Airfare, hotel and related expenses may be deductible if they are part of a professional development to maintain a job as a professor or researcher. For CEO or manager, the company normally paid all fees. One needs to consult tax preparer, CPA or accountant to find out tax deductibility for attending E-Leader.

CASA charges low fees ($300 for first paper, and $75 for each additional paper). The speaker gets an online publication and a copy of CD-ROM. These publications were approved by the US Library of Congress, with two different ISSN numbers. Twenty years ago, people attended conferences, and got a thick volume of conference proceeding, 500 to 1000 pages. It was so heavy. In the E-Leader era, CD-ROM is much better.

Embracing Web 2.0 Linkedin:

Since November 2009, this author started connecting professionals on Linkedin [2]. In the beginning, it was not active. Two or three people were linked in a week. Then this author joined the 50 discussion groups. As soon as someone posted a discussion, any one that belongs to this group can post a reply. This quickly became a threaded discussion. One person will say, yes I agree because or I disagree due to …. A variety of topics were discussed and some topics lasted for more than two years. As a result, this author built up a professional network employing Linkedin.

What about Facebook, Twitter, Ning and others? 600 million people are on Facebook daily posting pictures, chatting, etc. Millions are on Twitter, using iPods, BlackBerrys, texting or sexting. This author was not interested in posting photos or sharing photos with students. Anthony Weiner did the sexting and ended up resigning from Congress [3]. Professors, CEO, managers should behave in professional manners. Linkedin is a network with 100 million professionals worldwide. It provided the perfect forum for this author. As a result, many professionals became E-Leader speakers /customers because they understood the value of attending E-Leader conference.

Conclusion

It is ideal to start a business using Internet. Since 2006, using Email marketing, Web 2.0 Linkedin, a local university support, excellent staff, CASA ran 11 successful E-Leader conferences in Asia and Europe. 2,500+ people were connected to this author via Linkedin. CASA has 127 board members from 31 countries. Academic globalization is fantastically rewarding!

Speaker/Customer Testimonials

"Donald Hsu has demonstrated an exemplary leadership in delivering value in the fields of business ethics, e-learning, and globalization. It is a pleasure to work with such a strong leader, lecturer and business professional", March 1, 2011, Irene Jeremic, CEO, The Tableau Inc, Toronto, Canada

"Dr. Donald Hsu advocates deepening AND broadening the perspectives of scientists and professionals, by organizing inspirational bi-yearly conferences on a wide range of topics, in an informal atmosphere with ample room for a vivid and spirited exchange of visions and ideas between representatives from many countries around the globe. It's a truly intercontinental and cross-cultural event, taking place in locations in Europe (summer) and Asia (winter). I highly commend Donald for his on-going efforts to create these events, and encourage anyone to participate in a next E-Leader Conference." January 6, 2011, Loek Hopstaken, *Guest Lecturer & Professor, Wittenborg Business School, Netherlands*

"Donald Hsu is a superb conference organizer and one of the most amazing individuals I have ever met. He has boundless energy, is bright and knowledgeable in many areas, and accomplishes more work than anyone with whom I have ever been associated." November 7, 2010, Dr. James L. Morrison, Professor Emeritus Educational Leadership, The University of North Carolina at Chapel Hill, North Carolina, USA

"Dr. Donald Hsu is a very well versed professor in business and management and particularly in E-Commerce. He is running a very well organized association where fantastic academic papers from all around the world are presented by first class educators, professors, lecturers, and businessmen. He is a unique individual and extremely professional at what he does." August 10, 2010, Pooyan Fard, MBA, Universiti Malaya, Kuala Lumpur, Malaysia

"I attended the E-Leader conference in Budapest, Jun 7-9, 2010. The content was surprisingly broad, dealing with topics such as education, health, and consultancy. Society + technology = crowd-sourcing, one of the best marketing tools in the online offline community. I made good contacts with CEOs, managers, and professors, from different parts of the world. I strongly recommend E-Leader to anyone interested in lateral business thinking. Thank Dr. Hsu, for organizing this conference." August 3, 2010, Marco Monfils, *Owner-Advisor, MX4 Marketing, Budapest, Hungary*

"I had the honor of being invited to E-Leader conference, which is being hosted by Dr. Donald Hsu. This series of conferences mirrors through its unique design the management challenges of today." July 11, 2010, Luke McBain, *Freelance management trainer and consultant, McBain Consulting, Berlin, Germany*

"Donald is the driving force behind the e-Leader conferences, which are held bi-annually either in Asia or in Europe. The events are well organized and a great platform to exchange academic knowledge and build a personal network." May 16, 2010, Dr. Daniel F. Oriesek, *Principal, A.T. Kearney (International), Zurich, Switzerland*

"Donald ran a very professional and high-caliber E-Leader Conference in Singapore that included outstanding speakers, excellent and timely topics, and a vast array of C-levels, academics, and consultants. His extensive international business background, as well as a very approachable demeanor, created an environment in which conferees felt connected and enriched by the conference. As a result of the conference, Donald and I will be doing business together soon in international markets through our networks." February 8, 2010, Dr. Johndavid Kerr, *Assistant Professor and Chair, Harris-Stowe State University, St. Louis, Missouri, USA*

"Don is a savvy businessman who has transferred expertise from that area to education. His broad experience makes him a valued instructor. He is also reflective on the overall environment, and wrote a conference paper critically examining the educational process at the University of Phoenix. Through CASA, Don shows his ability to network with a large and learned body of scholars", October 3, 2009, Dr. Thomas Schmidt, Associate Dean, School of Computer Information Sciences, DeVry College of New York, New York, USA

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Thank Diana Silonova and Vee Adusei of Vase Management for website and marketing effort. Thank 11 universities/firms in Asia and Europe as local hosts. Thank CASA board members and staff. Dr. Leo Bruno from Dom Cabral Foundation Brazil, attended eight E-Leaders. Thank Prof. Ludmilla Sterbova of University Economics Prague in Czech Republic, Susan Sapsed of University Bedfordshire UK, Dr. Sidney Castle of National University California, and many others for promoting E-Leader to their colleagues. Thank 2500+ professionals on Linkedin to provide continuous collaboration and support. Zoominfo carries the biography of Hsu [4].

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The Study of Heterogeneous Cooperative Learning towards Blended Learning Performance

David W. S. Tai
Chair Professor, Dept. of Computer Science and Information Management, Hungkuang University
Taichung City, 43302, Taiwan

Soung-Po Shen, Yo-Wei Lin, Ren-Cheng Zhang, Jia-Ling Chen
Graduate student, Dept. of Industrial Education & Technology, National Changhua University of Education
Changhua City, 500, Taiwan

and

Vincent Tai
Department of Electrical and Computer Engineering, University of Iowa
Iowa City, Iowa, USA

ABSTRACT

This study analyzed the effects of two heterogeneous cooperative groupings' blended learning on programming design learning achievements and attitudes. To achieve the above objective, this study used a quasi-experimental design to conduct the experiment. Additionally, the research instruments used in this study included: Thinking Styles Inventory, cognitive style scale, programming design learning achievement scale, programming design learning attitude scale, and programming design blended learning teaching materials. The research subjects of this study are students from two classes of the first-year required programming design course within the information management department at a university of technology. The two classes were divided into experimental groups A and B. Experimental group A used academic achievement and thinking style grouping while experimental group B employed academic achievement and cognitive style grouping. The t-test, ANOVA and Hotelling's T^2 were used for statistical analysis. The results and concluding remarks are discussed.

Keywords: Heterogeneous Cooperative Learning, Thinking Style, Cognitive Style, Blended Learning, Programming Design

1. INTRODUCTION

The twenty-first century brings us a high-tech society with explosive information availability through Internet connectivity. The technological development rate has exceeded previous development speeds, surpassing human imagination; new technologies and techniques are constantly advancing. Therefore, in this information-based society, every citizen must have knowledge of and ability with information technology so as not to be drowned in the flood of information technology. Foreman [1] pointed out that programming design is for training essential computer knowledge and skills and also for understanding computer science. Accordingly, programming design is a relatively important computer competency. However, many research findings from European and American researchers have indicated programming design requires problem solving and analytical thinking skills. Unfortunately, many students of programming design courses lack these skills [2]. On the other hand, software development often requires coordinated efforts of multiple members of a team, so teamwork skills are important, such as communication, leadership, negotiation, and team management [3]. Accordingly, blended cooperative learning can be applied to programming design courses.

Sternberg [4] thought that numerous factors affect student performance. These factors can be divided into intelligence and non-intelligence categories. Intelligence test scores can only predict 20% of students' grade differences in school. As for the non-intelligence factor, the question of how to match the application of personal style has become the key to learning success or failure. In previous research, there have been numerous discussions of learner style, including thinking style, cognitive style, and so on. Therefore, this study mainly focused on exploring the impact of heterogeneous cooperative sub-groups that were formed with different thinking styles and different cognitive styles on blended learning performances. Accordingly, the purpose of this study was to investigate the blended learning performances differences for programming design between "thinking style and academic achievement" within a heterogeneous cooperative group and "cognitive style and academic achievement" within a heterogeneous cooperative group.

2. LITERATURE REVIEW

Cooperative Learning

Cooperative learning is a teaching strategy or approach that places individual students into teams or groups; it is a teaching strategy that is oriented toward accomplishing the teaching goals by encouraging group members to solve problems through cooperation, co-exploration, and discussion; teachers walk among groups to assist and promote students and peers to collectively improve [5]. Accordingly, this study defines cooperative learning as: using heterogeneous grouping to divide students into two or more groups to conduct teaching activities; in order to achieve common goals, group members become cohesive as well as help, share, communicate, and discuss with each another during learning process so as to increase student learning performances and to develop the teaching strategy that encourages team cooperative spirit.

Thinking Style

"Thinking" is the process an individual employs when using existing knowledge and experience as a base, through information processing, to apply his/her intellectual capacity to explore and select when solving problems and exploring new knowledge [6]. "Style" is the group of habits based upon personal preference, that is, a person's thinking attitude when looking at things. Style is not intellectual capacity but a method of using the intellect, and there is no good or bad style. Everyone has his/her own style and uses different styles for different situations [4]. Thinking style in this study references the score the subject student obtained on

Seterberg's Thinking Styles Inventory (TSI), and this study retrieved and divided the hierarchical aspect of the Thinking Styles Inventory into global type and local type to be used as the basis for heterogeneous cooperative learning grouping.

Cognitive Style

Messick [7] defined cognitive style as information processing habit, which the typical personal as an individual demonstrates when exercising perception, thinking, problem solving, and memory functions. Cognitive style influences learners on the choosing, compiling, organizing storage, retrieving, interpreting, and generating information methods of learning effect [8]. Therefore, cognitive style is the habit and characteristic that is exhibited with explicit behavior after an inner process of perception, memory, thinking, and problem solving of an individual when facing a situation [9]. Wu [10] translated the cognitive style compiled and made by Messick into Chinese and then modified the Hidden Figure Test score to be used as the reference of heterogeneous cooperative learning grouping. The higher the score, the more field independent the subject's cognitive style is, and vice versa.

Programming Design

Programming design is a task that involves creativity and logical thinking skills. Because it requires a wide variety of knowledge, traditional teaching methods cannot effectively help and guide students to come up with a solution to programming design related problems when encountered [11]. Therefore, programmers must use the programming design language set within the programming design software and apply their own logical thinking abilities and programming design skills to solve problems or accomplish tasks and goals. Simultaneously, students of programming should possess: ability to solidly understand programming design language description output/results, ability in programming design specifically oriented toward the specific problem, and ability to find, modify, and eliminate errors.

Blended Learning

Blended Learning is a learner-centered learning strategy, which enables learners to have increased choice and autonomy; learners can autonomously take advantage of digital learning's strengths and characteristics prior to or after traditional face-to-face courses, in order to enhance learning performances [12]. In other words, this approach combines online learning and face-to-face learning and may become the mainstream teaching model [13].

Curtis et al. [14] proposed three broad hybrid cooperative learning definitions: 1. combination of teaching methods, 2. combination of teaching approaches; 3. combination of online and face-to-face teaching. Even so, Dziuban et al. [15] thought that blended cooperative learning can be considered a social opportunity that combines the effectiveness and the advanced technology of classroom and online learning environments. In other words, blended cooperative learning combines face-to-face teaching and digital learning and can obtain teaching goals more effectively than digital learning alone [16-17]. In addition, blended cooperative learning is a redesign of the basic teaching model and its teaching method is based on the assumption that it has the advantage of face-to-face interaction and also has the advantage of online learning methods [18].

3. METHOD

Research Design & Participants

This study attempted to investigate the impact of heterogeneous cooperative learning on blended learning performances. Blended learning includes online discussions and face-to-face discussions. This study analyzed the effects of the heterogeneous cooperative groupings' blended learning on programming design learning achievements and attitudes. To achieve the above objective, after reviewing all related literature, this study choose students from a programming design class in a university of technology as the research subjects. This study used a quasi-experimental design to conduct the experiment. The research subjects of this study are students from two classes of the first-year required programming design course within the information management department at a university of technology. There are 92 students in these 2 classes.

Instruments

The research instruments used in this study included: Thinking Styles Inventory (TSI), cognitive style scale, programming design learning achievement scale, programming design learning attitude scale, and programming design blended learning teaching materials. The main purpose of the above scales was to gather the information and data that were related to this study while the programming design multimedia computer-assisted teaching material was used for blended learning.

Thinking Styles Inventory: In a study of TSI, R. J. Sternberg [4] noted the range of the internal validity of the TSI scale reliability was from .56 to .88, with a median of .78. Correlations greater than .50 in absolute value were global with local -.61, liberal with legislative .66, conservative with legislative -.50, conservative with executive .59, and liberal with conservative -.60. In this study, the Cronbach's α value of the TSI is .86.

Cognitive style scale: In the study of Wu [10], the split-half reliability was .86, and the criterion validity was .51.

Learning achievement scale: After item analysis, the programming design learning achievement scale's KR-20 value was .82, and the split-half reliability was .72.

Learning attitude scale: In this study, the Cronbach's α value was .90, and the criterion validity was between .892 to .917.

Thus, all the measurement scales have highly consistency.

Research Procedure

Implementation of Grouping: We randomly picked one class to give TSI; the other one was given the cognitive style scale.

Cognitive style heterogeneous grouping of the class was based on the subject's cognitive style score (Hidden Figure Test) [10]; a subject with a higher score means his/her cognitive style is more field independent whereas a subject with a lower score denotes his/her cognitive style is more field dependent. After arranging cognitive style scores in descending order, we divided the subjects into two sub-groups: the top 50% was field independent group and the bottom 50% was field dependent group. After arranging entrance examination scores in descending order in both field independent and field dependent groups, the top 50% of the entrance examination scores is field independent with high entrance examination scores sub-group and field dependent with high entrance examination scores sub-group, respectively. In contrast, the bottom 50% of the entrance examination scores was field independent with low entrance examination scores sub-group and field dependent with low entrance examination scores sub-group, respectively. We then extracted one person from each above four groups to form a heterogeneous cooperative learning sub-group (four persons per sub-group), thus grouping all participants to form experimental group A.

According to the score on TSI, developed by Sternberg [19], we undertook the thinking style heterogeneous grouping and then classified high entrance examination scores and low entrance examination scores students into global type and local type. Combining with the entrance examination scores, there were four sub-types of students: global and high entrance examination scores (25%), global and low entrance examination scores (25%), local and high entrance examination scores (25%), local and low entrance examination scores (25%), respectively. Next, we extracted one person from each above four groups to form a heterogeneous cooperative learning sub-group (four persons per sub-group), thus grouping all participants to form experimental group B.

Implementation of Experimental Teaching: After the administration of these tests, all students in both groups participant four hours a week of blended learning for six weeks. In order to ensure the internal and external experimental validities, both groups received blended heterogeneous cooperative learning using the same teaching material and content by the same instructor.

Implementation of Post-test: After the experimental teaching, all subjects received post-tests; the measurement scales used included: 1. programming design learning achievement scale, 2. programming design learning attitude scale. Post-tests were used to measure the programming design learning achievement and attitude.

Data Processing: We conducted statistical analysis on the data obtained from the post-test measurements to investigate programming design learning performances differences between the heterogeneous cooperative learning groups. For statistical analysis, SPSS 12.0 package was used. The significance level for the statistical results in the study was .05, and all the results were tested two ways. Hotelling's T^2 was run to compare the post tests scores.., ANOVA would be used if the Hotelling's T^2 value reaches the significance level.

4. DATA ANALYSIS

Data obtained after the experiment were used to statistically test hypotheses proposed by this research.

Basic Data Analysis of Samples

After removing the invalid sample who failed to participate all the way, experimental group A included 44 valid samples(11 heterogeneous cooperative learning subgroups) while experimental group B included 44 valid samples(11 heterogeneous cooperative learning subgroups), a total of 88 valid samples. Frequency distribution (N) and percentage (%) statistical methods were used to analyze valid samples' data. Research results are as follows:

Gender: 59 participants were male, accounting for 67% of all subjects; 29 participants were female, accounting for 33%.

Enrollment background: 42 students' belonged to the industrial track of vocational high school, which accounted for 47.7% of the all subjects. There were 29 students, accounted for 33.0% of the all subjects, whose backgrounds were business or management major, which are summarized into the business track of vocational high school; 17 students, accounted for 19.3% of the subjects, were from the background of general high school, which is classified as high school track.

Gender Analysis

In this study, Levene's test was used to test homogeneity on the programming design course learning achievement; Levene's test reached a statistically significant difference (F = 5.880, p = 0.017), accordingly, the variances of different genders were not homogeneous. Therefore, the degree of freedom of t-test required correction. On the contrary, Levene's test of homogeneity of variance for programming design course learning attitude did not reach statistical significance (F = 0.286, p = 0.584),

The result of t-test analysis shown that different genders did not have any significant differences on programming design course learning achievement (t =. 789, p =. 432) nor programming design learning attitude (t =-. 981, p =. 332), as shown in Table 1.

Table 1: Homogeneity test result for different genders on programming design course learning achievement

Variables	Male		Female		df	t	p
	Mean	SD	Mean	SD			
Achievement	12.360	6.820	14.210	8.960	44.469 a	.789	.432
Attitude	3.403	.437	3.327	.391	86	-.981	.332

[a] Degree of freedom after correction

Background Analysis

The Levene's test was used to test the homogeneity, on programming design course learning achievement (F = 1.855, p =. 163) and programming design course learning attitude (F =. 262, p =. 770) did not have any significant difference, which mean that there were homogeneous among different backgrounds.

In the ANOVA analysis, results indicated that students with different background did not have significant differences on both programming design course learning achievement (F = 1.328, *p* =. 271) and programming design course learning attitude (F = .570, *p* =. 568), as shown in Table 2.

Table 2: The ANOVA analysis summary among the different backgrounds

Variables		SS	df	MS	F	p	η^2
Achievement	Between-group	151.862	2	75.931	1.328	.271	.013
	Within-group	4861.036	85	57.189			
	Overall	5012.898	87				
Attitude	Between-group	.204	2	.102	.570	.568	.030
	Within-group	15.241	85	.179			
	Overall	15.446	87				

Programming Design Learning Performance Analysis between group A and B

This study used Hotelling's T^2 to test learning attitude and achievement differences related to the programming design course between two heterogeneous cooperative learning groups.

Both programming design achievement post-test scores (Levene F = 1.608, P =. 208) and programming design attitude post-test scores (Levene F =. 007, P =. 937) did not reach a statistically significant level in Levene's homogeneity test and in the overall homogeneity test (Boxes M = 1.989, p =. 585), which matched the assumption of homogeneity of variance.

In Table 3, the two heterogeneous cooperative learning group students had significant differences on post-test scores of the programming design learning performance (Hotelling's T^2 =. 422, F = 17.917, p =. 000).

Further more, ANOVA analysis indicated two heterogeneous cooperative learning group students had significant differences on the post-test scores of both programming design learning achievement (F = 22.982, P =. 000) and attitude (F = 12.835, P = .023).

Table 3: Hotelling's T [2]and ANOVA summary between group A and B

source of variation	df	SSCP (Achievement, Attitude)	Hotelling's T^2	F Achievement	F Attitude
Between-group	1	$\begin{bmatrix} 13.440 & -2.912 \\ -2.912 & 3955.795 \end{bmatrix}$	.422***	22.982***	12.835***
Within-group	86	$\begin{bmatrix} 1004.304 & 3854.580 \\ 3854.580 & 14794.102 \end{bmatrix}$			
Overall	87				

*p<.05

The mean and standard deviation of programming design learning achievement and attitude were shown in Table 4.

Table 4: Summary of programming design learning attitude and achievement post-test scores

Group	Samples	Achievement post-test scores		Attitude post-test scores	
		Mean	SD	Mean	SD
A	44 Students (11 Groups)	16.430	7.209	3.529	.376
B	44 Students (11 Groups)	9.500	6.326	3.227	.414

After comparing each group's average, students in the thinking style and entrance examination scores group had higher post-test scores on programming design achievement and attitude than students in the cognitive style and entrance examination scores group.

5. CONCLUSION AND SUGGESTIONS

Conclusion

This study attempted to investigate the impact of programming design course heterogeneous cooperative learning on blended learning performance among university of technology students. This study also examined the differences of student enrollment backgrounds and genders. Furthermore, to discuss the differences of "thinking styles with entrance examination scores" and "cognitive learning styles with entrance examination scores" on programming design learning performance. Findings indicated that backgrounds and genders had no differences on the programming design performance. However, the participants in the "thinking style with entrance examination scores" group had better programming design learning performance than the "cognitive style with entrance examination scores" group.

Suggestions

In the past two decades, numerous studies supported cooperative learning as a strong enhancer of learning performances and that cooperative learning is applicable to all academic years across various disciplines [05]. Slavin [20] stated that cooperative learning can enhance learning performances, improve interpersonal relationships among peers, and enhance students' thinking, problem solving, integration, and application skills. Findings from cooperative learning relevant literatures indicate the heterogeneous cooperative learning grouping has the best learning performances. Accordingly, this paper suggests the implementations of cooperative learning should lead to adoption of heterogeneous cooperative grouping. However, there are many references regarding heterogeneous cooperative grouping, therefore, in this study, participants of the "thinking style and entrance examination scores" heterogeneous cooperative learning grouping have significant better learning performances than students of the "cognitive style and entrance examination scores" heterogeneous cooperative learning grouping. As a result, this study suggests that teachers use "thinking style and entrance examination scores" as the reference for heterogeneous cooperative learning grouping when using heterogeneous cooperative learning approach to teach, so as to significantly enhance learning performances.

6. ACKNOWLEDGEMENT

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Connections, Information and Reality

'*thinking about the internet of things'*

Dr Ben van Lier CMC

Centric

Gouda, P.O. Box 338, 2800 AH, Netherlands

Abstract

The number of connections between people, organizations and technology is proliferating rapidly, and the amount of information they produce, exchange and share is increasing accordingly. These connections and the information they produce are defining and shaping our daily life and work and our perception of reality. Computers in all forms are becoming smaller and less visible, but they are omnipresent. This development of information technology 'everyware', as Greenfield calls it, is also referred to as ubiquitous computing. With the development of ubiquitous computing, computers not only disappear from our perception, but also from our experience. When these new and almost invisible technological devices are tied together, for instance in the Internet of Things, the information resulting from that connection will be more than the sum of its parts. The Internet is the place where subjects are connected and where they exchange and share information. With the development of the 'Internet of things', the Internet will also connect objects and enable them to exchange and share information. In this Internet of the future, subjects and objects are more and more connected in random coalitions and networks on the basis of information. These new connections and their seamless exchanging and sharing of information will challenge traditional organizational structures. The information produced in networks will be used for changes to our existing reality and will help create a new reality. Will this development of subjects and objects connected in networks raise new questions and challenges for science and for the development of knowledge within a changing reality?

Keywords: *Postphenomenology, ubiquitous computing, networks, interpenetration, enactment*

1. Postphenomenology

The connections that arise within and between combinations of man, organization and technology define, as observed by philosopher Martin Heidegger (1927), the way in which reality as created by the joint efforts of man and technology is approached. This specific combination also determines the eventual possibilities of what products or services can be produced (as in the combination of weaver and loom, and blacksmith and anvil). Heidegger attempts to unearth new and as yet non-existent phenomena in the relationship between man, organization and technology. Heidegger discourages us from considering technology as something mythical or unreal, urging us to look for the essence of applied technology, the relation with that technology, and the underlying objective of technology usage. He found that technology and technological applications are increasingly becoming a framework around the actions of individual people or the collective of people. Following on from Heidegger, philosopher Don Ihde (2003:2009) posited that modern man should start devising an interrelational ontology of entities that applies to new and hybrid combinations of man, organization and technology. Interrelational ontology refers to the inextricable link between human experience and the environment or world in which humans live. In this world, man and organization are subject to continuous changes to their perception and experience of reality. This process is affected by the fast development and uptake of technology and technological applications that play a fundamental role in man's environment. Ihde argues for research into and analysis of the new embodiment of these relations, and to analyze them as relations of man, technology and world (IT, digimedia). Embodiment is Ihde's concept signifying the way in which man approaches his environment or world, connects with it, and the role of artifacts or technology in that. Within that very framework we can, for example, consider the reciprocal relations of man-IT-man and organization-IT-organization in any possible manifestation as a kind of embodiment of relations between hybrid systems as defined by Ihde. The mutual relation that thus arises between subjects and objects, and between the physical and the digital world, requires a new and different approach to these relations. Continuing Ihde's train of thought, Verbeek (2005) goes on to designate that new approach using the term 'post'phenomenology: "*From the postphenomenological perspective, reality cannot be reduced to interpretation, language games or contexts. To do so would amount to affirming the dichotomy between subject and object, with the weight merely being shoved to the side of the subject. Reality arises in relations as do the human beings who encounter it*". (2005:113). During the ninety years that separate the ideas of Heidegger and those of Ihde and Verbeek, technology not only saw sweeping changes, but also became a more integral and indiscernible part of our daily existence. This has not only changed our relationship with this technology and these technological applications and made it more self-evident, it is also increasingly changing what we produce using this technology. Technology and technological applications are increasingly turning into the framework within which we live and work. They encase our everyday reality. In this context, I concur with Berger & Luckmann's definition of reality: *"It will be enough for our purposes, to define 'reality' as a quality appertaining to phenomena that we recognize as having a being independent of our own volition, and define 'knowledge' as the certainty that phenomena are real and that they possess specific characteristics."* (1966:13). Berger & Luckmann argue that everyday reality is experienced as something we take for granted and does not require additional verification in its everyday appearance and perception. Everyday reality is just there, Berger and Luckmann point out, as an undeniable axiom. Man's biological development therefore always feeds off his surroundings, *"in other words, the process of becoming man takes place in an interrelationship to its environment*". (1966:66). The increasing number of interconnections between man, organization and technology are causing them to be ever more intertwined. They are basically casually drawing on that relation in creating a new everyday reality as an everyday environment made up of reciprocally interacting elements. The Internet is one example of relations and the possibilities these offer for the exchange and sharing of information. The relation between man, organization, technological application and the Internet, and the information exchanged and shared within that realm, drives our perception of everyday reality.

2. Ubiquitous Computing and the 'Internet of Things'

At the end of the twentieth century, Mark Weiser (1991) concludes that a new way of thinking and working is needed in relation to the physical fashion in which computers present themselves in the world. The basic underlying principle for Weiser's new way of thinking is that computers in a new manifestation will eventually fade into the background of the human environment, both physically and in terms of perception, and will at the same time disappear from man's perception altogether. Computers will, in his view, become smaller, increasingly indiscernible and more autonomous over time. Weiser (1991) comes up with the concept of ubiquitous computing to refer to that new reality of computers. The real challenge Weiser (1993) sees in the development and shaping of ubiquitous computing is that it will involve reinventing and reshaping the relationship between man and computers *"one in which the computer would have to take the lead in becoming vastly better at getting out of the way so people could just go about their lives"*. (1993:2). The advent of the Internet adds, in Weiser's theory, a new dimension to the concept of ubiquitous computing. Weiser considers the Internet as a form of distributed computing (1996) connecting millions of people and computers through a network (i.e. the Internet) to exchange and share information. The evolution of the Internet will eventually not only make it a network of distributed computers, but also contain ubiquitous computers. These ubiquitous computers are small, indiscernible and, as the concept suggests, ubiquitous. When discussing the development of ever smaller and ubiquitous computers, Weiser says: "*tie them, to the Internet, and now you have connected together millions of information sources with hundreds of information delivery systems in your house*". (1996:5). The evolutionary development towards a combination of distributed computing and ubiquitous computing will, in Weiser's opinion, peak in the period between 2005 and 2020. According to Greenfield (2006), ubiquitous computing forebodes a development that will see everyday objects enabled to observe their own environment and record information about, for example, their environment, location, status and history. And the possibility of exchanging and sharing that information with other objects and subjects will inevitably lead to a changing relation with these objects. "*We'll find our daily experience of the world altered in innumerable ways, some obvious and some harder to discern*". (2006:23). Looking upon all available technological possibilities as components of a network of mutual connections leads to a whole that is more than the sum of its parts. The (im)possibilities and applications of this new whole are as yet uncharted. Greenfield therefore goes on to state: "*But when things like sensors and databases are networked and interoperable, agnostic and freely available, it is a straightforward matter to combine them to produce effects unforeseen by their creators*". 2006:143. Greenfield foresees the birth of this network of sensors and databases and the ensuing behavior throwing up some new and major challenges for us as individuals and as a society in the coming years. However, Bell and Dourish (2006) point out that Weiser's prophecy has basically already been fulfilled in that the network he foresaw has already taken root in our society: "*in the form of densely available computational and communication resources, is sometimes met with an objection that these technologies remain less than ubiquitous in the sense that Weiser suggested*". (2006:140). Bell and Dourish base their finding on the unstoppable development of mobile applications and the possibilities these offer to exchange and share information anytime and anywhere. Although mobile telephony is a form of ubiquitous computing that is still visible and tangible for subjects, that visibility and tangibility is a whole lot less in the case of a technological application such as the RFID chip. Wu et al. (2006) describe a radio frequency identification (RFID) chip as a: "*small tag containing an integrated circuit and an antenna, which has the ability to respond to radio waves transmitted from the RFID reader*" (2006:1317). One of the manifestations of the concept of ubiquitous computing is the development and shaping of the 'Internet of Things'. In a report published by the cluster of European research projects on the development and shaping of this 'Internet of Things' (CERP-IoT - 2010) the effect of this concept is considered an addition to existing interactions between man and their applications. Within the context of the 'Internet of Things', a 'thing' is defined as a real/physical or digital/virtual entity that exists and moves in time and space and that can be identified. The 'Internet of Things' is an integral part of the development towards and the future usage and application of the Internet. The 'Internet of Things' will slowly but surely create a dynamic network of numerous and wirelessly connected 'things' that are capable of intercommunication. The 'Internet of Things' arises and is developed based on, among other things, ideas stemming from the concept of ubiquitous computing. The 'Internet of Things' enables interconnections between people and things anytime and anywhere. Mark Weiser's vision is set to become reality in the coming years as the 'Internet of Things' evolves. The evolution of the 'Internet of Things' will, according to Clarke (2003) inevitably lead to changes in our private and work lives both on an individual and a collective level. On an individual level, new technological applications will further blur already diffuse boundaries between man and technology. On a collective level, this new form of distributed and activity-sensitive software will enable us to accrue new knowledge based on the electronic traces left behind through the use and application of that knowledge. Clarke formulates the latter as follows: "*These shiny new tools will not simply redistribute old knowledge; they will transform the ways we think, work and act, generating new knowledge and new opportunities in ways we can only dimly imagine. Our smart worlds will automatically become smarter and more closely tailored to our individual needs in direct response to our own activities. The challenge, as we are about to see, is to make sure that these smarter worlds are our friends, and that our tracks, tools and trails enrich rather than betray us*". (2003:165). In order to be able to develop and shape this new and smart world, we need better understanding of ourselves as humans, Clarke states. The first step en route to this greater understanding of the concept of the human being is the recognition that man is de facto already a hybrid being. Man as a hybrid being is a combined product of our biological origin and the cultural, linguistic and technological networks man is part of. Only based on that recognition of man as a hybrid being will we be able to make an active contribution to the development and shaping of a new and smart world, as well as the corresponding technology and culture, while also developing into the human beings we want to be in such a world.

3. Organizations and Networks

Biologist Ludwig von Bertalanffy (1966) claimed that the combination of technology and society (nuclear bombs, the space program) had become too complex for traditional scientific approaches and interpretative systems to grasp. He identified a need for more holistic or 'system-oriented' and more generic and interdisciplinary approaches, and therefore formulated a general systems theory; a doctrine or a collection of accepted and well-founded general principles and methods, which can be applied to all kinds of systems that are the object of scientific research in different fields. He defines a system as a complex of mutually interacting elements, with interaction meaning that these elements are in a mutual relationship and that they all have an effect on each other. The approach that ensues from general systems theory is, in the eyes of Von Bertalanffy, not limited to material entities, but rather intended for entities that are partly immaterial and largely heterogeneous in their make-up. This latter point is, in my view, fully applicable to the development of ubiquitous computing and the ensuing 'Internet of Things'. The development towards networked subjects and objects gives rise to new questions about the way in which organizations can handle that, and the consequences it will have for the process of organizing. After all, in that new reality, organizations and their environments will be hybrid systems (combinations of man, organization and technology) that will increasingly depend on information from networked systems and entities. However, modern organizations are generally still structured and shaped based on vertical principles, with information organized from the top down. This vertical principle is increasingly eroded by the process of hybridization, the use and application of ever more connections and the exchange and sharing of information across these connections. These developments are creating organizations that are increasingly connected horizontally on the level of their activities. There are, in the opinion of Baecker (2001), hardly any phenomena, events or activities in today's world that are not in some way interconnected or that do not co-produce as part of networks. In many situations it will be unclear or imperceptible whether communication and interaction actually takes place between two or more persons, two or more machines, or a random combination of both. This complex of networked, interacting and intercommunicating systems is perpetuated based on information from random combinations of hybrid systems. In this context, organizations are increasingly showing a metaphorical resemblance to the human brain, as suggested by Morgan (1986). He based this metaphor on the idea that every aspect of an organization's functioning depends on some kind of information processing. That makes an organization a more or less closed system of information processing, where information is interlinked and converted into new links back to the organization's environment, based on the exchange and sharing of information and corresponding actions. However, organizations' thinking and operations within information-based networks requires new insight. Barabasi (2003) claimed that real networks are made up of *communities*, which, in turn, are made up of nodes with tight mutual links, stronger than their links with nodes outside the network. "*Thus a web of acquaintances – a graph – emerges, a bunch of nodes connected by links. Computers linked by phone lines, molecules in our body linked by chemical reactions, companies and consumers linked by trade, nerve cells connected by axons, islands connected by bridges are all examples of graphs. Whatever the identity and the nature of the nodes and links, for a mathematician they form the same animal: a graph or a network.*" (2003:16). The network is then the result of the sum of all interaction and communication between the different hubs or nodes in the network. A relatively limited number of nodes, which Barabasi calls hubs, dominate most of these networks. These hubs are special and dominate the structure of the network they are part of, and make it come across as an independent small universe. Their central position amid a large number of nodes means that many connections between those nodes run through them, and they therefore enable quick links between any two nodes in the network or system. Barabasi claims that hubs make networks *scale-free* in the sense that some hubs seem to be able to maintain an infinite number of links with nodes, regardless of whether the nodes in question are similar or not. He goes on to distinguish between *scale-free* networks and what are known as *random* networks, with the large majority of nodes in the latter having a similar number of connections with other nodes. Barabasi's assumptions lead to the conclusion that the development of organizations as hybrid systems will, in the future, strongly depend on connections and communication. On the other hand, there is a dependency on the process of organizing this complex of connections and communication. That makes the extent to which organizations are capable of functioning as a hub in their section of the network, organizing their (information) links with other nodes and exchanging and sharing information within this process of organizing a decisive factor in the development and success of organizations in their environment. Baecker (2001) claims that our thinking on organizing and structuring organizations is changing, leading to drastic changes in both existing organizations and their management. The shift in our thinking is one from a hierarchical and functional approach to a more horizontal and connection-driven approach. This new and more horizontal approach mainly involves developing and maintaining relations between the hybrid system's interior and its exterior world. As a hybrid system, an organization will increasingly be incorporated into the networks in its environment on a social, technological and economic level. The ability and willingness to operate in these networks will pose a growing challenge for the existing organizational structures as they are today. But the organization as a social system, which is based on traditional principles such as hierarchy, will not quickly or easily accept a different form or allow itself to transform, or be transformed, as a matter of fact. New theoretical insights are needed to channel such developments and support organizations in developing a new basis for themselves. New insights are also needed to be able to further develop new connections between organizations as systems and hubs in the network for the exchange and sharing of information with their environment. In the eyes of Baecker, this will not add up to hierarchical or organizational layers being wiped out altogether by these developments and the exchange and sharing of information, but rather to new functions being added to them to absorb the insecurities that are part and parcel of operating in networks. In this changing environment, information is a crucial raw material for organizations. However, with an increasingly horizontal instead of vertical flow of information, organizations will have to start developing and implementing new and more ecological forms of management and control. These new forms of control and management must veer away from exclusively focusing on direct management of the execution or controlling of available information, and move towards self-organization and self-management of and by small hybrid systems. Organizing thus becomes focused on creating smaller sub-systems that, within the greater whole, independently organize their connections, and exchange and share information with their environment within the boundaries of predefined frameworks. That will not only contribute to the development and growth of each sub-system, but also to the development of the system as a whole. Organizations organize themselves as networks, and can therefore be included in networks around them without any problem, which is increasingly creating a likeness between organizations and living organisms sharing a living body with other organisms.

4. Information and Reality

Information generated by connections between man, organization and technology is increasingly making a mark on our reality. Bateson (1972) already observed that a complex network of interconnected entities is shaping our world. This connection is, in his view, formed by the exchange of messages, or in other words "*the relationship is immanent in these messages"* (1972:275). Bateson considers the connection the intrinsic result of the exchange and sharing of messages and "*a difference which makes a difference is an idea or unit of information*" (1972:318). In his view, information is a new and externally-created difference or change that installs new differences or changes in a new recipient environment. The message should, in Bateson's theory, end up in a structure that is capable of processing these new differences or changes. But, Bateson warns, structure alone is not enough. The recipient structure must be willing to accept and process the incoming difference or change, or in Bateson's own words: "*This readiness is uncommitted potentiality for change, and we note here that this uncommitted potentiality is not only always finite in quantity but must be appropriately located in a structural matrix, which also must be quantitatively finite at any given time*" (1972:401). In order to be able to understand and interpret the behavior and experience of people, Bateson claims we will, in principle, always need to depart from the complex of connections that systems are part of. Bateson considers these connections a simple unit of thought. Systems with higher levels of development and complexity should, in his view, be looked upon as systems of units of thought. The possibility and ability to exchange and share information between random systems and entities can also be referred to as information interoperability. Van Lier & Hardjono define information interoperability as: "*the realization of mutual connections between two or more systems or entities to enable systems and entities to exchange and share information in order to further act, function or produce on the principles of that information"* (2011:69). The information exchanged and shared between random people, organizations and technological applications in the form of communicative units can be either accepted or rejected by the recipient system. Luhmann's (1995) concept of interpenetration from his social systems theory starts with the possibility of receiving or rejecting an incoming communicative unit. When systems possess a reciprocal willingness and ability to accept the communicative unit, and grant communicative acts from other systems access to their system, a form of interpenetration comes about. "*Interpenetrating systems converge in individual elements – that is they use the same ones – but they give each of them a different selectivity and connectivity, different past and futures*". (1995:215). Luhmann (1995) uses the concept of 'interpenetration' to pinpoint the special way in which systems contribute to the shaping of other systems within the environment of the system. Interpenetration is more than just a general relation between system and environment, but rather an inter-system relation between two systems that make up an environment for each other, and through which a system makes its own complexity available to build other systems. Interpenetration therefore only really occurs when these processes are evenly matched. That is the case when both systems enable each other to introduce their own existing complexity to the other side. The concept of interpenetration presupposes therefore, according to Luhmann, the ability to connect different forms of autopoiesis, such as life, consciousness and communication. The concept of interpenetration is equally Luhmann's answer to the question of how double contingency between different systems is enabled, and a new system based on communication comes into being with sufficient frequency and density. Making connections between two or more systems leads to the evolutionary creation of a new and higher form of system formation, which only manifests itself as it occurs, i.e. in the process of entering into and maintaining a communicative commitment. In Luhmann's view, system evolution is only facilitated by the concept of interpenetration, i.e. in the form of reciprocity. In the systems theoretical approach, reciprocity turns evolution into a self-perpetuating circular process: "*Therefore evolution is possible only by interpenetration, that is only by reciprocity. From the systems theoretical viewpoint, evolution is a circular process that constitutes itself in reality*" (1995:216). Every system that participates in the concept of interpenetration must be willing and able to allow a difference created by another system access to itself without that leading to the erasing of its own difference between system and environment. The concept of interpenetration does not connect execution, but shapes connections every system uses to stabilize its own internal complexity. The difference adopted by the system is shaped by the communicative unit consisting of a combination of information, utterance and understanding. Systems, such as organizations, want to quickly obtain new and relevant information from their environment, and be able to adequately apply this information within their own complexity. New information must therefore be acceptable for the system, and enable the system to assign meaning to the information. Luhmann (1996) borrows the neologism 'sensemaking' coined by US scientists to refer to this process of assigning meaning. By assigning meaning to information, i.e. sensemaking, a system is enabled to perpetuate existing executions, and to pass the ambivalence between knowing and not knowing on to a subsequent situation. A system benefits internally from new information based on what a system can or wants to do with this new information.

Changes based on new information stemming from connections between the organization as a system and its environment create what Weick (1979) calls a meaningful environment. After all, incoming information requires the organization to act in the form of assigning meaning (enactment) to that new information. Intruding information is subsequently the raw material for a process of sensemaking in organizations. The concept of enacted environment, where changes from the environment interpenetrate into the organization as a system, is, in Weick's view, not the same as the concept of a perceived environment. If a perceived environment were to be the core, this phenomenon would have been called 'enthinkment' and not 'enactment' (the act of assigning meaning). Weick considers reality a product resulting from an active process of social construction, and sees the concept of 'enactment' as the starting point of that process. Weick joins Berger and Luckmann (1966) in stating that observing our environment from different viewpoints does not lead to everyone observing a common world in the same way. Similarities in our perception of this common world are based on, among other things, the fact that we use language as a common system. Berger and Luckmann point out that man uses language to construe his social reality. The concept of an ecological environment and the ensuing process of construction of social reality is based on the fact that knowledge is developed through connections between subjects and between subjects and objects. The subject observes the object, and subsequently processes that observation cognitively, labels it in different ways and links it to various other isolated or external events. Weick states that there is too little focus on the possibility that the development of knowledge can also move into another, seemingly opposite, direction, namely the potential effect of the subject on the object. This effect turns knowledge development into an activity where the subject, partly through his own interaction, establishes the object both within his environment and within existing relations in that environment. In Weick's view, that vindicates the principle of a mutual relation between subject and object. That reciprocal influencing is what Weick sees as the model for the relation between enactment and ecological change, which he mainly sees in organizations that greatly depend on technology and technological applications in their operations. Such organizations have to shape enactment around and while taking account of the (im)possibilities of the technology. The high level of entanglement with technology and technological applications causes the process of enactment at organizations to change. But arguing that enactment reduces when the intensity of technology usage increases goes too far, in Weick's view. According to Weick, that argument loses sight of the fact that it is not the technology in itself that is leading to these changes. It is the information this technology generates and the information that is edited and processed using and through the intervention of technological applications that breed change. Technology generates ever greater volumes of raw data, which is a development that is also making ever greater demands on organizations to assimilate this raw data into their own context, in such a way that this data can be turned into usable and manageable information. Weick compares the term enactment, when used in the context of organizing, to the relation that evolution theory established between the term variation (the existence of differences within a kind) and natural selection. He prefers the concept of enactment over variation as enactment has a more active connotation. That reflects the active role participants at organizations play in the creation of their environment and the readiness to impose the environment they created upon themselves. The act of assigning meaning is closely linked to the principle of ecological change. Weick, like Luhmann, follows Bateson's (1972) epistemology, which states as follows: "*Ecology, in the widest sense, turns out to be the study of the interaction and survival of ideas and programs (i.e., differences, complexes of differences etc.) in circuits*" (1972:491). Especially where new differences arise within existing knowledge and experience in the organization, such as through the arrival of new information from the environment, this requires action from one or several actors to isolate and further scrutinize this new difference in order to eventually assign meaning to it. This kind of bracketing of new differences is merely one manifestation of enactment. Another manifestation of enactment can, for example, come about when an actor does something that leads to a new ecological change, i.e. a change that subsequently leads to a limitation in the environment, which, in turn, reproduces a next ecological change, making this an endless sequence. The process of assigning meaning is the only process through which the organism or the organization approaches its external environment. The perspective of being able to assign meaning gives people in organizations greater self-confidence. They become willing to reflect on their own day-to-day actions to a greater degree, as well as on the influence they exert on their environment and the influence their environment has on them. The organization needs to be more committed to and aware of its environment and the influence it has on the reality the organization constructs. If man and organization are more aware of the fact that they construct their own environment and hence their own reality, they can influence that process more. When organizations approach environments from the perspective of active meaning assignation, the focus shifts from the question of what's true and what's not, to the question whether the presented or conceived version of reality is more reasonable or less reasonable. That would prevent endless discussions and questions aimed at showing whether things are perceived and judged correctly and whether they are true or not. From the perspective of assigning meaning, such discussions can, in Weick's view, be replaced by questions along the lines of: what have we done? what meaning can we, and do we want to, assign to certain actions and information? and which actions did we refrain from? This way, people are, on an individual level, challenged to analyze whether the meaning they assigned to changes in their environment has led to the right form of common meaning or sensemaking for that change.

5. Conclusions

The new, reciprocal relations that arise between subjects and objects, and between the physical and digital world, demand new and different approaches to the connections between the different phenomena. Postphenomenology offers an ontological basis for further research into and the development of these new connections between man, organization and technology. Postphenomenology also offers a basis for further research into a changing reality, as developed and shaped based on these new relations between man, organization and technology. New, emerging forms of technology, such as ubiquitous computing, are breeding technological applications that are becoming ever smaller and less discernible, are all around us and drive our human behavior, but are also leading to new connections between objects amongst themselves and between objects and subjects. These connections facilitate an ever greater stream of information exchange and sharing. This information influences the development and shaping of our perception of reality. Everyday reality is hence the product of the connections between man, organization and technology. The increasing volume of exchanged and shared information will slowly but surely erode the vertically-oriented structure and shape of organizations. A more horizontally-oriented approach, based on random combinations of people, organizations and technological applications with a capability to exchange and share information between them, therefore becomes a necessity. This approach to organizations has yet to be developed. A more ecological management and control set-up must lie at the root of that approach, as well as the creation of smaller sub-systems that independently organize connections and exchange and share information with their environment within predefined frameworks. Such a horizontal and ecological approach would have organizations organize themselves as networks. Organizations can then be incorporated into networks around them without any problem, conjuring up a likeness to a living organism co-habiting with other organisms in a living body. Systems theory offers an epistemological framework for further research into and development and shaping of hybrid networks made up of man, organization and technology. Reality comes into being and gains shape as people, organizations and technology exchange and share information. Information that is received leads to active sensemaking by the recipient system. Assigned meaning, in turn, triggers ecological changes to reality as perceived and experienced by humans and organizations. If people had greater awareness of the fact that they create their own environment, which is made up of new combinations of man, organization and technology, they would be able to exert greater influence on the creation of this new and self-constructed reality. Social constructivism can be a methodological framework for further research into the development of a new reality springing from connections between man, organization and technology.

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CFD-Based Optimization Methods Applied to Polymer Die Design

Laura DIETSCHE,
Patrick LEE and Joe DOOLEY
The Dow Chemical Company
Midland, MI 48674 USA

ABSTRACT

The integration of optimization algorithms with computational fluid dynamics (CFD) is becoming more practical as the software becomes more robust and the hardware more efficient. In order to investigate the application of CFD-based optimization methods in the chemical process industry, two polymer die design examples were explored using different slot die geometries, different CFD codes, and different optimization packages and methods. In both cases, various geometric parameters were modified in order to meet the two often competing objectives of uniform flow at the die exit while minimizing or limiting the pressure drop. In some of the trials, CFD was used to create response surface models (RSM) and the optimization algorithms were applied to the RSM. In other trials, the optimization algorithms were directly coupled to the CFD. The advantage of the response surface model approach is that the RSM runs much faster than the CFD model. However, this is offset by the need to run numerous CFD cases up front in order to generate an accurate RSM. Designs with improved performance over the base cases were identified for both die geometries.

Key Words: Computational Fluid Dynamics, CFD, Optimization, Genetic Algorithm, Response Surface Model, Slot Die, Coat-Hanger Die

INTRODUCTION

Computational Fluid Dynamics (CFD) modeling is often utilized to improve the performance of a process or product by identifying advantageous changes to the geometric design, operating parameters, or material properties. This is frequently accomplished through a parametric study, which provides insights into the effect of the various parameters. A more rigorous approach might incorporate a design of experiments (DOE) and statistical analysis to point towards a more optimal operating space to meet some set of objectives. This can include the creation of a response surface model (RSM) based on the CFD results. In order to arrive at a truly optimal solution (or solutions, in the case of competing objectives), the CFD or RSM can be coupled to an optimization algorithm to drive the parameters towards optimal space [1]. CFD-based optimization has become more practical with the more recent development of commercial optimizer software and more robust CFD codes, as well as the evolution of more powerful compute resources. Some commercial CFD codes now offer built-in DOE and response surface capabilities or provide links to commercial optimizer packages.

There are challenges to the successful execution of CFD-based optimization. For geometric optimization, a parameterized geometry and meshing algorithm needs to be developed to automatically create high quality meshes over the allowed geometric parameter ranges. Appropriate boundary conditions and physical properties may also need to be parameterized, and solution outputs extracted and converted to objective parameters. The geometry, mesher, and CFD software need to communicate with the optimizer software. Once the objective functions, constraints, and optimization algorithms are set up, the optimizer should be able to automatically run the CFD cases and drive towards the optimal solution without significant user intervention. However, since each CFD simulations can take a significant amount of time to run, one needs to be smart about the optimization methods that are used in order to optimize the optimization process.

The design of polymer dies has historically been more of an art than a science, requiring numerous trial-and-error experiments of various die geometries in order to get the desired processing results. Complex geometries and non-Newtonian rheology present challenges to analytical flow modeling [2-3]. In more recent years, CFD has been used to predict flow, pressure, and temperature profiles to aid the design [4-5]. However, even this method normally involves a trial-and-error procedure to hone in on a more or less optimal design. Since there are often numerous geometric parameters and conflicting design goals, this can be very time and compute-resource intensive. The use of optimization algorithms to aide in identifying the best cases to run should enable us to approach an optimal solution with fewer simulations. In this paper, we will discuss two test cases using CFD-based optimization to modify polymer die geometries in order to approach the dual objectives of uniform flow across the die exit and a minimized or limited pressure drop. In general, higher back pressure tends to improve flow uniformity, so the two objectives are often in competition.

CFD GOVERNING EQUATIONS

Simulation of the flow of fluid in a die involves the numerical solution of the equations governing viscous fluid flow on the specified computational domain, subject to the stated boundary conditions. Steady, laminar flow of an incompressible, non-Newtonian fluid, such as that in a slot die, can be described by the following forms of the equations of continuity and motion [6]:

$$\nabla \cdot \underline{u} = 0 \tag{1}$$

$$\rho \underline{u} \cdot \nabla \underline{u} = -\nabla p - \nabla \cdot \underline{\underline{\tau}} \tag{2}$$

where ρ, $\underline{u}$, p, and $\underline{\underline{\tau}}$ are the density, velocity vector, pressure and deviatoric stress tensor, respectively. Equation (2) shows the equation of motion in stress-divergence form. This is the form typically used for flows involving non-Newtonian fluids, as it properly accounts for the spatial variation of viscosity. A shear dependent Carreau viscosity model was used in both of the polymer die simulation cases to be presented:

$$\eta = \eta_\infty + (\eta_\circ - \eta_\infty)\left[1 + (\lambda\dot{\gamma})^a\right]^{\frac{n-1}{a}} \qquad (3)$$

where η is the viscosity and $\dot{\gamma}$ is the shear rate. The material fitting parameters include the zero and infinite shear viscosities, η_0 and η_∞; the time constant, λ; and the exponential constants, n and a.

Although conductive and convective heat transfer, along with shear heating effects, are often encountered in polymer die applications, the energy equation will not be solved in these exploratory examples. Two different CFD codes will be used to solve the differential equations over the computational grids. One is a finite volume code, Fluent™ (ANSYS®, Inc), and the other is a Finite Element code, Polyflow™ (ANSYS®, Inc).

OPTIMIZATION PACKAGES

Two optimization packages were used during this study. In one case, we used the DesignXplorer™ software that is available for the ANSYS Workbench™ platform (ANSYS®, Inc). This package allows the user to set up and run a set of CFD simulations that follow a Design of Experiments (DOE) grid based on various design protocols. A Central Composite Design was used for this study. The simulation results can then be used to create algebraic response surface models, and optimization algorithms can be employed to find a set of optimal solution parameters based on the response surfaces (RSM-based optimization). In our test case, we used the Kriging algorithm (polynomial fit combined with an interpolation scheme) to create the RSM.

As we began this study, there was only one optimization algorithm available, a simple Screening method in which the RSM space is sampled at a large number of points (e.g., 1000) determined by a quasi-random number generator (Hammersley algorithm). The resulting objective function values can be plotted against each other to visualize the emerging Pareto front, and the data can be queried for minimums and maximums or other constraints. This is the method that was used for our initial investigation. More advanced single- (NLPQL) and multi- (MOGA) objective function algorithms are now available.

Once optimal solution candidates are identified, CFD simulations are run using the parameters from these candidates in order to verify that a more optimal solution has been found, and to check the goodness-of-fit of the RSM. The RSMs may or may not accurately represent CFD results as you get away from the initial DOE conditions, so a RSM-based optimization method may not identify a true optimal solution space. The accuracy of the RSMs should improve with larger, well designed DOEs. Numerous analysis tools are available to further query the data including sensitivity and sample charts.

ModeFRONTIER™ (Esteco® North America Inc.) was used as the optimization package for the second study. ModeFRONTIER offers numerous algorithms, methods and options for optimization studies. The runs are again initialized with a DOE-based set of simulation results. We chose a Uniform Latin Hypercube space filling design. Numerous algorithms are available for creating RSMs. Although we explored the use of RSMs using Radial Basis Functions, our main emphasis in this study was to directly apply the optimization algorithms to the CFD compute engine (direct CFD_based optimization). Again, modeFRONTIER has numerous optimization methods available, including gradient based algorithms, Genetic Algorithms, and Evolution strategies. We used Genetic Algorithm based methods, which use the concepts of natural selection, gene cross-over, and genetic mutation to determine each next generation of simulations to perform. The method pushes the parameter sets towards a local optimum while allowing for jumps (mutations) into different parameter spaces, in case there is a different global optimum space. For this study we used the NSGA-II (Non-dominated Sorting Genetic Algorithm) method for both single- and multi-objective optimizations.

The evolution of both the input parameters and the optimization parameters can be followed with history plots and the optimization run stopped when it appears that the parameter space has stabilized. With the direct CFD-based optimization approach, the resulting Pareto graph will show a true optimization front. Numerous analysis tools allow further exploration of the data to determine parameter sensitivities and interactions.

RESULTS AND DISCUSSION

CASE 1 – COAT-HANGER DIE: In this test case, we used the “response surface model” optimization capabilities in DesignXplorer to reach a more optimal design for a coat-hanger die. The geometry was created with ANSYS DesignModeler™ and meshed with ANSYS Meshing. The finite element CFD solver was Polyflow. Our objective was to obtain a uniform flow rate distribution across the die width at the die exit while minimizing the pressure drop.

We modeled half of the die geometry, as depicted in Figure 1, with the inlet pipe located on the symmetry plane. The geometry below the inlet pipe can be created using CAD lofting operations between topologically identical "sketches" as depicted on the right in Figure 1. In this way the geometry can be broken up into multiple sections and the optimization will occur on the geometric parameters in each of the sketches. For this study, we used three sketches (one near the inlet, one in midsection, and one at the die edge). For the first trial, three geometric parameters (H4, H9, and V11) along the die edge were allowed to change. For the second trial, four geometric parameters (H4, H9, V10, and V11) along both the die edge and midsection sketches were allowed to change (8 parameters total). The final rectangular slot shape at the die exit was kept constant (gap = 0.152 cm, width = 25.9 cm). An all hexahedral mesh with ~110,000 elements was created.

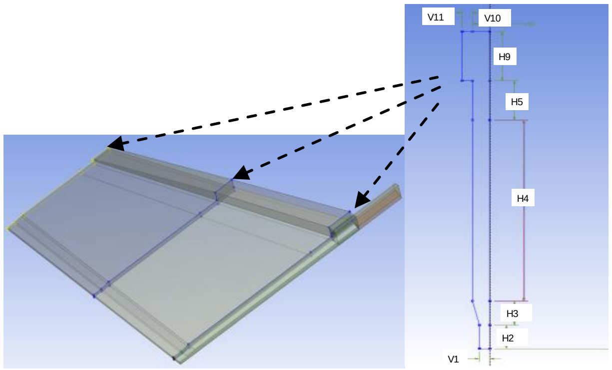

Figure 1. Coat Hanger die geometry with three sketches and the parameters in each sketch

A shear thinning Carreau rheological model was fit to rheological data as shown in Figure 2. The density was close to 1 g/cc. A fully developed inlet velocity profile was specified with a flowrate of 4.7 cm^3/s. The die exit was divided into 10 segments along the width, and the degree of flow uniformity was defined as the ratio between the minimum and maximum flow rates through these exit segments (a value of 1 represents perfect uniformity). In both trials, response surface models of the flow uniformity and the pressure drop were created (using the Kriging algorithm) based on CFD results from a DOE grid. The geometric parameter values were constrained to +/- 30% of the baseline geometry. RSM results were obtained for 1000 randomly generated sets of input parameters and an optimum case was identified from these sets. CFD simulations were performed on the suggested optimal designs to get actual results. For the first optimization trial with three parameters, the DOE grid consisted of 16 simulations, including a baseline (previous "best solution") design. The DOE for the second trial (eight parameters) consisted of 81 simulations, including the baseline as well as the optimal design from the three parameter trial. The DOE simulations constituted the main computational cost of the optimization runs.

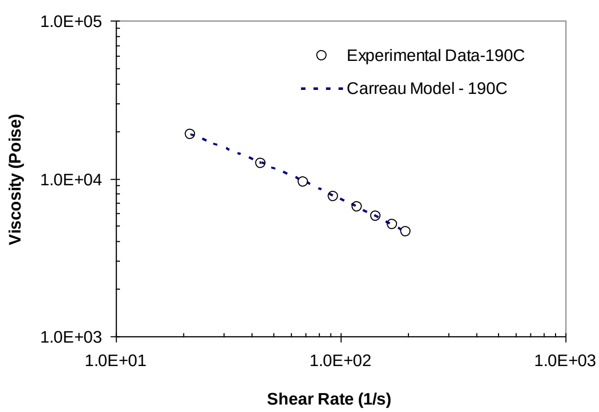

Figure 2. Resin Rheology at 190°C

Table 1. Coat Hanger Die Baseline vs. Optimized Input & Output Parameters

		baseline	3 parameter optimized	8 parameter optimized
Die Edge	H4	3.69	2.81	2.65
	H9	0.8	0.99	0.99
	V11	0.28	0.35	0.34
	V10	0.25	-	0.25
Midsection	H4	5.78	-	5.78
	H9	1.06	-	1.06
	V11	0.57	-	0.57
	V10	0.25	-	0.25
Output Parameters	Pressure drop, MPa	31.0	30.6	30.6
	min/max flow rate	0.83	0.93	0.94

Table 1 reports the geometric parameters and results for the baseline vs. the optimized solutions for the two trials. The optimized parameters for the three- and eight- parameter trials are almost identical indicating that the edge parameters may be controlling. The optimized dies have deeper manifold channels and shorter land lengths compared to the baseline die. The flow uniformity has improved from 0.83 for the baseline to 0.94 for the optimized cases, while the pressure drop has decreased from 31.0 to 30.6 MPa. Thus we do not appear to have competing objectives in this case.

The baseline and optimized die shapes are displayed in Figure 3. The exit flow distributions are shown in Figure 4. It can be seen that the optimized geometries were able to more uniformly feed the die end furthest from the symmetry plane. This is quantitatively shown in Figure 5.

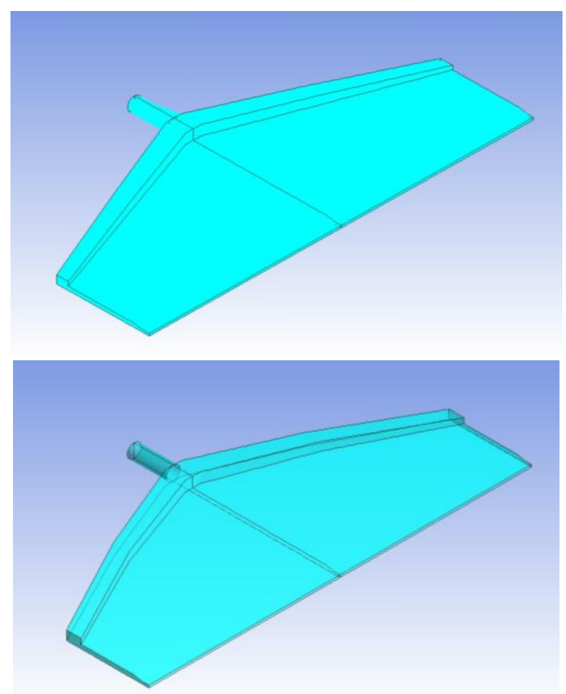

Figure 3. Coat Hanger die Baseline (top) vs. Optimized (bottom) geometries

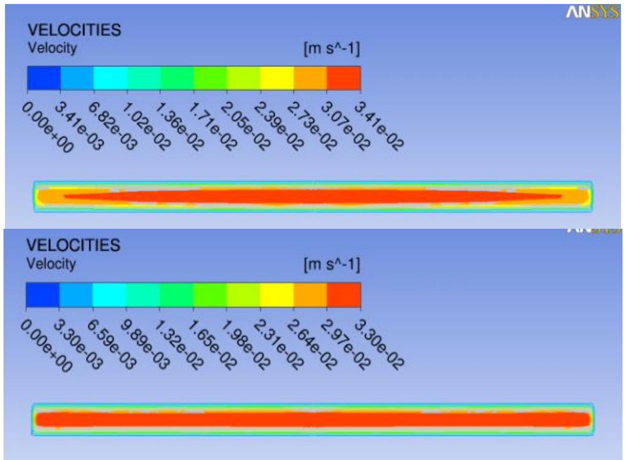

Figure 4. Coat Hanger die Baseline (top) vs. Optimized (bottom) exit velocity distributions

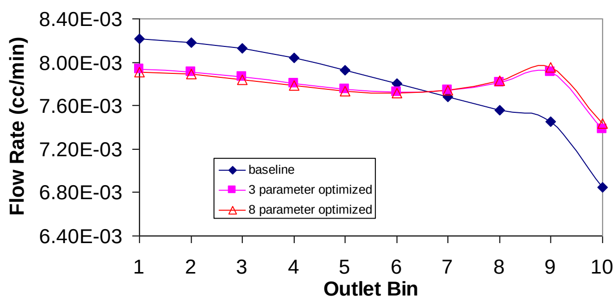

Figure 5. Exit flow variations along the Coat Hanger die width (symmetry plane adjacent to outlet bin # 1)

Although the decrease in pressure drop that accompanied the improvement in flow uniformity was initially unexpected, we can understand it better by considering how the flow is being redistributed. In this case the flow distribution was improved by reducing the restriction on the polymer flowing towards the edge of the die (rather than by increasing the restriction on the polymer flowing down the middle). The path length of the flow going through the extreme edges is also shortened. These changes would also tend to decrease the pressure drop.

It should be noted that although we have found a more optimal geometry for the coat hanger die compared to the baseline, we have not necessarily found the most optimal CFD solution, since we based the optimization on an imperfect representation of the CFD results and used a very simple optimizer that did not do a rigorous search for an optimal solution. We could potentially reach a more optimal solution by running more CFD cases in the initializing DOE to create a more accurate RSM and by using the new MOGA optimization algorithm. We also limited the extent of the geometric changes which could take place. We could increase the number of geometric parameters by adding more intermediate sketches to the geometry and allowing more parameters in each sketch to change. However, the DesignXplorer package cannot currently handle significantly larger parameter sets, and is limited in the ability to define constraints between parameters to gain better control over the design space. All these efforts to identify a more optimal solution would come at a cost of requiring more CFD simulations, and the value added by this effort would need to be considered.

CASE 2 – SLOT-DIE ADAPTER: The next case involves a different slot-die design used to straighten the flow profile from a pipe inlet to a long rectangular outlet. The interactive software included Gambit® (ANSYS®, Inc) for geometry and mesh creation, Fluent as the finite volume CFD solver, and ModeFRONTIER as the optimizer. A Carreau rheological model was used and the flow was assumed to be laminar. The seven geometric parameters included the height and width of the dogbone tab, the width of the dogbone center, and the lengths of the four die block segments, as indicated in Figure 6. Each of these lengths was constrained by a minimum and maximum value. The inlet pipe diameter and length, as well as the final rectangular die dimensions, were kept constant. We used a hexahedral mesh with a total cell count of around 250,000. The output parameters included the overall pressure drop and the flow uniformity at the die outlet determined by three different numeric measurements of standard deviation. We focused on a standard deviation determined by dividing the outlet into 15 sections (bins) of equal area and capturing the integrated normal velocity (volumetric flowrate) out of each section. The flow uniformity objective function was to minimize the standard deviation across these flowrates.

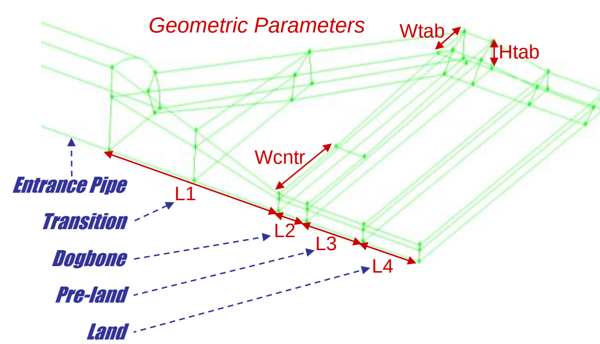

Figure 6: Segments and Geometric Parameters for the Slot-Die Adapter (1 quadrant is depicted)

Before beginning the optimization simulations, we ran two simulations representing a "rectangular dogbone" geometry and a "base case" geometry (utilizing geometric parameters from a previous "best solution" from an intelligent trial-and-error CFD approach). The redistribution effect of the dogbone segment can be seen in Figure 7. The standard deviations of the integrated outflow for the rectangular and base cases were 47% and 20% respectively. Thus, the base case has already significantly improved the flow distribution over a rectangular geometry (with a 10% increase in pressure drop).

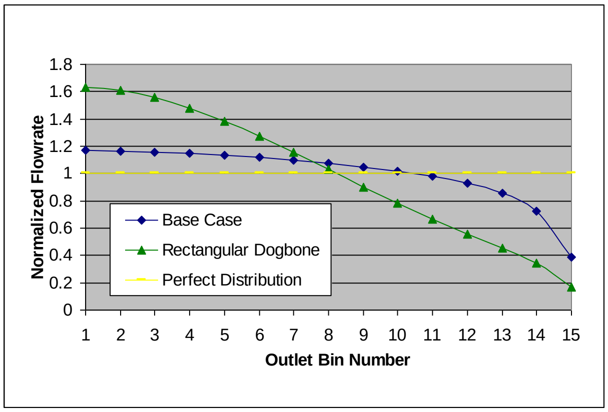

Figure 7: Normalized Flowrate in the Outlet Bins for the Base Case and a Rectangular Dogbone Case.

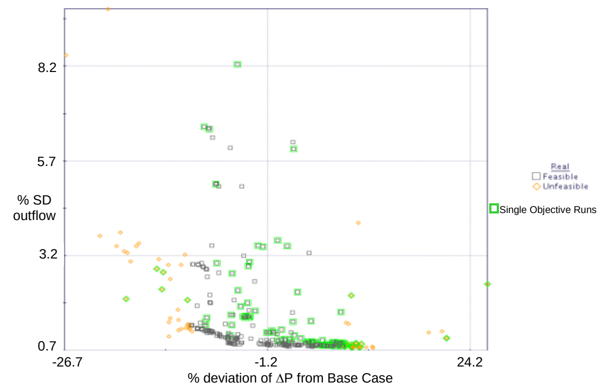

Figure 8: Scatter plot of the Objective Parameters from both the Single- and Multi-Objective Function Runs

The genetic algorithm population for the optimization runs was initialized with 15 CFD simulations, following a space filling DOE grid. Statistical correlation analyses on this early data set showed that the pressure drop and outflow uniformity were negatively correlated, and also indicated input parameters that were more strongly correlated with the objective parameters.

A single objective function approach was initially used to minimize the standard deviation of the outlet flow, while keeping the pressure drop within specified bounds. We ran CFD cases for nine genetic algorithm generations (15 simulations per generation); the parameters began to settle down after five generations. As expected, we reached an optimal solution where the pressure drop was at its upper limit. The outflow uniformity was improved over the base case (the standard deviation dropped from 20 to 15%), but the pressure drop was higher by 8%.

We then added a second objective function to minimize the pressure drop (while staying within the specified limits) and ran another 16 generations. Since we have competing objectives, there is no single optimal solution. Figure 8 shows a scatter plot of the standard deviation (SD) of the outflow versus the percent deviation of the pressure drop (ΔP) from the base case. The diamonds represent solutions that are outside of the allowable pressure drop range. The framed points represent solutions from the single objective function runs. The Pareto front along the bottom of the plot shows possible optimal solutions, and indicates a range of conditions where the pressure drop can be lowered without strongly affecting the outflow uniformity.

Analysis of the results using a combination of scatter plots, correlation matrices, effects matrices, and parallel coordinate charts suggested that the dogbone tab height and the transition zone length can be increased to improve the outflow uniformity without a large increase in pressure drop, and the dogbone and die land zone lengths can be decreased to improve the pressure drop without significant increase to the flow non-uniformity. Other parameters had little effect on either objective or affected them both strongly, but in opposite directions.

We identified a solution that had similar outflow uniformity as the optimal single objective function solution, but with a 14% lower pressure drop. The normalized flowrate for the base case and this new optimal case are shown in Figure 9 along with a contour plot of the normal velocities along one quadrant of the outlet face for the optimal case. It can be seen that the new optimal solution is diverting more of the flow towards the edge. The two vertical dashed lines indicate where the extrudate would need to be trimmed in order to keep the total flowrate variation within 0.2 normalized flowrate units. A significantly larger portion of the base case extrudate would need to be trimmed (~27% vs. ~9%).

We also created a set of radial basis function RSMs (for both the pressure drop and the outflow standard deviation) based on data from all of the CFD runs in the single-objective investigation, then created a second set of response surface models which also included data from multi-objective investigation. Thus the models will be biased with data from an already optimal space which might have both advantages, in increasing the accuracy of the model in this space, and disadvantages, in decreasing the accuracy elsewhere. In both RSM sets, the goodness of fit between the RSM predictions and the CFD data set that the RSMs were built from was very good.

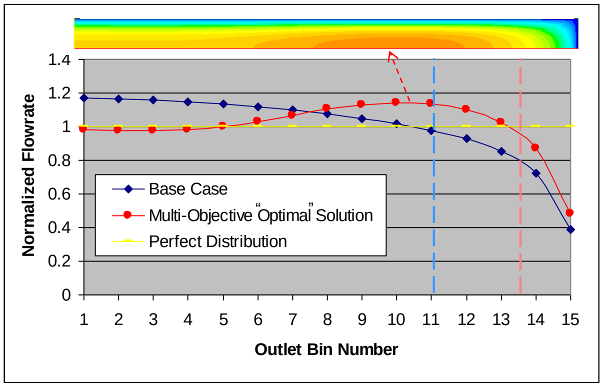

Figure 9: Normalized flowrate in the outlet bins for the Adapter Block Base Case and a Multi-Objective Optimal Case. The contour plot on top is for the normal velocity at the outlet of the Optimal Case

A NSGA-II optimization algorithm was applied to both sets of RSMs. Figure 10 shows the Pareto front predictions from both RSM-based (virtual) optimizations, along with the CFD (real) results based on the same parameter sets, with lines connecting the paired virtual and real results.

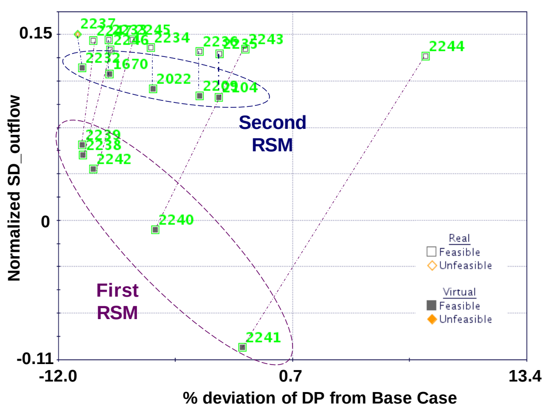

Figure 10: Predicted Pareto Fronts from RSM-based optimization runs with paired CFD results using the same geometric parameters.

It can be seen that the RSM predictions do not match the CFD results. This is particularly true for the first RSM Pareto front which predicts non-realistic negative values for the standard deviation and pressure drops that are too low. The agreement is better for the second RSM Pareto front, which is based on additional CFD data. The pressure drop predictions are very good, and the outflow standard deviations are giving the correct trends, even though the values are still somewhat low.

Even though the optimization runs went significantly faster for the RSM-based optimizations, the number of CFD simulations necessary to get a reasonably accurate RSM seems to be approaching the number of simulations we used for the direct CFD-based optimization. So in this case we see no advantage to using the RSM approach. We did not try using an RSM based solely on a well distributed DOE, so we do not know how many CFD simulations would be needed to run to get good predictive RSM in this case.

CONCLUSIONS

We have explored the use of CFD-based optimization in two different polymer die geometries. In both cases, the value of CFD-based optimization was realized with designs for better performing dies when compared to base cases. The RSM-based method used in the first case required fewer CFD simulations than the fully coupled CFD-based method used in the second case, but it left us wondering if we found a true optimized CFD solution. The RSM-based optimization tests in the second case suggested that the number of CFD simulations needed to get a good predictive RSM model might be close to the number needed for the direct CFD-based method, but this needs to be confirmed. The fully coupled method provides a reliable Pareto front of optimal solutions and an abundance of information to further analyze.

A possible compromise that we would like to explore is the newer F-MOGA (Fast Multi-objective Genetic Algorithm) hybrid model available in modeFRONTIER, which uses an adaptive response surface model method. The main optimization routine would still be based on the RSM, but at the end of each generation, the most interesting parameter sets would be simulated with the full CFD model and the RSM would be retrained with the additional CFD data. This has the potential to provide faster convergence with a RSM tuned to the optimal region.

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Model-driven Methodology for Real-Time Software Design

Rédha HAMOUCHE, Rémy KOCIK
Université Paris-Est, ESIEE Paris, Embedded Systems Department
Cité Descartes - BP 99 - 2, Bd Blaise Pascal - 93162 Noisy-Le-Grand Cedex, France
e-mail: {hamouchr, kocikr}@esiee.fr

ABSTRACT

This paper presents a model-driven methodology and tool for Real-Time Embedded Control Software (RTECS) design. This methodology leads to evolve the RTECS development process from a classical code-oriented development to a model-driven development where the code is generated automatically. It uses a component-based and aspect-oriented approach. The component approach should add significant value to the design process, helping the software designer to produce modular and reusable system model. The aspect approach represents a significant paradigm shift from the traditional monolithic view. It provides a better ability to model extra-functional properties of RTECS. Both approaches lead to make the RTECS design significantly easier and improve the model accuracy and reduce the design time and cost. A tool called MoDEST implements this methodology and provides automated model transformations and real-time code generation. It should help designers to analyse system models.

Keywords: Model-based design, software component, aspect-oriented programming, metamodeling, embedded system design, embedded control software.

1 INTRODUCTION

Real-time embedded control systems are ubiquitous nowadays. They are used in a broad spectrum of applications, from simple temperature control in household appliances to complex and safetycritical automotive brake systems or aircraft flight control systems. The design of real-time embedded control systems tends to be more and more difficult due to the strong constraints (cost, price, energy consumption, control performance,...) and the growing complexity of the used software and hardware components. The software deals with different application domains (video processing, signal processing, telecom, ...), implemented onto heterogeneous distributed architectures composed of processors (DSP, RISC) and specific integrated circuits (ASIC, FPGA).

As shown in figure 1, designing RTECS follows usually a V-process, which allows building a system step by step according to top-down and then bottom-up design flow. A typical V-process for real-time embedded control systems design can be decomposed into three major steps [5]: functional control modeling and analysis, specification of control software and real-time implementation of control software. The result of each step is a model which is refined in the next one, until the implementation step. The functional system modeling and analysis, usually performed by control designers, is a modeling step where the behavior of plant and controller (control law) is described by a mathematical model, using dedicated languages and tools (like Matlab/Simulink or Scilab/Scicos), in order to model and analyze the plant and synthesize the control law. The specification of control SW is usually achieved by computer science engineers in order to implement the mathematical equations resulting from the modeling step, to capture the structure of the software, and to specify the high-level implementation constraints (input/output latency, jitter, etc.). The real-time implementation of control SW, realized by computer science engineers, corresponds to writing the controller as real-time software that will be executed on the hardware, and meets the implementation constraints. Usually, this implementation is described as a set of tasks, functions with real-time execution constraints (period, priority, deadline, etc.) and properties (execution duration, memory footprint, etc.). These tasks are scheduled in order to guarantee they meet

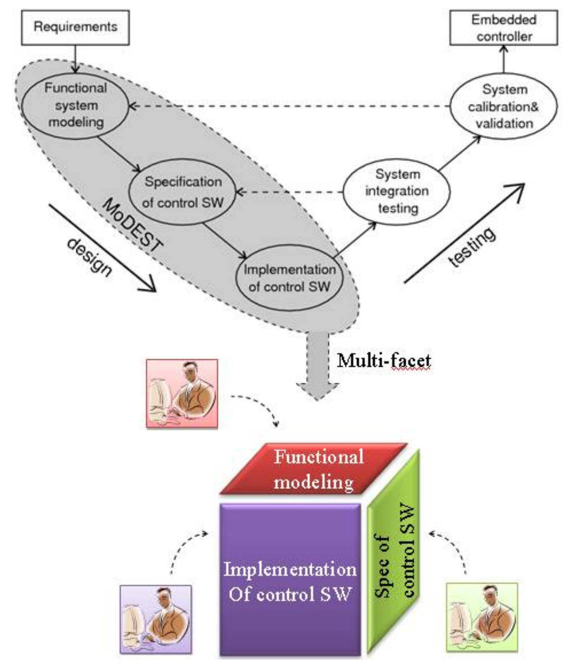

Figure 1. The design process using MoDEST

the specified real-time constraints.

Along the design process of RTECS, several actors belonging to different domains (control theory, signal processing, real-time software, ...) are involved. They use domain-oriented method, languages and tools. Therefore, produced models at the different steps are heterogeneous. They differ mainly by the specified functionality, real-time constraints and models of computation (MoC) [6]. This heterogeneity of models introduces lacks of consistency in the system design and leads usually to a disconnected design process where translations between the steps are needed. These translations are error-prone because they are usually performed manually by engineers. These errors may appear very early in the development process and be propagated into further steps. They can be only detected in the validation steps. Thus, correcting these errors needs numerous backtrackings (reiterations of V-cycle) in the design process, which lengthens the design lifecycle and time to market. Furthermore, the inconsistency of models may affect the implementation of the control system by disturbing its stability and reducing its performance [9][1].

Nowadays, there are research challenges to define methodology and tools which reduce the design time and cost, and ensure the consistency of models from system level to implementation level. Tools that allow a control design and real-time design are quite a few. Ptolemy, Jitterbug [3], TrueTime [7], SynDEx [10] are examples of such tools. Unfortunately, they are, in general, specialized on a certain aspect of the co-design problem or impose some restrictions [8]. Ptolemy tool, for instance, imposes some restrictions by the timed-multitasking model of computation. It only facilitates simulation of fixed priority scheduling of tasks with constant execution times [8]. Another approach like AADL (Architecture analysis and Design Language) is emerged recently for a high level design and evaluation of the architecture of embedded systems. They are powerful but the complexity of models can be higher. In fact, the different real-time/embedded concerns (safety, security, real-time constraints, scalability, etc.) are mixed in the models. When one of the concerns of the model needs to be modified, manipulating the parts of the model related to that concern can prove to be challenging since these parts are mixed with the elements from other concerns [4].

In this context, we have defined in [6][5] methodology and tool for design real-time embedded control software. Section 2 describes this methodology. Section 3 presents a model-driven tool, called MoDEST, and shows the benefits of this tool via a case study. Finally, the paper is concluded in section 4.

2 MODEL-DRIVEN EMBEDDED SYSTEM DESIGN

As depicted in figure 1, the proposed methodology offers a multi-facet design where the system model is viewed on different design facets as complementary. Each facet is well suited to the problem of each design step. It provides domain-oriented toolset for building model, using specific terminology (control, computer science or real time), by the corresponded actor (control designer or real time software designer). This design approach leads to unify the design steps into a homogeneous approach, with handling the complexity and the heterogeneity of models. It allows to link the functional system modelling step with the real-time implementation step, and it then provides an efficient real-time implementation of models with the control performance in mind. This is in order to evaluate the system performance and stability during their design. We aim to define real-time scheduling policies taking better account of control models constraints (sampling periods, input/output latencies, jitters. . .). On the other hand, we seek to take into account the temporal characteristics of the implementation in the hybrid simulation. The consistency between the design steps is ensured using the a model-driven development (MDD) [2] approach.

MDD approach

The main goal of the methodology is to evolve the RTECS development process from a classical code-oriented development to a model-driven development where the code is generated automatically. The automatic transformation of models improves their consistency and traceability throughout the development cycle. This consistency is achieved through the notion of metamodel. A metamodel is a description pattern which is able to capture concepts used in system models. The proposed metamodel is able to capture the three facets description by defining an unified terminology and semantics to share information without having to duplicate it. As depicted in figure 2, each change in a facet description updates another one by carrying out model transformations and reconciliation between the facets, which guarantee consistency of models in the earlier stages of design. The metamodel also allows to build bridges with external approaches and tools, as well as code generators to multiple targets. The proposed metamodel is based on two paradigms: software component and aspect-oriented programming.

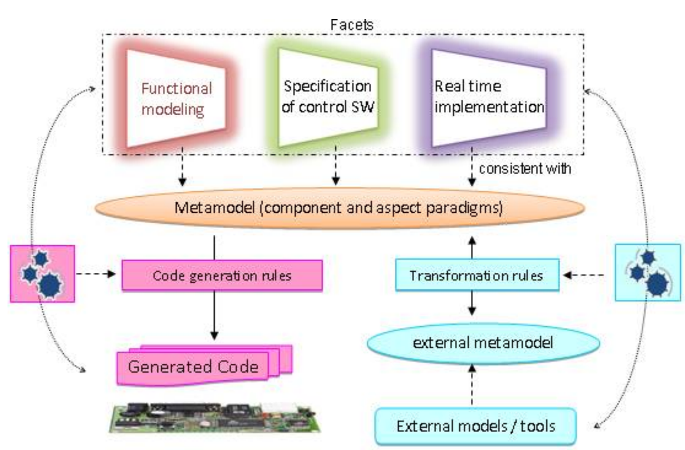

Figure 2. Metamodel and Facets

Component Approach
To offer a better level of abstraction and strengthen the construction of reusable modules, we adopt a component-based design approach [11]. This representation of the software architecture brings with it all the advantages of modern thinking in software development. Designs are instantiated largely by navigating and choosing pre-written configurable components from libraries rather than by implementing the design from scratch. The reusability of models should be increased despite the fast technological evolution of embedded platforms and the design time should be reduced.

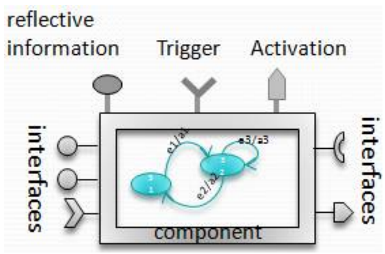

Figure 3. component model

As shown in figure 3 and 4, a new component model that is lightweight and that addresses explicitly the real-time properties of embedded systems is defined. It interacts with the environment through its interface (exit points of component interactions with its environment), it is characterized by properties stored as reflective information (such as worst-case execution time, jitters, memory footprint or location of its source or binary code), and its internal behaviour described by sub-components and a real-time automata (statechart).

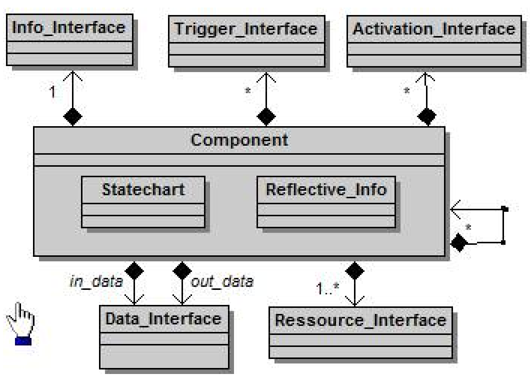

Figure 4. Metamodel of a component

Aspect Approach
A RTECS is characterized by its dependence on the execution context (the environment in which the system is operated). It reacts to the context changes (sensors, operators, . . .), and its behavior is constrained by the context (real-time, embedded, security or energy constraints, physical constraints, . . .). A major properties of a RTECS are context-dependent. Real-time, embedded, security, energy or physical constraints are an example. While designing and modelling RTECS, we have to overcome the following difficulties: (1) The major properties of RTECS, such as reliability, security, schedulability and synchronization, are global and transverse to the system and they cannot be cleanly encapsulated in a generalized procedure. Therefore, if the system analysis shows that the design is not schedulable, it is necessary to re-design and go back to models or codes to make some changes. Navigating and applying changes to models/codes are increasingly difficult as the models/codes grow more complex; (2) As we have to treat various kinds of context, it is difficult to model them from one point of view; (3) By its nature, the model for internal processing tends to depend on the model of external context, and changing the context, causes direct effects on internal model. This make reusability, modifiability and extensibility of RTECS not efficient. On the other hand, in the system design and analysis, the most difficult issues are ensuring that extra-functional properties such real-time performance are being met. What is required is a mechanism that make consistent and global changes, and offers better modularity and ability to analysis extra-functional properties. This is one value of the aspect paradigm.

The aspect-oriented approach addresses the separation of functional and extra-functional aspects in an application development, in order to avoid the usual interweaving between those aspects. Application is manipulated regarding specific aspects, rather than in its whole. Therefore, modifying any functionalities or extra-functional properties does not lead to change the whole application description. This separation gives a new dimension of modularity, reusability and maintenance, and increases configuration capacities. Unlike in monolithic development, this approach offers a better ability to analyze extra-functional properties. In the literature, an aspect is defined at the programming language level. For example, AspectJ [12] provides syntax that permits the specification of aspects and a weaver that weaves the code specified in the aspect into the base Java code. We extend the concept of aspects and apply them at the design level. Our aspects are defined as an extra-functional entities which can be applied to the facets, not to source code, in a transversal manner. An example of key aspects for embedded software systems are: security aspect, energy aspect, platform aspect, scheduling aspect, temporal aspect, profiling aspect,... By this way, designers are encouraged to describe system facets in a functional manner and then to apply extra-functional updates to the design in a global and consistent manner.

As shown in figure 5, an aspect may crosscut an facet of the system in order to affect behavior of the system model, change its semantic or its performance. It crosscuts components of a model for adding extra-functional treatment and/or imposing non-functional constraints. We distinguish four ways of crosscutting : (1) to supervise and control the behavior of components via *trigger interface*. An aspect uses this interface for sending context-sensitive

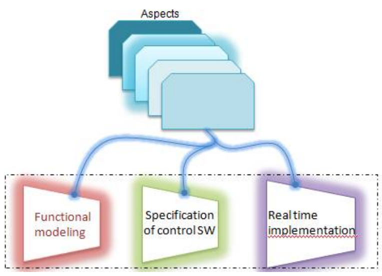

Figure 5. Aspects and facets

events (urgent event, operator command, device failure or dysfunction) and making then the statechart of components context-sensitive without a strong coupling with the context; (2) to constrain the components behavior by the context requirements. Via an interface called *activation interfaces*, the designer can introduce constraints in the component statechart as guards or invariants. Some system functionalities don't then work for example even if users try to operate it. An aspect may also introduce communication constraints on the interfaces of the component to impose a communication mode (synchronous or asynchronous) or a rate of data production/consumption; (3) to control data of components via an interface called *introspection interface*. An aspect can control access to certain data of components for managing concurrent access, verifying the data values for security reasons, and so on; (4) to define the resource constraints (via *resource interface*) associated with the target execution platform of the system. An aspect can define timing constraints such as period, deadline and jitter. It can crosscut components for defining the WCET (worst-case execution time) of component operations. This resource information is needed at design level to evaluate the system schedulability for specific execution platform. Change a target execution platform consists then in replacing only the corresponding aspect by another one specific to a new execution platform.

Component/Aspect weaving
The model of each facet is built by an assembly of components, and then by a weaving of those components with a set of aspects (see figure 6). The components are interconnected via data interfaces and they are crosscutted with the aspects via aspectual interfaces: trigger interface, activation interface, interface of reflective information, and resource interface. The weaving is described by a declarative language which allows the declaration of weaving rules as follows:

```
WR1 : IF (bool_expr) THEN
Aspect.TriggerInterface->GEN(event)

WR2 :IF (bool_expr) THEN
Aspect.ActivationInterface = bool_value

bool_expr ::= bool_expr op
IS_IN(Aspect.State)
bool_expr ::= IS_IN (Aspect.State)
op ::= and | or
```

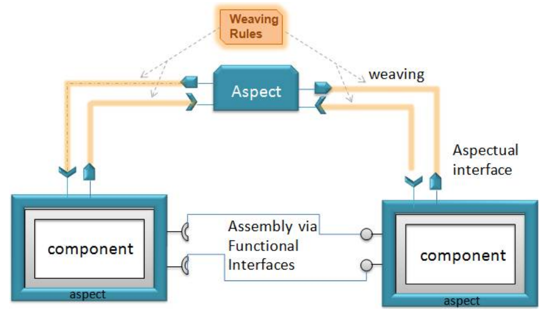

Figure 6. Aspect and components weaving

```
bool_value ::= true or false
```

An example of weaving rules is described in section 3. In our methodology, those weaving rules have the benefits to built an analysable or executable model. In fact, weaving rules allow building global conditions, based on the statecharts described in the different facets. This constitutes global invariants which serve for validating the system with external tools (model checking tools for example).

3 TOOL AND CASE STUDY

MoDEST
For evaluating the proposed methodology, a new toolkit called MoDEST (Model-Driven Embedded System design Tool) is currently under development. It implements the proposed methodology and offers a design environment ranging from control algorithm modeling to code generation on a single-processor target This tool is not doing what other domain tools done, but enabling to build links between them in order to support in a same environment the whole design process of embedded systems. The tool supports the importation of control models and provides helpful construction of embedded software specification and its real time implementation with careful consideration of model transformations. The MoDEST tool provides facilities for scheduling analysis and simulation as well as the code generation for multiple targets.

Case Study
As an example we consider the software design of a DC electrical motor speed control system, such as the control of a robot motor. Usually, the control law of such system is based on a well known PI algorithm. In this example, we will see how this algorithm can be specified and implemented with MoDEST.

Functional System modelling: The functional view of the PI controller is shown in figure 7. In the first step, the control law provided by a control engineer must be imported in the functional view of the MoDEST tool. The control law algorithm is here described using a graphical description language. The formalism of this language is well known to control engineers, since it is similar to that used by the tools for design and simulation of the control laws. The development of a gateway for an automatic import from Simulink is in progress.

The controller algorithm is here composed of 5 main functional blocks. The first block called `Input_speed` defines digital sampling of the motor measured speed. The blocks `P`, `I`, and `ADD` define the PI algorithm, while the block `motor_cmd` applies the computed voltage to the motor. For a demonstration purpose we have added 6 more blocks (`in1`, `in2`, `control1`, `control2`, `out14`, `out15`) in order to introduce temporal perturbations on the PI algorithm execution. We can see on the graph that sampling rate of `Input_speed` and `motor_cmd` is defined by a clock `CLK1`. It can also be noticed that 2 other clocks (`CLK2` and `CLK3`) are used to define sampling rate on `in1`, `in2`, `out14` and `out15`. In this example `CLK1` define a 1000ms clock, `CLK2` define a 800ms clock and `CLK3` is set to 500ms.

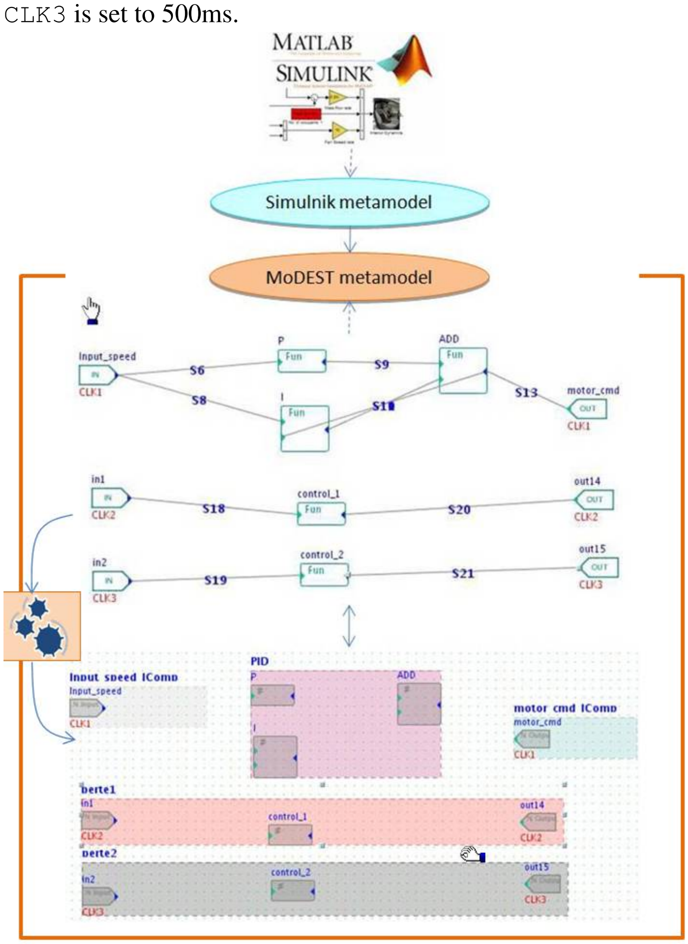

Figure 7. PI example: MoDEST functional view.

Specification of control SW: From the functional description, The computer engineer specifies the software functions which will implement the functional blocks. This is achieved using the MoDEST specification view. This view defines a mapping of functional blocks into implementation components (*IComp*) which will be executed at runtime. Figure 7 illustrates this mapping for our PI controller. Here, the input sampling block `Input_speed` will be implemented by an IComp named `Input_speed_IComp`. The 3 blocks `P`, `I` and `ADD` will be both implemented by only one IComp called `PID`.

Implementation of control SW: The third view of MoDEST allows the user to define the real-time software components and the runtime software context. First, it necessary to define the *tasks* which will support the real-time periodic execution of the *IComps*. Several *IComps* can be ordered in a *sequence* to be executed in the same task. The set of task can be defined manually by the user but it can also be automatically generated by the tool taking into account the *IComp* and clocks characteristics. On the example (see figure 8), a control task has been generated by combining the IComp of the same clock: `Input_speed_IComp`, `PID` and `motor_cmd_IComp`.

In this facet, three extra-functional aspects are defined in this view. The energy aspect constrains the functionalities of the task: if the battery level becomes low, the task should be in the limited control state. The security aspect is a watchdog which resets the task if its behaviour diverges. The platform aspect defines the runtime context of the task. The user should define a platform aspect which provides several information on the software and hardware architecture where the application should be executed (processor type, operating system, compiler, software libraries,...). The execution duration of each IComp (Input_speed_IComp, PID and motor_cmd_Icomp) depends on these parameters. When an IComp has never been used on the described architecture, the user must also provide an estimation of it. This estimation should be refined with measurements by the profiling aspect.

Analysis and Simulation

For a real-time implementation of tasks, the designer can define a scheduling aspect in order to crosscut the tasks with information related to a scheduling policy. At the design step, this aspect may adjust real-time properties such as the tasks priority. At the code generation step, it allows to add into the generated code of the tasks the OS functions which are appropriate to the selected scheduling policy. The MoDEST tool provides an automated schedulability analysis for assess the schedulability of the design without implementing the system. The result of the analysis is whether the system is feasible or not in the worst case. This analysis provides the processor charge and the response time to show if tasks meet their stipulated timing constraints. The tool implements several classical real-time scheduling algorithms such as Rate Monotonic, Deadline Monotonic and Earliest Deadline First. To reduce design time, it can automatically identify a list of applicable scheduling analysis that matches the system characteristics (Operating System, task dependencies). The results of scheduling are drawn graphically with chronogram chart as depicted in figure 8. From this simulation, MoDEST is able to perform a temporal behavior analysis by using temporal aspect. Latencies between inputs and outputs of the system, delays and jitters on tasks and IComp executions are measured and displayed as histograms. By

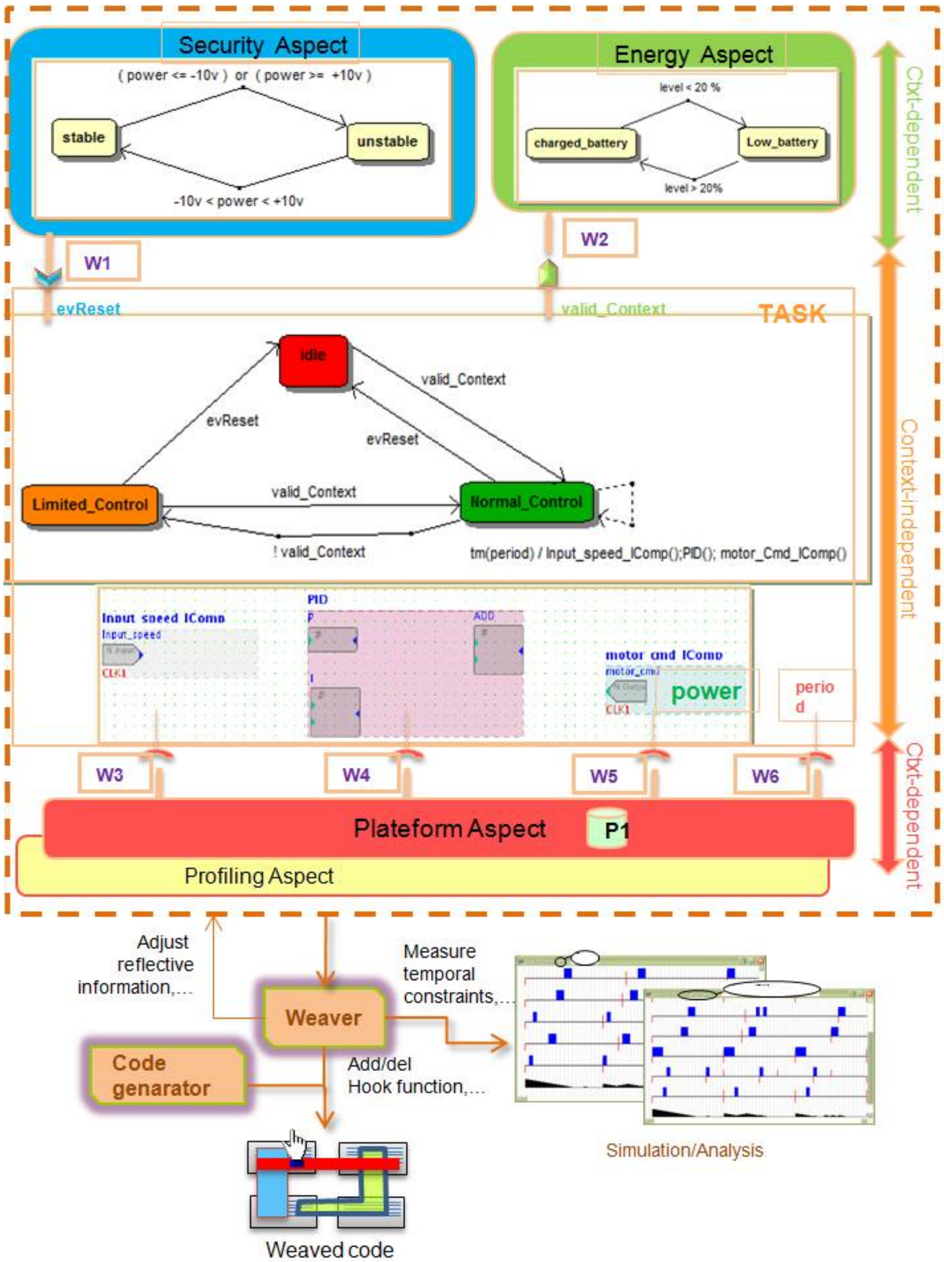

Figure 8. PI example: MoDEST implementation view

this way, the control designer can evaluate the jitters and delays induced by the real-time implementation. Taking into account these delays and jitters, he can perform some hybrid simulations to choose the scheduler which induces the best control performances.

Weaving, code generation and profiling

The weaving between the aspects and the task component is mainly described through the rules W1-W6 as follows:

```
WR1 :  if (IS_IN(unstable) then
GEN(evReset)
WR2 :  if (IS_IN(Stable) and
IS_IN(Charged_Battery) ) then
valid_Context=true
WR3 :  if (chosen(P1) then
wcet(Input_speed_Icomp) = 100ms
WR4 :  if (chosen(P1) then wcet(PID) =
200ms
WR5 :  if (chosen(P1) then
wcet(motor_cmd_Icomp) = 100ms
WR6 :  if (chosen(P1) then period = 200ms
```

The rule WR1 specifies that the task is reset (event evReset) if the robot becomes instable. The rule WR2 constrains the task to control the system only if the security constraint and the enregy constraint are met. The rule WR2 constitutes a system invariant to check the model with an external tool for model checking. The rules WR3, WR4, WR5 and WR6 define the code source path of IComp (Input_speed_IComp, PID and motor_cmd_Icomp) within the platform P1. As shown in figure 8, these rules constitute directives for the weaver and the code generator.

The MoDEST tool supports currently the code generation on a single-processor target. From the implementation facet, the designer can generate code on a target C/RTAI, real-time Java, and C on DSPBios kernel of Texas Instruments. The figure 9 shows an example of C/RTAI generated code concerning our case study. The PID task is generated as periodic task scheduled with EDF policy, and weaved with a profiling aspect. This aspect crosscuts the task code and adds into this task the profiling functions (hook functions named `chrono`) in order to measure at runtime the execution times of its IComp.

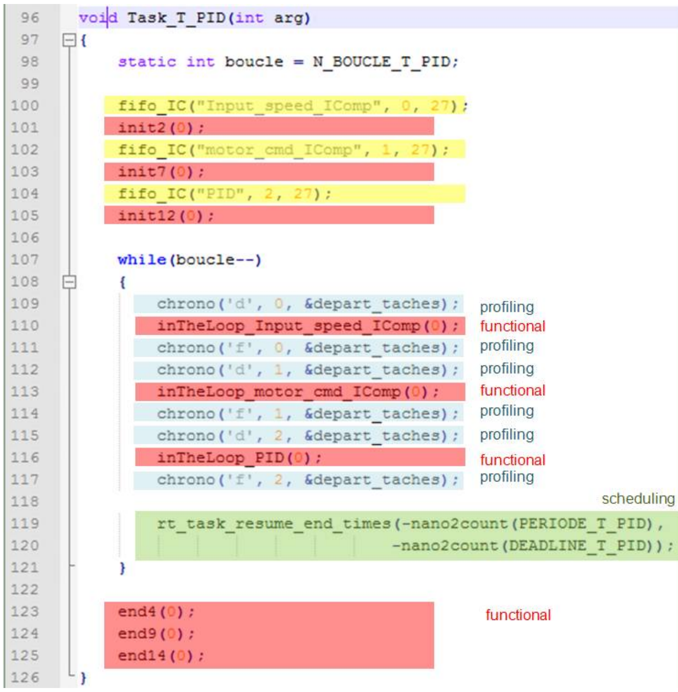

Figure 9. PID generated code with profiling aspect

The measured times are then sending back to the simulation/analysis framework of MoDEST. Based on this collected information, a real scheduling chronogram is drawn to compare it with the theoretical scheduling chronogram. Timing measurement could be done on this result in order to get some relevant temporal information to send back to control design tools.

4 CONCLUSION AND FUTURE WORKS

This research work is undertaken by collaborations between control designers and computer sciences designers to clarify and distinguish the models handled in control performance design and those manipulated in real-time implementation. Current results are a first step towards a harmonization of these heterogeneous models. The component approach should add significant value to the design process, helping the software designer to produce modular and reusable system model. The aspect approach represents a significant paradigm shift from the traditional monolithic view. It makes the system model easy to extend/contract system capabilities with global wide changes being performed automatically, avoiding errors of forgetting to change one or more locations. This leads to make design easier, improves accuracy and reduces design time. The tool provides a way to speed up design-code-test-debug cycle through analysis/simulation of the system model, and automated transformations and code generation. These features can substantially improve the development, implementation and evaluation of embedded system software.

This research work is in progress to be fully implemented in the MoDEST tool. In the near future, we will define and implement transformation rules to improve the automatic transformation between the facets. These rules will be based on the MDA approach (Model-Driven Architecture) approach and its associated tools. Software bridges to external tools are envisaged in order to allow models validation in the earliest steps of the design process.

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Fuzzy logic. A link for behavioral computer simulations of collaboration in emergency management

Cecilia LEMUS-MARTINEZ, MSc
Population Health, University of Ottawa
Ottawa, ON, K1N6N5, CANADA

Louise, LEMYRE, Ph.D., FRSC
School of Psychology, University of Ottawa
Ottawa, ON, K1N6N5, CANADA

Celine, PINSENT, PhD
GAP-Santé research unit, University of Ottawa
Ottawa, ON, K1N6N5, CANADA

and

Paul, BOUTETTE, MBA
GAP-Santé research unit, University of Ottawa
Ottawa, ON, K1N6N5, CANADA

ABSTRACT

Emergencies by nature are unexpected events with high levels of uncertainty and extreme complexity, which dynamically change along the different phases of the disasters. Emergency management is an interdisciplinary field that involves the participation of multiple organizations that hold different mandates and structural chains of command. This poses a challenge for collaboration in the way strategic problems are solved at each stage of the emergency, given that they may not follow the traditional normative linear patterns of decision making. To address this query, this work explores the application of fuzzy logic to analyze the problem and to connect diverse epistemological fields such as behavioural cognitive psychology and management, and link them to computer sciences and systems engineering. Of special interest here is the operationalization of the experiences and perceptions of expert emergency managers, which do not follow strict or simple rules but rather convey the ambiguous and flexible negotiations of interpretations folded into extreme events. Fuzzy logic provides the opportunity to model these elements under flexible patterns of interaction. Hence, the results from this paper presents fuzzy logic from a modeling perspective that aims to enable an efficient inter organizational emergency management environment along the different phases of the crisis, by rendering fuzzy logic models of inter organizational coordination, cooperation and collaboration, which can then be applied to develop behavioral computer simulations. The expected contribution of this document is to facilitate the interaction within and across the diverse fields of study involved in emergency management, by translating and interpreting their individual contributions into fuzzy logic models that can inform and complement the inter-disciplinary effort, and potentially establish a virtuous collaborative cycle for Inter-disciplinary communication of knowledge production that goes beyond the institutionalized boundaries imposed by each one of the disciplines.

Keywords: Fuzzy logic, Emergency Management, Collaboration, simulation, multi-organizational problem solving, model, complexity.

INTRODUCTION

Emergencies by nature are unexpected events with high levels of uncertainty and extreme complexity, which dynamically change along the different phases of the disasters. The study of emergency management involves the intersection of many different organizations and research fields, each one of them holding differing objectives, mandates and structural chains of command. This poses a challenge for collaboration in the way strategic problems are solved at each stage of the emergency, given that they may not follow the traditional normative linear patterns of decision making. To address this query, this work explores the application of fuzzy logic to analyze the problem and to connect diverse epistemological fields such as behavioral cognitive psychology and management, and link them to computer sciences and systems engineering.

Emergency management approaches

There are different approaches to classify emergency management, one of them is a categorization based on the time of the occurrence of the emergency events. In these terms, crisis management studies the onset of an emergency whereas consequence management is responsible for the recovery period [1]. The activities entailed are also different, crisis management is focused on the response of the emergency and it is considered to be reactive. While consequence management deals with the effects in the aftermath of the event [2]. Risk management on the other hand, covers all the stages of the disaster (see Fig. 1), and the control of the crisis is a continuous task [3]. However each approach possesses strengths and weaknesses.

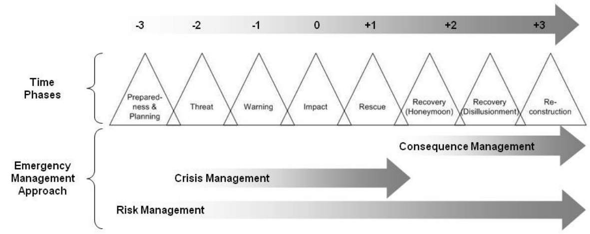

Fig.1. Emergency management approaches by time phase [3]

Lemyre et al. [4] explain that there is an intrinsic dynamical relationship within the activities encompassed along each phase of the crisis, where the only two constants are "*change and movement*". To understand the dynamic evolution of these tasks, Lemyre et al [4], developed a model for problem solving of extreme events, based on two main components: "*situational complexity (complex, complicated or simple)"* and "*inter organizational approach (collaboration, coordination or cooperation)*", each one of them being modify by multiple factors, such as "*assets (information, resources and power)"* and "*time (stage of crisis)"*.

Similarly, Scholtens [5] found that as the global complexity of the crisis increases the organizations involved in the response tend to collaborate to solve the manifold challenges faced. In these terms, Lemyre et al [4] in their model pointed out that at every stage of the emergency, there are "*kernels of coordination, cooperation and collaboration*", as well as "*kernels of complexity"* involving "*situations simple, complicated and complex*". This description can be captured by Zadeh's [6, p.310] definition of fuzzy information granulation, where he stated that: "*fuzzy information granulation may be viewed as a human way of employing data compression for reasoning and, more particularly, making rational decisions in an environment of imprecision, uncertainty and partial truth"*.

Fuzzy logic and emergency management

Along his "*quest for better models of reality"*, Zadeh [7, p.2774] developed the theoretical basis for fuzzy logic in 1965, where the traditional binary logic was replaced by a multi-valued logic that reflects more closely the human capability of process perception based information, where language and qualitative statements plays a major role [8]. Zadeh [9] explains, that the behavior of very complex or "wicked" systems does not easily admit precise mathematical analysis and this effect increases as the complexity of the system increases. However, an approximate description can be successfully achieved based on linguistic variables and fuzzy algorithms. He envisioned the application of fuzzy logic in research fields where the main roles are played by "*animated systems constituents*", such as psychology, management, medicine, biology and artificial intelligence.

In these terms, the usefulness of fuzzy logic applications is especially well suited to assist in the solution of social problems; of special interest for emergency management is the intricate process of inter-organizational decision making. In this context, Fedrizzi et al. [10] explained that most of the decision making activities are performed within and across actors, groups or organizations with differing "*value systems"* along the different problem solving stages. For this reason they developed a decision support system to reach consensus based on fuzzy logic principles. Similarly Kacprzyk [11] developed algorithms to represent fuzzy majorities in group decision making contexts. Therefore fuzzy logic has the potential to assist decision makers to deal with complex problems within an environment of uncertainty, and decision support systems based on fuzzy logic can assist in this task [12].

Given the close fit between the interdisciplinary needs and requirements in the emergency management field, and the theoretical and applied capabilities fuzzy logic has to offer, this paper, proposes the use of fuzzy logic in the field of emergency management, where diverse research disciplines intersect to study and analyze emergencies and crisis. Although fuzzy logic is not a new theory, the multiple benefits and attributes it provides, have not yet been exploited nor applied in the complex field of emergency management but in a few cases to address information security management problems [13]. However this document presents fuzzy logic from a modeling perspective that aims to enable an efficient inter organizational environment along the different phases of the crisis, by rendering fuzzy logic models of inter organizational coordination, cooperation and collaboration, which can then be applied to develop behavioral computer simulations.

METHOD

Fuzzy logic as a modeling language

Fuzzy Logic is a powerful tool to deal with imprecision and uncertainty, which offers instruments to solve real-world problems. According to Zadeh [7], one of the main legacies of fuzzy logic is its remarkable capability of "*precisiation"* that is the reason why it is highly reliable to represent different models of reality. Another important feature of fuzzy logic is that it can deal with uncertainty "*in terms of imprecision, nonspecific, vagueness and inconsistency*" [14, p. 226]. Likewise Carlssson, Feddrizzi and Fuller [15] pointed out that fuzzy logic can manipulate data and information with unknown statistical uncertainties. In fuzzy modeling, the arithmetic used for inference is based on "*if then rules"*, fuzzy reasoning is an inexact reasoning anchored in partial knowledge [16]. Consequently, fuzzy reasoning is rather qualitative than quantitative [17].

In addition, fuzzy logic offers inference mechanisms that make possible human cognitive processes capabilities to be translated into knowledge based systems [14][8]. Thus in general, the aim of fuzzy logic reasoning is to achieve conclusions from incomplete facts which are produced from experts; Bouchon-Meunier [18] described this as an "*approximation of standard evidence*". As a result, fuzzy linguistic models (FLM) are qualitative descriptions of systems behaviors, sustained on the fuzzy reasoning theory, which is a foundation for the development of expert systems [19]. In this kind of models, traditional equations and numerical symbols are not needed [16].

Moreover, Sugeno and Yasukawa [16] described an expert system as a model build on conclusions obtained from "*observable features"* of the situation under analysis, obtained from experts' qualitative knowledge and experience. Therefore they explain that the design procedure is to build the linguistic rules, to then adapt the fuzzy parameters that bound the linguistic terms involved. The authors mentioned as one possible source of information and data for fuzzy qualitative modeling, observations based on knowledge and /or experience and linguistic data.

Likewise, Chartuvedi [14] describes two methods to outline fuzzy membership functions, classified as direct and indirect methods. In the direct method an expert intuitively designate a membership rating what in his perception portrays more meaningfully the linguistic terms under design. Whereas in the indirect methods, several experts are asked to respond plain probes that indirectly describe the membership function under construction. The answers are then processed via interpolation, curve fitting or through artificial neural networks methods.

Membership function features

In order to understand the designs presented in the results section, a brief explanation of the main characteristics of a membership function developed by Chartuvedi [14] is provided. He indicates that the *core* of a membership function is the area of the fuzzy set where there is a complete membership value (see Fig. 2). Meanwhile, the area of a membership function that has any value different from zero is called *support* (Fig. 2). Whereas the *boundaries* are the parts of the membership function that neither have a full membership value nor a zero one (Fig. 2).

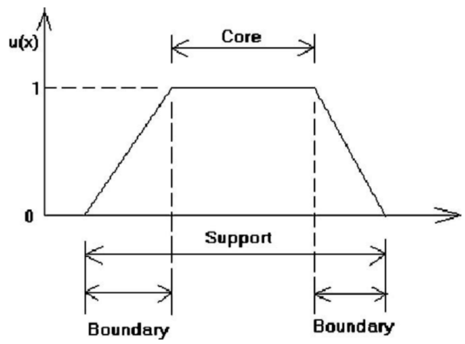

Fig. 2 Core, support and boundaries of a membership function [14, p.251]

A *generalized membership function* [14], is a concept to design membership functions with different shapes. Each generalized membership function has at least four segments of different dimensions holding different positions which can be customized to the design under construction (Fig. 3).

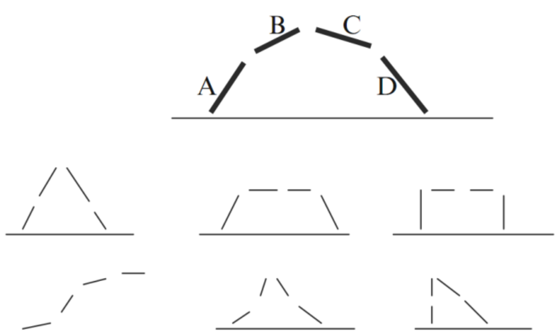

Fig. 3 Generalized membership function [14, p.252]

Another concept to describe the features of the fuzzy sets is *normality* [14]. A fuzzy set is named as *normal,* if the maximum value of its corresponding membership function is 1, and *subnormal* in any other case.

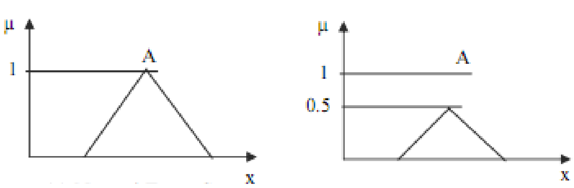

Fig. 4 Normality of a fuzzy set [14, p.244]

Data collection and Materials

Given the low likelihood of occurrence of emergencies and extreme events, retrospective data collection methods such as interviews, case studies, and other documental sources such as, governmental reports, newspapers, social media feeds and magazines are used to reconstruct the events of major crisis and emergencies. These elements have been recollected and analyzed by several researchers to develop the theoretical foundations for the emergency management field. Within these, the outlines for a theory on inter organizational problem solving and decision making during emergencies is still under development in the empirical literature, and its underlying theoretical logic is not yet completely developed. However there are already enough theoretical elements to develop the outline of fuzzy logic models that enable an approximate representation of the phenomenon.

Therefore the qualitative data to populate the fuzzy logic models was obtained from a series of research articles and reports that portrayed the expert observations and lived experiences from several first responders, governmental authorities, nongovernmental organizations and researchers who had experienced a major crisis, emergency or extreme event. The inclusion criteria for articles were: a multi-organizational environment and an observed effort to achieve collaboration between the organizations involved. After the selection process, only three key articles were chosen to design the fuzzy logic models.

Membership function design

Within the literature reviewed, preconditions to enable collaboration between organizations during emergencies and extreme events were found. These findings were then related to the phase of the event where they were observed or reported, and were also related to the level of complexity of the event. Next, each of these elements were interpreted as linguistic modifiers and outlined as a fuzzy membership function and its corresponding fuzzy set. Each fuzzy set was setup in a Microsoft Excel spreadsheet as tables of membership values, which enabled the plotting of each membership function using an area type chart. Using these methods we look to acquire a proxy of the general outlines for inter organizational approach to problem solving applied during the different stages of the crisis along the different levels of complexity.

RESULTS

This section shows the designs of fuzzy membership functions classified by level of crisis complexity, based on the experiences and expert knowledge described in the literature reviewed. First a brief summary of the major literature findings is provided, followed by the set of corresponding fuzzy rules, complemented with a description of the membership values showed in table format, and finally each membership function is graphically presented and discussed.

Simple Crisis

According to the analyses presented by Lemyre et al. [4] from a series of Canadian case studies, within an emergency or major event, there are tasks that can be performed by organizations individually without any interaction with other organizations responding to that particular event. Due to organizations being able to solve the crisis under their own availability of resources, information and mandate. Therefore the pattern observed was a mild coordinated effort mainly around the impact phase of the crisis. Translating these results into a fuzzy logic rule, this can be expressed as:

Rule 1. IF Situational complexity is low, THEN Inter organizational approach used is LOW COORDINATION.

Table 1 show the membership values during a simple crisis, where a value of 0.3 is assigned to represent a low level of inter organizational coordination in the impact and rescue phases. In a simple crisis the membership values for cooperation and collaboration were set to zero along all the crisis phases.

Table 1. Membership values: Simple crisis.

		Approach to problem solving		
		Collaboration	Cooperation	Coordination
Time phase	Preparedness & planning	0	0	0
	Threat	0	0	0
	Warning	0	0	0
	Impact	0	0	0.3
	Rescue	0	0	0.3
	Recovery	0	0	0
	Reconstruction	0	0	0

The corresponding fuzzy membership function is shown in Fig.5. In this graph, the vertical axis shows the membership function values (Table 1), and the horizontal axis shows an approximate depiction of the evolution of the timeline of the event. It is worth mentioning that the scale used in the timeline axis, is just an approximation and in any other event it may have different proportions, in other words, each one of the phases of the event may not have the same length and may overlap, this statement is valid for all the membership functions presented in the results section. The membership function shown in Fig. 5 is rendered as a subnormal plot to capture the low level of inter-organizational interaction, given that in a simple crisis the expected level of coordination is low.

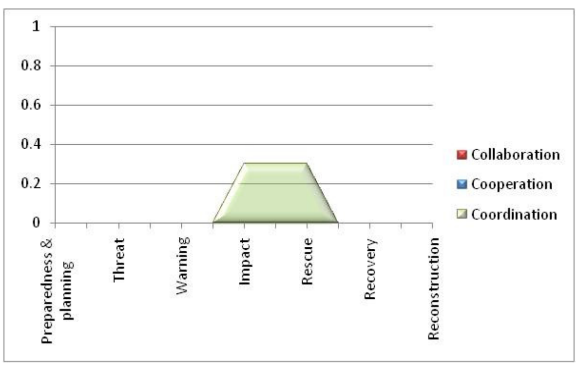

Fig. 5. Membership function for the three levels of problem solving approaches during a simple crisis.

Complicated Crisis

Berlin and Carlstrom [20] found during emergency exercises and simulations in Sweden, four different kinds of inter organizational approaches for emergency response. Parallelism is described as a similar concept to coordination; where each organization works independently from the activities of other response organizations. First initiative, on the other hand, can be classified as inter organizational cooperation, because resources and/or information were shared. Switching is described as another level of cooperation, characterized by a shifting of organizational mandates. Collaboration was barely observed between the response actors. Therefore in their experience, the most frequent pattern of interaction was coordination, followed by cooperation and the less observed pattern was collaboration. However the dynamic interplay of the patterns observed were "*kernels*" of medium coordination and low cooperation around and after the impact stage of the crisis. Translating these results into fuzzy logic rules, these results can be expressed as:

Rule 1. IF Situational complexity is medium, THEN inter organizational approach used is MEDIUM COORDINATION.

Rule 2. IF Situational complexity is medium, THEN Inter organizational approach used is LOW COOPERATION.

In this case, Table 2 shows the membership values during a complicated crisis, where a value of 0.5 is assigned to represent a medium level of inter organizational coordination, and a value of 0.3 to characterize a low level of cooperation, both approaches were identified during the impact and rescue phases. In a complicated crisis the truth values for collaboration were set to zero along all the crisis phases.

Table 2. Membership values: Complicated crisis.

		Approach to problem solving		
		Collaboration	Cooperation	Coordination
Time phase	Preparedness & planning	0	0	0
	Threat	0	0	0
	Warning	0	0	0
	Impact	0	0.5	0.3
	Rescue	0	0.5	0.3
	Recovery	0	0	0
	Reconstruction	0	0	0

The corresponding fuzzy membership functions are shown in Fig. 6. In this graph, the vertical axis shows the membership functions values (Table 2), and the horizontal axis shows an approximate depiction of the evolution of the timeline of the event. The membership functions shown in Fig. 6 are rendered as subnormal plots to capture the low and medium levels of inter-organizational interaction, given that in a complicated crisis the level of coordination expected is medium, and a low level of cooperation. In this case, coordination is represented as a precondition to enable cooperation, which in turn may overlap with some coordination activities that may require resource, information and authority sharing between organizations.

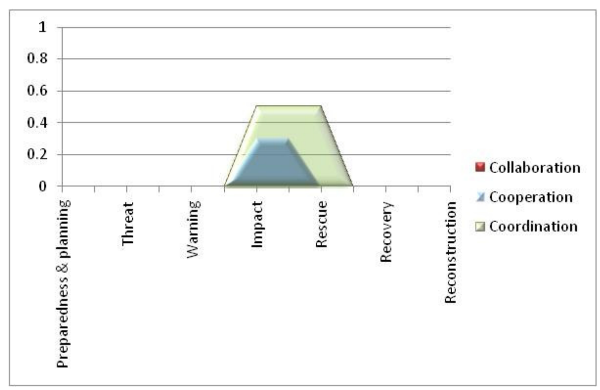

Fig. 6 Membership functions for the three levels of problem solving approaches during complicated crisis.

Complex crisis

In the Netherlands, Scholtens [5] based on field and documental studies for inter organizational emergency response; found that collaboration was only observable when life of people was in danger. That was the only key moment when organizations, had to work jointly and shared resources, information and authority. After this short period of time, the organizations return to work preferably independently. These findings coincide with the observations made by Berlin and Carlstrom [20]. The authors hypothesized that collaboration is not the prefer pattern of interaction, due to the high efforts and costs involved in deploying this kind of response. In this case as well, dynamic interplays or "*kernels"* of coordination, cooperation and collaboration were observed. Translating these results into fuzzy logic rules, these results can be expressed as:

Rule 1. IF Situational complexity is high, THEN inter organizational approach used is MEDIUM COORDINATION.

Rule 2. IF Situational complexity is high, THEN Inter organizational approach used is FAIRLY HIGH COOPERATION.

Rule 3. IF Situational complexity is high, THEN Inter organizational approach used is HIGH COLLABORATION.

For complex crisis, Table 3 shows the membership values interpreted from the literature descriptions. Inter organizational coordination was set up to a value of 0.5 to represent a medium level. Cooperation was assigned a value of 0.7 to characterize a fairly high level of inter-organizational interaction; both approaches were identified during the impact and rescue phases. On the other hand, collaboration was set up to a value of 1, to represent the high level of inter organizational interaction needed during the life-danger period of the impact phase of a complex crisis.

Table 3. Membership values: Complex crisis.

		Approach to problem solving		
		Collaboration	Cooperation	Coordination
Time phase	Preparedness & planning	0	0	0
	Threat	0	0	0
	Warning	0	0	0
	Impact	1	0.7	0.5
	Rescue	0	0.7	0.5
	Recovery	0	0	0
	Reconstruction	0	0	0

The corresponding fuzzy membership functions are shown in Fig. 7. In this graph, the vertical axis shows the membership functions values (Table 3), and the horizontal axis shows an approximate depiction of the evolution of the timeline of the event. The coordination and cooperation membership functions shown in Fig. 7 are rendered as subnormal plots to capture the medium and fairly high levels of inter-organizational interaction. Notice that the pattern described for collaboration is a normal triangular membership function, with slopes so steep that its shape recalls a Dirac's function. As in the former case, both coordination and cooperation are represented as preconditions to enable collaboration. In the impact phase of the crisis patterns of dynamic interplays between collaboration, coordination and cooperation are shown.

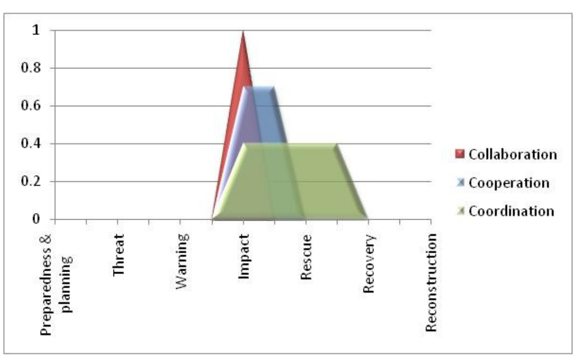

Fig. 7 Membership functions for the three levels of problem solving approaches during complex crisis.

Very Complex Crisis

In the analysis presented by Lemyre et al [4] from a series of case studies of international major events and disasters, the 2003 SARS case stands out, due to the high level of international collaboration involved to overcome the extreme complex challenges faced. In this case as well, the main danger was the lost of hundreds of lives related to the high power of viral transmission, and the uncertainty related with its treatment and prevention. Therefore collaboration was observed over an extended period, because the impact phase was geographically extended as well. Translating these results into fuzzy logic rules, these results can be expressed as:

Rule 1. IF Situational complexity is very high, THEN inter organizational approach used is MEDIUM COORDINATION.

Rule 2. IF Situational complexity is very high, THEN Inter organizational approach used is FAIRLY HIGH COOPERATION.

Rule 3. IF Situational complexity is very high, THEN Inter organizational approach used is HIGH COLLABORATION EXTENDED.

For very complex crisis, Table 4 shows the membership values interpreted from the literature descriptions. Inter organizational coordination was set up to a value of 0.5 to represent a medium level along the impact, rescue and part of the recovery phases. Cooperation was assigned a value of 0.7 to characterize a fairly high level of inter-organizational interaction during the impact and rescue stages. Finally, collaboration was set up to a value of 1, to represent the high level of inter organizational interaction needed during the extended life-danger period of the impact phase of a very complex crisis.

Table 4. Membership values: Very Complex crisis.

		Approach to problem solving		
		Collaboration	Cooperation	Coordination
Time phase	Preparedness & planning	0	0	0
	Threat	0	0	0
	Warning	0	0	0
	Impact	1	0.7	0.5
	Rescue	1	0.7	0.5
	Recovery	0	0	0.5
	Reconstruction	0	0	0

The corresponding fuzzy membership functions are shown in Fig. 8. In this graph, the vertical axis shows the membership functions values (Table 4), and the horizontal axis shows an approximate depiction of the evolution of the timeline of the event. The coordination and cooperation membership functions shown in Fig. 8 are rendered as subnormal plots to capture the medium and fairly high levels of inter-organizational interaction. Collaboration, on the other hand, is portrayed as a normal trapezoidal membership function. And as in the former complex case, both coordination and cooperation are represented as preconditions to enable collaboration. During the extended impact phase of the crisis, patterns of dynamic interplays between collaboration, coordination and cooperation are shown.

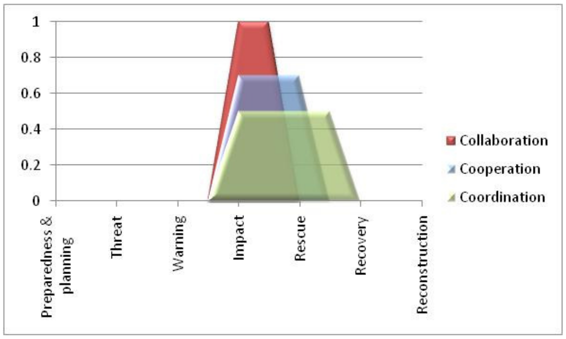

Fig. 8 Membership functions for the three levels of problem solving approaches during very complex crisis.

DICUSSION

The fuzzy logic models presented are first attempts to characterize inter organizational patterns of interaction during emergencies based on fuzzy rules. These models can inform computer behavioural simulations by offering basic low cost instructions to build on more complex algorithms. They can also be applied in situations where experimentation is a challenge for data collection. Although neither optimal nor comprehensive, the models portrayed provide an approximate description of inter organizational problem solving patterns along different levels of crisis complexity. These models provide a graphical depiction of the literature results descriptions, which potentially could bring forth more precise or complete models that fit better the phenomena based on qualitative analogies.

The refining and tuning up of fuzzy models will have to be accomplished in order to provide more accurate tools to develop expert systems to assist in the field of emergency management. One of these future steps is to validate the models from experimental and other documental data to assess their external validity. However, the first step is given an fuzzy logic already acts as a mediator linking epistemologically differing fields, such as social and computer sciences by enabling the representation of degrees of human rationality bounded by vagueness.

ACKNOWLEDGEMENT

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The System Structure of Architectural Design
- a model approach

Kasper Sánchez VIBÆK
CINARK - Centre of Industrialised Architecture, Royal Danish Academy of Fine Arts, School of Architecture
Copenhagen, Denmark

ABSTRACT

A new concept of *system structure* and a model to describe it is proposed as an analogy, within construction, to the notions of product architecture and supply chain management as they are used in the product industry. The model can potentially be used as a way of bridging an apparently increasing gap between architectural conception and the actual building process and its result – the final building. The system structure of architectural design introduces a system structural view on buildings and how they are put together and the suggested model should be seen as a tool to help understand and qualify the choice and combination of different more or less industrialised systems of varying complexity into a coherent modern industrialised architecture. Perspectives in the conscious use of the system structure model could be architectural, ecological, economical, legislative and technical by introducing a way of handling the complexity of architectural design and of focussing design attention. As an inherently integrative discipline architectural design is perhaps the most obvious place in construction for the application of such a systems approach.

Keywords: System structure, supply chain, product architecture, architectural design, visual model, industrialised architecture.

1. INTRODUCTION

Present paper presents a new concept in architectural design – *system structure* - and a model to describe it. The concept and the model address an increasing need for tools to handle the complexity of architectural design from idea via construction to the final physical result. The initial outset is an apparently growing distance between how architecture is conceived and how it can be produced. The industrialisation of the construction sector has considerably accentuated this tendency. With point of departure in the idea of an integrated systems approach, the suggested model is supposed to help bridging the gap between architectural ideation and contemporary industrialised construction by enabling a more active use of products from the building industry already from early design phases. This can potentially reduce the need for resource intensive and time consuming translation of architectural concepts into physical matter and form. The *system structure of architectural design* gives a system-structural view on buildings and how they are put together and thus brings issues of supply chain management and product architecture into the architect's toolbox.

The ambition has been to develop a model that can visualise the use of systems, their system level – understood as their degree of complexity – and their combinations, interrelations and nesting into a complete building seen as a complex system. The model is a visual tool that, apart from being relatively easy to code, moreover, through its graphical qualities, is able to communicate various levels of information in an easily perceivable way. The primary target group is the architect – working in education, practice and/or research. Other potential users are construction engineers, other consultants and contractors as well as manufacturers of building products of more or less integrated nature. The visualisation provided by the model serves in the first place scientifically as an analytical tool for understanding the system structure of already built projects. In a more developed form the model will potentially become a proactive design tool used both in architectural conceptual and design development phases for a more conscious decision making concerning the combinations of systems into specific building projects. This aspect is much in line with Christopher Alexander when he states that:

> *'Scientists try to identify the components of existing structures. Designers try to shape the components of new structures. The search for the right components and the right way to build the form up from these components, is the greatest physical challenge faced by the designer. I believe that if the hierarchical program is intelligently used, it offers the key to this very basic problem – and will actually point to the major physical components of which the form should consist'* (Alexander 1964:130)

Alexander's use of 'patterns' are however concerned with the *functional* organisation whereas the proposed system structure model is rather focussing on *physical deliveries* thus integrating the genesis of the physical structure into the model. The focus is how buildings can be divided into subelements or systems in different ways, how these systems in some cases are integrated into larger units or chunks (= more complex systems) and, finally, how they interface with adjacent systems in the finished building. This points towards a definition of the system entity for the model being physical systems and their related processes as they are delivered and inserted into a building. Systems in this definition of *delivery* will always contain physical elements that become a part of the final building.[1]

[1] To talk about a final building is intuitively easy to understand. It can however be problematic to conceptualise a building as something stable over time. In the current context we will not

2. PRODUCT ARCHITECTURE AND SYSTEM STRUCTURE

In product development within the product industry the concept of system level design designates a phase between the conceptual design and design development. The system level design establishes what is termed the product architecture. The definition of such product architecture is required when developing complex technical systems with many interacting subsystems and components as e.g. automobiles, airplanes or even smaller systems like a photocopier or a laptop. Ulrich & Eppinger defines the system level design phase as including:

> *'[…] the definition of the product architecture and the decomposition of the product into subsystems and components. The final assembly scheme for the production is usually defined during this phase as well. The output of this phase usually includes a geometric layout of the product, a functional specification of each of the product's subsystems, and a preliminary process flow diagram for the final assembly process.'* (Ulrich & Eppinger 2008:15)

The (new) concept of system structure in construction is analogue to the product architecture in the product industry. In architectural design of complete building projects considered as complex systems a characteristic difference must however be considered. The idea of a system level design being a delimited phase in a linear process is problematic. As write Maier & Rechtin:

> *'A true systems approach [in architecture (ed.)] means that the design process includes the 'problem' as well as the solution. The architect seeks a joint problem-solution pair and understands that the problem statement is not fixed when the architectural process starts'* (Maier & Rechtin 2009:8)

Architectural design is probably more than any other process of creation characterised by iteration.[2] Problem and solution are not linearly connected but to some extent juxtaposed influencing each other in both directions – they are interdependent. The purpose of a system structure in architectural design is to enable modelling of different system scenarios representing different boundary or interface definitions between available systems early in the architectural design process that can then be hold up against each other and continuously be modified according to the development of the design. A final assembly scheme rarely exists in building design; it is developed and modified continuously. A system structure in architectural design is the organisation, structuration or subdivision of a building's physical deliveries on different levels of complexity and represents an actual or potential delivery and assembly scenario.

3. TIER MODEL AND SUPPLY CHAINS

KieranTimberlake – an architectural office in Philadelphia – has worked with a way of describing applied systems in building projects through the use of supply chain models. These models are inspired by industrial management and production systems. According to Nagurney:

> *'A supply chain, or logistics network, is the system of organizations, people, technology, activities, information and resources involved in moving a product or service from supplier to customer. Supply chain activities transform natural resources, raw materials and components into a finished product that is delivered to the end customer. In sophisticated supply chain systems, used products may re-enter the supply chain at any point where residual value is recyclable'* (Nagurney 2006)

KieranTimberlake's version of the supply chain model is not to be understood as complete supply chains showing the absolute flow of materials from 'natural resources, raw materials and components into a finished product'. Rather these 'chains' are limited to the *focus of the architect in a particular architectural project*. The model is split into two separate chains – of offsite and onsite processes ending respectively with a fabricator delivering offsite production *to* and a manager controlling onsite processes *on* the building site (see figure 1 and Kieran & Timberlake 2008). Each of the chains is divided into a number of tiers – three offsite and two onsite tiers.

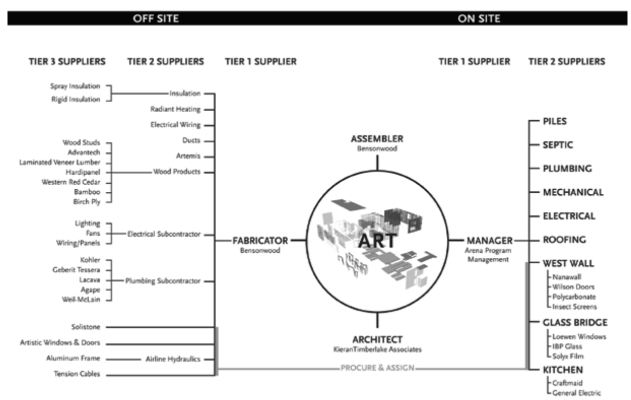

FIGURE 1 – SUPPLY CHAIN FOR LOBLOLLY HOUSE BY KIERANTIMBERLAKE, COURTESY OF KIERANTIMBERLAKE

Interesting about this model is the capacity of displaying how the architect is working with systems and their interfaces. To some extend it also shows the sequencing (or nesting) and combinations of these systems from simple subsystems over more integrated ones to the final building. Although working with the concept of different tiers in sequence, the model does not include the system level – the complexity of each delivery – as a consistent parameter of the different systems found in the diagrams. The system level will here be more specifically

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go further into this discussion and, at least provisionally, accept that such finished state of a building will exist for an amount of time.

[2] Trial-and-error, prototypes and subsequent product development are not viable paths in architectural creation where the end result is always 'one-of-a-kind'

defined as *the complexity of a subsystem at the moment of its delivery*. To use KieranTimberlake's tier model for this aspect is further complicated by the distinction between offsite and onsite suppliers in separate supply chains.

4. SYSTEM STRUCTURE – A MODEL DRAFT

Strongly inspired by KieranTimberlake's supply chain model and the concepts of system level design and product architecture, a revised version is proposed that combines offsite and onsite into one single tier hierarchy that integrates a graduation of system levels with a slightly enhanced number of tiers (T1-5). Lower tier numbers express a higher system complexity 'downstream' in the supply chain while higher tier numbers represent simpler systems 'upstream'. The sequence of the tiers is: Raw materials (T5), Building materials and standard components (T4), Subassemblies and system components (T3), Sub-chunks/assemblies by system (T2) and Volumetric chunks/assemblies by zone (T1). A last 'Tier 0' (T0) is the finished building onsite where all systems independently of their complexity are integrated (see figure 2). Theoretically there could be additional 'upstream' levels in the hierarchy (higher tier numbers) e.g. a next level focussed on molecular properties of materials. However the included levels express the range of what would normally be the focus of the architect within normal building projects.

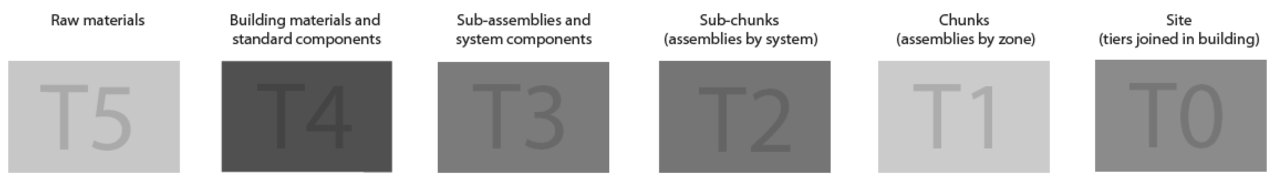

FIGURE 2: NEW TIERS EXPRESSING THE SYSTEM LEVELS OF THE SYSTEM STRUCTURE MODEL

The system level (expressed by tier #) contains apart from the characteristics described above three dimensions: An integration level, a standardisation level and a commoditisation level. Integration is defined in four levels (see figure 3):

1) Building material (MAT): manufactured raw material, one single material/composite material
2) Building component (COM): assembled building component, simple custom made components or standard technical unit/device
3) Kit of parts (KOP): standardized and customised system components delivered as a kit for assembly
4) Assembly (ASM): Integrated assembly of materials and/or components by system or by zone

Equally standardisation is defined in four levels (see figure 4):

1) Off-the-shelf (OTS): standard dimensions made for unknown customers
2) Cut-to-fit (C2F): standard material cut and delivered in customized dimensions
3) Made-to-order (M2O): customised version within existing system
4) Custom made (CM): Non-standard COM, KOP or ASM made specifically for a project[3]

Finally, commoditisation is also defined in four levels. The *integration point* means where a subsystem is integrated in to a larger system:

1) Purchase (BUY): purchased and brought to integration point by buyer[4]
2) Delivery (DEL): delivered to integration point by supplier[5]
3) Installation (INS): installed at integration point by supplier
4) Serviced (SVC): installed, warranted and serviced at integration point by supplier

Commoditisation has to do with additional delivery aspects of immaterial quality around the physical system. It expresses something about e.g. liability and responsibility issues connected to a building product: The two first dimensions – integration and standardisation level – have a directional but non-linear relation to the system level (= the tier #). This means that a system with higher integration and lower standardisation *normally* also means a higher system level (= a more complex downstream delivery). However, both low standardisation and high integration can also be imagined further upstream in the supply chain. Composite, smart or phase changing materials are e.g. upstream (T4) but can be considered as highly integrated deliveries (COM, KOP or ASM). Concerning standardisation, for e.g. a high end project, such materials could even be custom made (CM). The purpose of these supplementary dimensions is to introduce a second layer in the model that makes it more robust in terms of capacity for consistent classification of *any* system or delivery applied in a building project. The dimensions nuance the coding of the deliveries that each of them is represented by a box in the system structure model.

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[3] Theoretically even custom made materials (MAT) could be a possible combination

[4] On different tier levels upstream deliveries are integrated to downstream deliveries always ending the final building. A 'purchased system' is collected by the buyer himself or by request of the buyer. The buyer could also be called the integrator (on a certain tier level)

[5] The 'supplier' can be the manufacturer but can also be an authorised supplier of the system

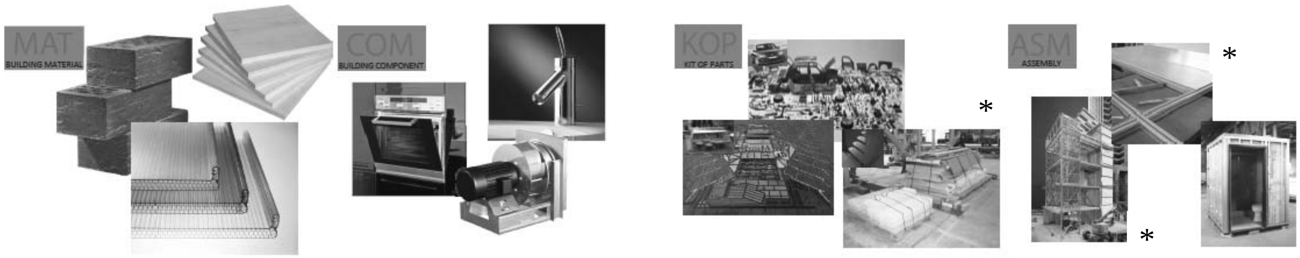

FIGURE 3: INTEGRATION LEVELS – ILLUSTRATIONS MARKED WITH * ARE COURTESY OF KIERANTIMBERLAKE

FIGURE 4: STANDARDISATION LEVELS – ILLUSTRATIONS MARKED WITH * ARE COURTESY OF KIERANTIMBERLAKE

5. ANALYSIS OF SYSTEM STRUCTURE SCENARIOS

The system structure model has a generic character that potentially can be applied to any building project as a way of analysing and visualising the system structure in question.

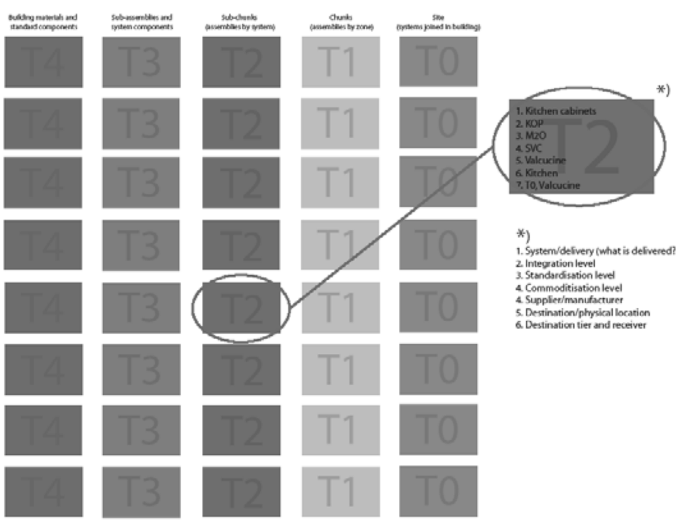

FIGURE 5 - GENERIC SYSTEM STRUCTURE MODEL AND AN EXAMPLE OF A SPECIFIC DELIVERY CODING (A BOX)

As mentioned earlier, it expresses a *focussed* view representing a specific viewpoint i.e. the architect's, the contractor's, the manufacturer's etc. In each case the details relevant for this view can be expressed in the system structure. Some of the systems (in focus) will appear nested as chains of subsystems, systems and supersystems (from upstream to downstream tiers) with the building itself as the final integration point (T0). A characteristic of the model is that it combines the idea, the process, and the product into one single system entity circumscribed by the concept of delivery and expressed like a box (See figures 5 and 6). [6]

Theoretical scenarios are put into the generic model for showing its explanative power in a simple way (see figure 7). Different ways of defining and organising systems in construction projects will be reflected differently in the model – read: result in different system structures. As an example traditional and contemporary onsite construction scenarios will have a large amount of T4 and some T3 deliveries that are integrated directly at T0 – the building site. On the contrary standardised and customised prefab scenarios can have virtually the same T4 and T3 deliveries but with integration point at the T1 level – volumetric chunks/assemblies by zone. Finally a more tentative 'future industrialised construction' scenario will have longer supply chains of deliveries on various system levels. While some deliveries are nested into others upstream others on various levels are integrated directly at T0 – the building. Future industrialised construction, it is asserted here, will tend towards a larger amount of mid-level deliveries as T2 and T1 – 'subchunks by systems' and 'volumetric chunks by zone'.

The different theoretical scenarios do present different – visually easily distinguishable – system structures. These differences provide a first basis for a discussion about the concept of system structure when applied to real architectural projects as well as it suggests an incipient language for characterising this 'system-structural' aspect of architectural design. It is the author's belief, that such a language is useful in

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[6] A detailed explanation of the genesis of the model has been left out due to the limited length of this article. Further details including a methodological discussion can be found in Vibæk, Kasper Sanchez (2011) *Creative knowledge production as a special paradigm for architectural research - a research case in abductive method* IN: Proceedings for Symposium and annual meeting in the Nordic Association of Architectural Research 2011.

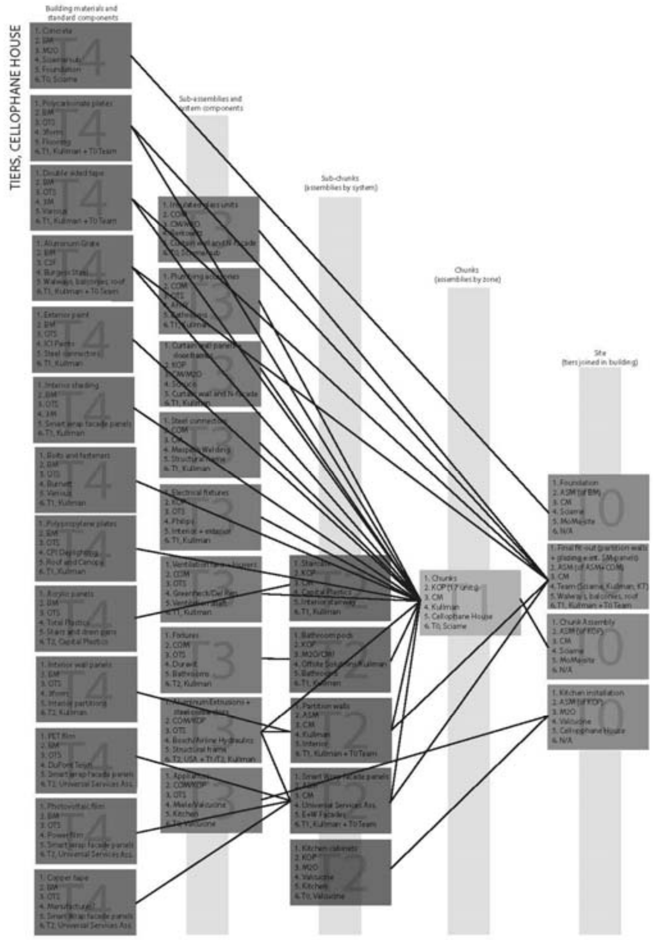

FIGURE 6 – SYSTEM STRUCTURE ANALYSIS OF CELLOPHANE HOUSE™ BY KIERANTIMBERLAKE

the discussion and further application of increasingly more industrialised and more complex products and deliveries in architectural design and construction. Being able to discuss the system structure of a building project – in the first place analytically and retrospectively – enhances the researcher's and the designer's capacity to understand and handle a complex structure or organisation through a kind of *levelled complexity* where the relevant focus or level of detail is chosen for the analysis in question. As an intermediate systems layer the model introduces different system levels (the tiers) and can in a more developed state enable a dynamic management of the focus of attention while keeping the overall structure – the system structure – easily visually perceivable and editable.

6. USE, FURTHER RESEARCH AND TESTING

But what are the perspectives of applying a more systemic approach to architectural design and facilitate a better understanding of the integration of systems in construction projects as they move towards more industrialised and complex integrated product deliveries? An easy answer could be that there is no way back to traditional construction exclusively based on the use of simple building materials and components brought directly to and processed on the building site (T0). As Alexander points out there is no way the current and increasing complexity in architectural design can be grasped intuitively by the designer. If that is the case, several arguments could be put forward for an industrialised architecture as assemblage of integrated and nested systems managed through the use of system structures:

- Architectural advantage of embedding complexity (in discrete sub systems) while still leaving more flexible and robust the solution space than in closed all-encompassing building systems
- Ecological advantage of being able to select the subsystems most adequate to the local situation
- Business/legislative and liability advantage of dealing with products – not buildings
- Systematic product development, specialisation and quality improvement is more probable in (sub) systems as Integrated Product Deliveries by allowing high up-front research and development expenses to be amortized across bigger and more international markets.

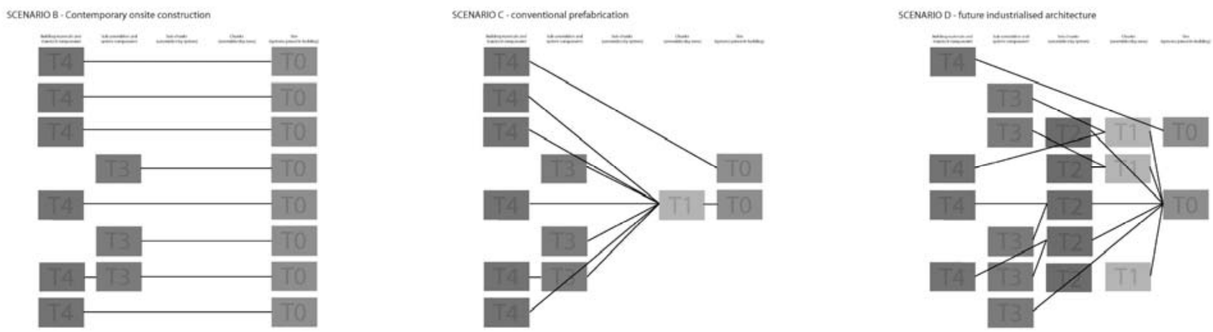

FIGURE 7 – DIFFERENT THEORETICAL CONSTRUCTION SCENARIOS EXPRESSED AS SYSTEM STRUCTURES

- Real industrialised/automated production rather than offsite construction more feasible as solutions become products (not simply traditional construction under roof)
- New market possibilities (compared to closed all-encompassing systems) within retrofitting of existing building stock as an alternative to demolition and new construction. This is particularly interesting concerning sustainability aspects.

Subsequent steps in the model development – in order to further refine and test the model – has been to apply it to a limited number of already realised building projects selected according to their supposed similarity with the theoretical scenarios presented above. Important to state again is that the model only visualises the architect's or other stakeholders' specific focus of attention. It is does not reflect complete material supply chains.

Another ambition which is already opened is equally to be able to follow the disintegration or un-nesting of a building and its systems through reuse, disassembly and demolition after a period of service. Although most buildings in our part of the world are conceptually designed as if they were to exist forever this is seldom the case. The world and our culture are nonlinear, turbulent, and dynamic entities – perhaps even at an accelerating rate. Changing needs put demands on buildings as systems to be adaptive over time. Concepts as design-for-disassembly and cradle-to-cradle design have been forwarded. A mirrored version of the present model draft could provide a scheme for handling deliveries as sophisticated supply chain systems where, as Nagurney (2006) was cited above: "used products may re-enter the supply chain at any point where residual value is recyclable" Systems and their nesting could be conceptualised as series of closed loops interfacing materially

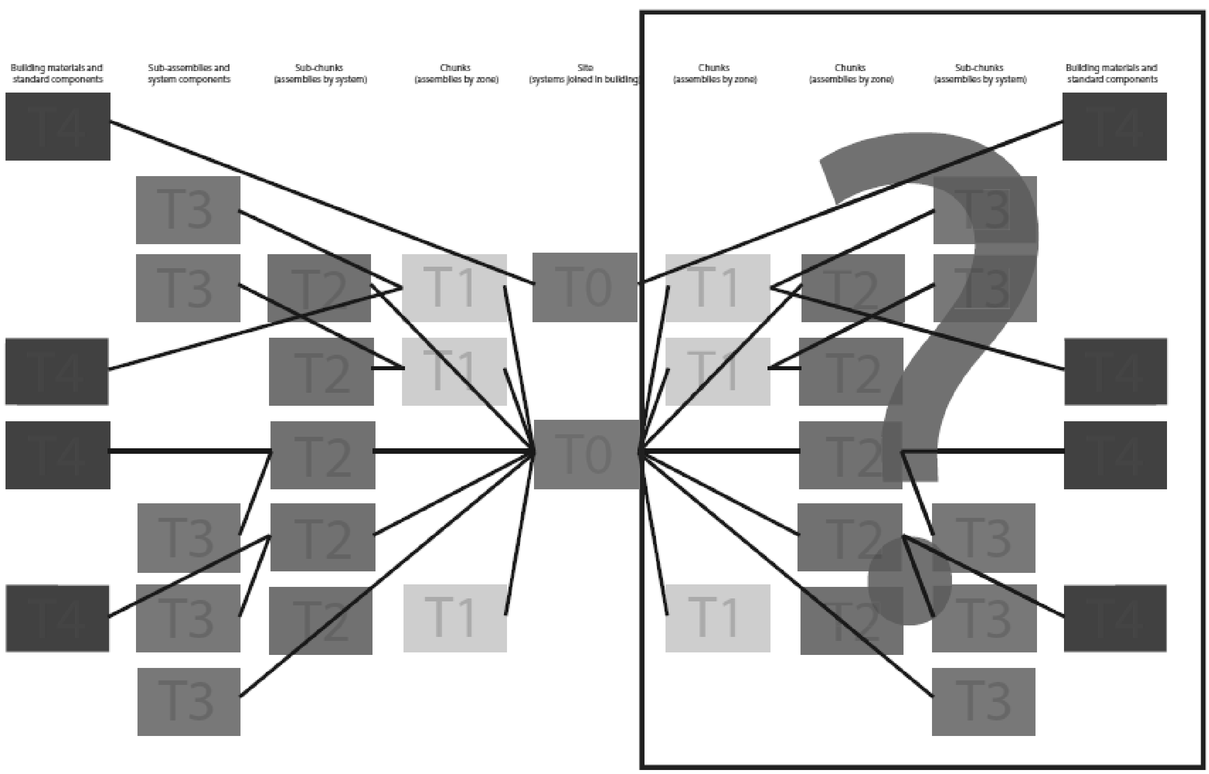

FIGURE 8 – SKETCH FOR A DISASSEMBLY SCENARIO EXPRESSED AS SYSTEM STRUCTURE.

and procesually in the building on a temporal basis. Buildings would then be system nodes in a network of systems.

7. LETTING GO

In the eagerness of systemising and controlling architectural design it is however important to keep in mind as Meadows ironically states that:

> *'Encouraging variability and experimentation and diversity means 'loosing control'. Let a thousand flowers bloom and anything could happen! Who wants that? Let's play it safe and push this lever in the wrong direction by wiping out biological, cultural, social and market diversity!'* (Meadows 2008:160)

Perhaps there is no need – or wish – at least from an architectural point of view to get the process of building and architectural design completely under control. This is not the same as saying that it does not make sense to understand and visualise buildings and their coming into being as complex systems of ideas, processes and products. The model draft is a step in this direction. The architect has a special position in the process of building perhaps, as Bachman states representing the only truly integrative discipline (Bachman 2003). This could mean that the architect is the most obvious candidate for the systems approach. Here the ability to handle complexity becomes crucial. Maier & Rechting states that: '*It is the responsibility of the architect to know and concentrate on the critical few details and interfaces that really matter and not become overloaded with the rest.*' (Maier & Rechting 2009:9)

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Investigating how Graphical and Textual Computer-based Programming Environments Support Student Inquiry in Science during Modeling

Zacharias ZACHARIA
Department of Educational Sciences, University of Cyprus
P.O. Box 20537, Nicosia 1678, Cyprus

and

Loucas LOUCA
Department of Educational Sciences, European University,
Diogenous Str. 6, Engomi, Nicosia 1516, Cyprus

ABSTRACT

In this paper we investigate the ways that a graphical and a textual Computer-based Programming Environment (CPE) support student inquiry in science during scientific modeling. We analyzed the conversations of 78 sixth-graders (39 students per CPE group) that took place during the construction of models, as well as, student-constructed models specifically looking for ways that CPEs support student scientific inquiry. Our findings showed that CPEs enable students to develop models of physical phenomena and operationally define physical entities and physical properties, which provides students with a commonly shared language for communicating and understanding each others' ideas in science. We also found that programs in CPEs produce a computer microworld that is a structured environment learners can use to explore and manipulate a rule-generated universe, subject to particular assumptions and constraints that serve as representations of aspects of the natural world. Microworlds can also provide learners with opportunities to manipulate realities in ways that learners cannot do with physical objects. Implications from this study suggest productive features for computer-based tools that can be embedded in web-based learning platforms for supporting students' inquiry and science learning.

Keywords: Computer-based Programming Environments, modeling-based learning, inquiry, science

1. INTRODUCTION

Models and the process of modeling are core components of scientific literacy [1, 2, 3, 4, 5, 6], not only because the heart of learning in science is the construction and use of models of natural phenomena, but also because part of learning in science entails learning with and about the process of scientific modeling [7]. Science proceeds through the construction and refinement of models [8], and learning science should include developing understanding about natural phenomena, as well as learning the process of developing and refining those models [9, 5].

Modeling-based Learning in Science

Modeling-based learning (MbL) can provide the context in which the development and refinement of models can achieve better quality outcomes in terms of fundamental understanding of concepts, operational understanding of the nature of science and the ability to employ procedural and reasoning skills, than what is currently possible through other learning environment/tool in many educational systems [10, 11]. Moreover, any learning experience that is grounded upon the premises of MbL offers students, through an authentic inquiry-oriented practice, an opportunity to think and talk scientifically about natural phenomena [12], to share, discuss and criticize their ideas [13, 14, 15] and to reflect upon their own understanding [16, 17].

MbL is highly related to the modeling tool used (drawings, mathematical equations, graphs, three-dimensional structures, computer-based programming media and computer-based modeling environments or even words). Hence, one important parameter that should be considered before implementing MbL within a learning environment is the modeling tool itself. The quality and functionality of a model depends upon the representation medium that is used to represent and develop the model of a natural phenomenon. Consequently, the degree of how well students conceptualize natural phenomena varies according to the modeling tool used to construct and communicate a model to others [18]. The most promising educational modeling tools that appear in the literature are computer-based [19, 20, 3, 4, 5, 6].

Computer-based modeling tools: A computer-based modeling tool consists of an open-ended, dynamic and exploratory learning environment which among others supports the construction of representation of complex phenomena through the simultaneous application/execution of multiple processes in order to go beyond static representations or static structural depictions to dynamic representations of cause/effect relationships among variables [21]. In addition, it allows students to visualize abstract concepts [22] and complex relationships [23]. This latter feature is very important for learning in science because it can enable learners to overcome some of the conceptual and reasoning difficulties they face when studying complex systems.

Currently, a large number of computer-based modeling tools are available and suitable for educational purposes. Despite their similarities, most of these tools have unique characteristics that differentiate them from others, thus, making their selection for a particular modeling assignment a challenging task. Research thus far has failed to describe the criteria (e.g., interface, modeling language, availability of tools/features) that should be used for the selection of the most suitable computer-based modeling tool given a specific age-group and/or a particular natural phenomenon/system.

The current study aimed to contribute towards this direction by investigating how two groups of fifth-grade elementary school students used two different computer-based modeling tools to develop models of natural phenomena. Specifically, this study aimed to investigate the use of a particular family of computer-based modeling tools, namely, computer-based programming environments (CPEs) that research has confirmed their importance of being used as tools for teaching practices of modeling and science (e.g. 23). CPEs provide microworld environment that has no rules and follows no physical laws, and provide a program language as the modeling tool for developing representations of natural phenomena. In contrast to other computer-based modeling tools that can be used only for the construction of symbolic simulations (models), CPEs enable users to develop "concrete" simulations of natural phenomena/systems that can include animation-like representations of those phenomena/systems that are result of the program code. Our decision for using CPEs as modeling tools lies on the idea that the process of scientific modeling can be compared to the process of computer programming, and modeling can be carried out through developing a computer program, when the program itself becomes the scientific model.

Programs in CPEs produce *a computer microworld* which is a structured environment that learners can use to explore and manipulate a rule-generated universe, subject to particular assumptions and constraints that serve as representations of aspects of the natural world. Computer microworlds are idealized environments composed of a collection of objects, relationships among objects and operations that transform the objects and their relationships, all of which are represented in well-specified rules [24, 25]. Microworlds can also provide learners with opportunities to manipulate realities in ways that learners cannot do with physical objects [1].

Currently there is a number of widely-varying CPEs designed for young learners including textual programming [Microworlds Logo, REF 26, 27], animated programming [ToonTalk, REF 28], 3-dimensional programming [Alice, REF 29], visual programming (RoboLab), and graphical programming [Stagecast Creator, REF 30 and Icicle, REF 31]. Given the wide range of different CPEs specifically developed for young learners, it is necessary to define which characteristics meet learners' programming needs and learning habits in science.

Purpose of the Study: This study investigated the use of two different CPEs [Microworlds Logo, REF 26 and Stagecast Creator, REF 30] that use different program languages (formal textual language and graphical program language, respectively) by two groups of learners, seeking to provide insights in the ways young learners use different CPEs during MbL.

2. METHODS

Participants: Seventy eight sixth-graders, coming from four different classes of two metropolitan elementary schools in Cyprus, comprised the study's participants. Thirty-nine of them were included in the graphical program language group and used Stagecast Creator and the other thirty-nine were included in the formal textual language group and use Microworlds Logo. All students met with the same science teacher once a week for 90-minutes for a total of 7-months. All meetings were videotaped. Students studied the same physical phenomena through a modeling-based approach.

During the study, students worked in small groups of 2-3 members each. All students in the study had some experience with computers, even though none of the participants had previously used any of the CPEs that were used in the study.

Study parts: The study was divided into two parts. The first part (lasted for 6 meetings) was devoted to learning the program language and some modeling procedures and the second part was devoted to developing models of natural phenomena with the use of the CPEs. The data analysis for this study is based on the data collected during the second part of the study.

Study part I: During the first part of the study, students in the Stagecast Creator condition (2 classes) familiarized themselves with the environment using the software tutorial that was previously demonstrated to be a successful tutor for this CPE [18, 32]. After going through the tutorial, students were introduced to several examples of ready-made microworlds in order to investigate their structure, and practice their programming skills by altering features of the microworlds.

For the Microworlds Logo condition (2 classes), the teaching focus was on the program primitives and basic program structure. Teaching was also done through presenting students with simple pre-programmed microworlds, asking them to figure out how the behavior of the characters was created and how to modify that behavior. These activities provided students the opportunity to investigate the capabilities of the programming environment, and to develop an understanding about the function of programs in Microworlds Logo.

Study part II: During the second part of this study, each group developed a representation of a natural phenomenon. Prior to any work, group members collaboratively decided the topic of their final project, to support different student preferences and likes. Students in each group spent a meeting brainstorming ideas about possible phenomena that could be modeled through the available CPEs. Each group selected a different phenomenon. Due to the fact that the topic/phenomenon varied across groups within each CPE club, only findings that were common among all student groups using the same CPE were reported in this paper.

Data sources and analysis: For the purposes of this study we collected video data which included students' group work with Microworlds Logo and Stagecast Creator. From these videos we transcribed a total 1335 minutes of conversations that involved episodes of inquiry, looking for different processes of inquiry while students were having conversations about the models they constructed. Then, these episodes separately coded for (a) activity patterns, (b) communication patterns and (c) technology scaffolding (how CPEs scaffolded student-conversations). Students' activity and conversation patterns were then separately presented in time-line graphs, following the approach of Schoenfeld [33]. After converting all data into graphs, graphs from units of the same case (groups from the same CPE club) were compared to isolate similarities in the patterns of students' activities and conversations. From this comparison activity and conversation types emerged, based on combinations of codes that were similar among all analyzed groups for each CPE. In this paper, only activity or conversation types that were observed in all groups' data are reported.

We also used student conversation analysis, as a gateway to student thinking and experience. Analysis of student conversation provides in detail the particular context in which students' work (activities and conversations) took place, seeking to map possible relations between the conversations and the context in which they happened.

Finally, we also analyzed all the models that students developed (a total of 118 models) by looking both at the resulted model (simulation) and its underlying program. The aim was to identify the ways students working with different CPEs defined and represented physical objects and entities, their behaviors and interactions. For all analyses we followed open coding [34] and all codes emerged from the data.

3. FINDINGS AND CONCLUSIONS

Our findings showed that CPEs shared similar ways of supporting student-inquiry. First, all CPEs enabled students to design, develop and defend models of physical phenomena. Second, the programming aspect of CPEs helped students to operationally define physical entities and properties, thus, engaging students in knowledge identification and building. Third, CPEs provided students with a commonly shared (programming) language that enabled them to disseminate their ideas and understand others' ideas. Fourth, modeling through CPEs involved all the inquiry processes introduced through scientific modeling (e.g., deploying the model in a new situation to evaluate it and better understand its properties, its mechanistic behavior, and its limitations). Fifth, the constructed models provided a structured environment in which learners tested hypotheses, made observations, collected data, and explored and validated ideas/theories. Sixth, constructed models provided learners with opportunities to represent and manipulate reified/conceptual objects in ways that learners cannot do in real-life.

On the other hand, the differences identified were mostly programming language depended. For instance, student communication through the use of the programming language was more efficient in the case of textual CPEs and students were able to operationally define physical entities and properties at more ease though textual CPEs, rather than graphical CPEs. Moreover, the findings of this study appeared to show that differences in the program language influence the "mode of work" that learners enter when using the CPEs, pushing their learning experiences into different directions with an effect on both the programming and modeling processes. Consequently, the type of the programming language has implications on (a) the programming process: textual language systems are more open-ended environments, enabling users to create many kinds of routines with limited scaffolding, whereas graphical language systems restrict users to pre-defined scaffolding for creating programs, and (b) the modeling process: Microworlds Logo which is a textual language system seemed to more easily trigger causal accounts of natural phenomena whereas Stagecast creator which is a graphical language system seemed to better support narrative accounts. These findings have implications for teaching and learning in science, because this study primarily involved documentation and analysis of actual student work with computers as tools for learning.

Although findings are not meant for generalization in the student population, they could serve as a basis for further investigations into how learners use programming as a modeling tool in science in two ways. These findings may help re-define the questions that teachers ask when using CPEs with young learners. It was evident that students in this study entered a particular "mode of work" depending on the kind of the programming language of the CPE they used. Therefore, teaching purposes and decisions, student abilities and learning styles should be viewed through this lens. Additionally, future research may investigate whether the different ways that learners use CPEs such as the ones used in this study, and the differences in these CPEs can lead to different knowledge representations of physical phenomena and different types of models.

Furthermore, findings suggest that despite the overall differences in student work, each CPE had design features that were productive and helpful for students in particular contexts of their work. While a recommendation for how a good CPE should look is not applicable for this study (partly due to the study design and analyses used), software designers might use findings to determine which combination of characteristics to include in future software, depending on their purpose. Future researchers may also find it useful to investigate in more details (a) how students use, for instance, debugging and code in various CPEs and (b) the particular activity contexts that can support productive science conversations during modeling.

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Efficient Video Surveillance with Intent Recognition

Alireza Tavakkoli and Donald Loffredo
School of Arts and Sciences, University of Houston – Victoria
Victoria, TX 77901, USA

ABSTRACT

In video surveillance applications trained operators watch a number of screens simultaneously to detect potential security threats. In order for a system to improve the human surveillance performance it should be able to detect security events before they occur. The automated mechanism may highlight areas, in which a potential event is about to occur to redirect the human observes' attention to the potential location of the event. In this paper an automated object tracking mechanism, in conjunction with an intent recognition module, is used to predict the occurrence of security events in a simulated environment. A two phase trail is conducted to quantify the performance of human observers in detecting various events and to evaluate the performance improvement achieved by employing the intent recognition module. The results of the two phase trial proved that the intent recognition has a great potential in improving the performance of many human-computer interaction applications.

Keywords: Object Tracking, Intent Recognition, Statistical Significance, Video Surveillance.

1. INTRODUCTION

Maintaining the security of public and private buildings is an essential priority for governmental agencies, private industries, and individual home owners. The smallest commercial video surveillance packages contain 4 cameras and display the videos on a 2x2 grid of display screens. To cover large areas for video surveillance more cameras are required. This increases the number of cameras and screening monitors to 9 or even more. Performing video surveillance tasks by monitoring the screens is a difficult process. Trained security personnel have to constantly watch several screens to detect potential security threats from simultaneous video feeds of the secured areas. The detection of threats becomes cognitively more challenging if multiple events occur almost simultaneously in different videos shown on different screens.

Kasturi et al. in [1], studied the effectiveness of human operators on performing video surveillance tasks on 2x2 and 3x3 grids. Since 3x3 and even 4x4 monitor grids are common in video surveillance applications, their study showed a considerable need for augmenting video surveillance tasks to improve the surveillance efficiency. However, their study used simple graphics – 2 dimensional rectangles as the screens and moving boxes as people. The study quantified the reduction in the performance of volunteers who participated in their study in detecting single, double, and triple events.

In this paper, we proposed an automated mechanism based on object tracking [2], and intent recognition [3], to assist human operators in detecting security events in video surveillance applications. The study uses a factory like simulated environment designed in an advanced 3D game engine to produce video images for the surveillance application. One important aspect in modifying visual surveillance tasks is to reduce the perceptual and cognitive demands on human operators. To this end, the proposed automated system processes images from multiple sources –i.e. security cameras- to detect and track moving objects of interest. The tracking trajectories are used by the intent recognition module for the purpose of predicting possible events before they occur. The screen(s) which may contain events are highlighted by the automated mechanism to redirect the observer's attention.

Section 2 below provides the background about the computational tools employed for processing video surveillance applications and the review of the literature. Section 3, discusses our methodology for implementing the object tracking and the intent recognition modules. In section 4, detailed quantitative and statistical results of our system are presented and a discussion about the expected and achieved outcome of the study is given. Section 5 concludes the study and provides future possible directions of the work.

2. LITERATURE REVIEW

The detection of the intent of people from videos has been a recent study area within the field of computer vision [4]. Two main processes are required to develop a reliable intent recognition framework. The first process looks at detecting humans from a stream of video images [6]. This process provides tracking trajectories for objects of interest. These trajectories are employed in a computational framework to calculate probabilities of future possible activities [7]. These activities, before they occur, carry information about the.

Object Tracking

The process of object tracking requires a low-level modeling of the background as well as the appearance of the objects of interest. Most of the state-of-the-art foreground detection algorithms model the color appearance of the background pixels statistically either non-parametrically [7], or by specifying the parameters of the density functions governing the distribution of the pixel colors [8] or variations of these two main tracks [9].

The advantage of the parametric modeling techniques is their low memory requirements. However, the non-parametric techniques require that the distribution of the background pixel colors to be known, or at least assumed, heuristically. On the other hand, the non-parametric background modeling techniques do not require the pixel color distribution be known *apriori*. Unfortunately, for the model to be trained accurately the non-parametric modeling approaches have large memory requirements. To alleviate these problems, the proposed framework employs an incremental modeling approach based on Support Vector Data Description [9].

Once foreground objects are detected their geometric or photometric appearances could be used for tracking purposes. For rigid objects, whose geometric appearance does not undergo major changes, a data association mechanism such as Kalman filtering [10] is able to provide sufficient tracking accuracy. However, more sophisticated tools such as Monte Carlo Sequential Importance Re-sampling [12] employed in Particle Filters [14], and Hidden Markov Models [13] may be used. But these techniques suffer from a great computational cost. To address the speed of the probabilistic models based on Monte Carlo Re-sampling, Comaniciu et al. in [15] proposed a histogram-based tracking approach based on non-parametric appearance modeling.

Most recent tracking approaches use an attention-based localization method [16] and an interconnected target detection/tracking loop [17] for object tracking. A significant issue with these current tracking algorithms is their slow speed as well as poor scalability in tracking a large number of objects. In this paper a tracking model is proposed based on finding correspondences between detected objects and their photometric appearance of known objects.

Intent Recognition

For a robotic or an intelligent agent to successfully communicate with humans, it is very critical to understand the potential intents of humans with whom it is interacting. Although natural to humans, even in their early developments, endowing intelligent agents with such capabilities has proven to be difficult. The general principle on which the intent recognition may be formalized relies on the psychological evidence of the Theory of Mind [19]. The premise is that humans understand about others' intentions by taking their perspectives [20] while using their own experiences to infer about the potential intents [21].

The intent recognition system approaches the lower level intentions similar to the models proposed in [3]. However, the models for the passing-by and the meeting intentions are combined to achieve a higher detection rate. In this visual surveillance application, the passing-by scenario loses its meaning while the intention to meet can be modeled as the intention to enter a forbidden area, when such contextual clues exist. This also differs from the modeled intent proposed by Gray *et al.* in [22], in that the intent to enter a forbidden area conveys lower level task goals with the integration of the context.

3. METHODOLOGY

In this work the objective was to implement a computational framework for simulating visual surveillance applications and to employ the simulated scenarios as the input for an automated mechanism for detecting potential security events. The simulated videos will be challenging to human observers since they contain different moving objects in natural looking environments with different movement patterns. Therefore, human observers will be faced with several perceptual challenges to detect events as well as the difficulty of simultaneously watching multiple screens.

This framework serves as the essential platform for quantitatively studying the efficiency of human visual surveillance. Moreover, the proposed simulation system is employed for evaluating performance improvement obtained within visual surveillance tasks, by the proposed processes for the recognition of animated objects' intents. To study the statistical significance of the proposed intent recognition models 54 undergraduate college students were recruited to participate in the study. The volunteers participated in two phase trials.

In the first phase of the study the participants were given 6 videos to watch and to interact with the computer to record the timeline of the security events they detected. Of the 6 videos, 3 simulated a 9 monitor video surveillance system showing simulated videos taken from 9 different environments in a 3x3 grid, while the other 3 simulated a 4 monitor video surveillance system. Through the timeline of each video there were three kinds of events. Singular events where defined as a single security breaches – e.g. entering a forbidden area – occurring in one of the 4 or 9 sample videos in the case of 2x2 and 3x3 surveillance systems, respectively. Double events contained two security threats occurring almost simultaneously in two different videos in 2x2 or 3x3 surveillance scenarios. Finally, the triple events were the events with three almost simultaneous security breaches in three of the 9 or 4 videos.

The participants were asked to return for the second phase of the study two weeks after the first phase. In the second phase, participants observed similar videos processed with the intent recognition module. In this case the intent recognition highlighted one, two or three screens out of 4 or 9 simulated monitors, when there was a high probability of a security breach in the respective simulated monitors.

Once the two phases of the study were complete, a comprehensive statistical analysis based on Multivariate Analysis of Variance (MANOVA) was performed to find the statistical significance of the intent recognition in improving the efficiency of human observers. In particular we were interested in achieving a system-independent performance between the 2x2 and 3x3 simulated system settings in the detection of single, double or triple events.

Object Tracking Mechanism

The object tracking mechanism uses the foreground regions detected by a background segmentation mechanism. The background segmentation step of the proposed architecture models the boundary of the color distribution of each pixel in the video frames. This boundary is an analytical description of the distribution and as such is not bound to the statistical accuracy of the probability estimation methods. The analytical boundaries of the pixel colors are trained using an Incremental Support Vector Data Description [9].

Once the foreground regions are detected the relevant regions are processes to detect contiguous blobs for the object of interest, i.e. moving objects. The important features used to create blobs for each object is the spatial proximity of the connected components detected from the background segmentation step. The pseudo-algorithm of the proposed object tracking can be found in Fig. 1. The important step in the proposed tracking algorithm is the Spatio-Spectral Connected Component (SSPCC) tracking mechanism performed in step 1.4.1.

The SSPCC tracker maintains a list object whose photometric models are created and maintained. The list is empty before the introduction of any object in the scene. For every frame the tracker maintains a correspondence matching process to assign the list of unlabeled blobs with an appropriate photometric model. The tracker also maintains the geometric information of each blob for the purpose of collision detection. These geometric moments, as well as the tracking trajectories for each pair of blobs, are used in predicting their possible location in the next frame to detect the possibility of a collision.

```
1. For each video frame
1.1. Receive Foreground Masks
1.2. Detect Connected Components (CC)
1.3. Process CCs to detect blobs.
1.4. Process Collision Potential
1.4.1. If No Collision
        Build Spectral Model
        Connected Component Spectral Tracker
        Model Update
1.4.2. If Collision
        Stop occluded object(s) model update
        Connected Component Spectral Tracker
        for the occluding object
          Meanshift tracking for occluded objects
1.4.3. Kalman update and post process
```

Fig. 1. The object tracking algorithm.

The photometric models employed in the SSPCC tracker are composed of two components. The upper model maintains the first order statistical model of colors of all pixels in the upper half of the object, while the lower model represents the first order statistical representation of the lower part of the object's pixel color. The models are shown in the following equation where O_u is the model for the upper part and O_l is the model for the lower part of the object i at time t.

$$O_{u,l}^{t} = N\left(\mu_i^t, \sigma_i^t\right) \forall i \tag{1}$$

In the process of correspondence matching each blob is divided into an upper and a lower part. The first order statistics of the upper and lower parts are calculated and matched with each model encountered and maintained by the SSPCC. The model with the highest matching score will be used to label and track the blob. If the matching scores are low, a new model for the blob is created and maintained for the future. The correspondence matching assigns the label of the highest scoring model to the blob whose statistical models closely resemble the model. This is shown in the following:

$$O_{u,l}^{t-1}(j) = \arg\max_{K} \left[median \begin{pmatrix} P\left(c_l^t(i) \mid O_l^{t-1}(k)\right) \\ \times P\left(c_u^t(i) \mid O_u^{t-1}(k)\right) \end{pmatrix} \right] \quad : \forall k \tag{2}$$

where C is the current blob being matched with O, the model from the previous frame.

Intent Recognition Module

In the proposed approach a method for constructing the model is chosen in formulating models for an agent's interaction with the world while performing the activity. This is done through the way in which parameters that encode the goals of the task are changing (e.g. increase, decrease, and stay constant or unknown). This is in contrast with the traditional approaches that solely model transitions between static states. With this representation, the *visible states* encode the changes in task goal parameters and the *hidden states* represent the hidden underlying intent of the performed actions [4].

The reason for choosing the activity goals as the parameters that are monitored by the HMM is that goals carry intentional meanings, and thus tracking their evolution is essential for detecting and understanding an agent's intent.

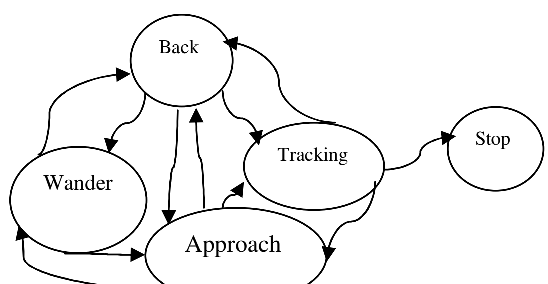

Fig. 2. The intent recognition Hidden Markov Model.

In the proposed intent recognition mechanism a model is developed based on each observed moving object in the scene and a location designated as the forbidden area. The parameters of the moving object with respect to the designated forbidden area are used as observable variables and a probability for each observable state is calculated. The Hidden Markov Model and its corresponding intentional hidden states are shown in the Fig. 2.

Simulated Surveillance Environment and Experiment Setup

The computational framework for this project has been developed with various advanced computer graphics, multimedia and programming software packages. Fig. 3 shows the details about the infrastructure of the framework.

The primary means for implementation of the platform to simulate the realistic graphics of visual surveillance scenarios is based on the Unreal Development Kit 2010 game engine. The simulated scenarios are rendered in two programs implemented with the C++ platform to develop test videos and to evaluate the performance of the subjects.

Once the visual surveillance scenarios are created within the UDK, the frames are used in a rendering program developed as a part of this project. In order to carry out the rendering tasks the module uses the results obtained from the intent recognition component to highlight the respective videos.

The rendering program generates the final 2x2 and 3x3 grid sizes for each visual surveillance scenario. Realistic animated objects – i.e. robots and people – wander in the scene. Some simulated scenarios may contain one or more violations of a number of secured regions resulting in "events". The performance of human subjects in detecting one of more events accurately will be quantified.

Each file containing the 2x2 or 3x3 video screens has an associated log. This log includes vital information about the contents of the video and the number of possible security violations as well as their exact timing. This database is deployed in a computer lab on multiple client workstations.

After deploying the software packages in the computer lab, each workstation runs the evaluator software. This software is an advanced Graphical User Interface (GUI) which shows the videos to the users in a random manner. Each user can watch the video and detect possible security issues contained in one or more of the videos within the 2x2 or 3x3 grids. The user may report the violation of secure regions that he/she detected by interacting with the Evaluator program. The Evaluator software records the reactions of its users in a database associating each user with his/her recorded data files.

Similar videos are created with the inclusion of the intent recognition module. The purpose of this module is to observe the videos and to apply a computational process to detect the intent of each animated object. Once the module gathers enough evidence about the possibility of a security issue within a video in the 2x2 or 3x3 screen grids, it will highlight the appropriate grid location. Therefore, it directs the intention of the user to the location containing the possible issue. By employing these software packages user performances in detecting single, double, and triple security breaches can be recorded, evaluated and compared for each scenario. On a cognitive level, by employing the intent recognition modules, the simultaneous observation of multiple screens transforms into watching – with the attention being directed to the highlighted screen – one video screen (out of 4 or 9) at a time, when the screen is highlighted. This is a big step toward achieving the system independence performance – regardless of the number of screens observed.

Research Design and Statistical Analysis

The study's design was a mixed-design experiment. There were two phases to the experiment. In phase 1 there was no intent recognition aid. In phase 2 there was an intent recognition aid, the red perimeter of a square. In each phase each participant was presented with single events, double events and triple events first with four videos (2 x 2) and then with nine videos (3 x 3). There were five dependent variables: SDR: percentage of single events detected by the participant, DDR: percentage of double events detected by the participant, TDR: percentage of triple events detected by the participant, FP: total number of false positives (participant detected a non-existent event), and FN: total number of false negatives (participant missed a significant event).The within-subjects factor was time (phase 1 versus phase 2). The between-subjects factor was the number of videos (4 videos versus 9 videos). A mixed-design multivariate analysis of variance (MANOVA) was performed to determine if there was a statistically significant difference by time (phase 1 versus phase 2) or number of videos (4 versus 9) on the dependent variables or if there was a statistically significant interaction between time and the number of videos on the dependent variables.

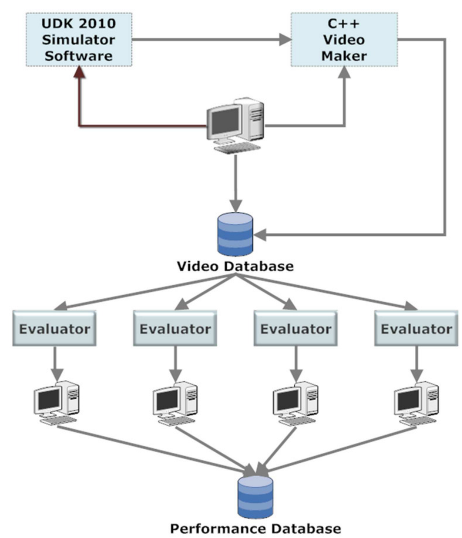

Fig. 3. The proposed visual surveillance evaluation architecture.

4. EXPERIMENTAL RESULTS

The mixed-design MANOVA revealed a statistically significant difference between time (phase 1 versus phase 2), $F(5, 102) = 59.89$, $p < .001$, partial eta squared = .75 and between number of videos (4 versus 9), $F(5, 102) =$

5.22, p <.001, partial eta squared = .20 as well as a statistically significant interaction between time and number of videos, F (5, 102) = 4.85, p = .001, partial eta squared = .19. This interaction effect indicated that the difference between the number of videos on the linear combination of the five dependent variables was different at phase 1 than it is at phase 2.

Follow-up ANOVAs revealed that the significant change from phase 1 to phase 2 was statistically significant for each of the five dependent variables (see Table I).

Table I. FOLLOW-UP ANOVAS BY PHASE

Dependent Variable	F(1,106)	p	Partial η^2
SDR	34.20	<0.001	0.24
DDR	60.11	<0.001	0.36
TDR	128.68	<0.001	0.55
FP	54.87	<0.001	0.34
FN	136.24	<0.001	0.56

Examination of the means (see Table III) and profile plots of the means for each dependent variable indicate that the lines converge or cross for all five dependent variables. However, follow-up univariate F statistics indicated that the only statistically significant interactions between time and number of videos were for dependent variables TDR (percentage of triple events detected by the participant), F (1, 106) = 10.43, p = .002, partial eta squared = .09 and FN (total number of false negatives), F (1, 106) = 16.78, p <.001, partial eta squared = .14 (Table II).

Table II. SIGNIFICANT INTERACTIONS BETWEEN PHASE AND NUMBER OF VIDEOS

Group	F(1,106)	p	Partial η^2
TDR	10.43	0.002	0.09
FN	16.78	<0.001	0.14

Examination of the means indicated that for the dependent variable TDR the mean for four videos was higher than the mean for nine videos in phase 1 but not in phase 2 where the mean for both sets of video was equal but higher. Examination of the means indicated that for dependent variable FN the mean for 9 videos was much higher than the mean for four videos in phase 1 but not in phase 2 where the means for both sets of video were much lower and almost equal.

The statistically significant increase and convergence of the triple detection rate (TDR) means indicated the powerful effect of intent recognition on triple events detected for both 2x2 and 3x3 videos. The statistically significant decrease and convergence of false negatives (FN) means indicated the powerful effect of intent recognition on decreasing the number of false negatives for both cases.

Table III. DESCRIPTIVE STATISTICS

Group		Mean	σ	N
SDR1	4 Videos	.65	.26	54
	9 Videos	.62	.21	54
	Total	.64	.23	108
SDR2	4 Videos	.79	.22	54
	9 Videos	.80	.21	54
	Total	.79	.22	108
DDR1	4 Videos	.83	.22	54
	9 Videos	.78	.25	54
	Total	.81	.24	108
DDR2	4 Videos	.99	.04	54
	9 Videos	.98	.11	54
	Total	.98	.08	108
TDR1	4 Videos	.55	.34	54
	9 Videos	.33	.34	54
	Total	.44	.35	108
TDR2	4 Videos	.83	.27	54
	9 Videos	.83	.30	54
	Total	.83	.29	108
FP1	4 Videos	9.31	6.00	54
	9 Videos	8.96	9.09	54
	Total	9.14	7.67	108
FP2	4 Videos	4.96	3.94	54
	9 Videos	5.57	5.50	54
	Total	5.27	4.77	108
FN1	4 Videos	3.50	2.33	54
	9 Videos	5.78	2.82	54
	Total	4.64	2.82	108
FN2	4 Videos	1.67	2.28	54
	9 Videos	1.96	2.36	54
	Total	1.81	2.32	108

5. CONCLUSIONS AND FUTURE WORK

As shown in the experimental results section and Table III, the intent recognition improved the event detection rate by individuals performing video surveillance tasks in all experiments. The event detection rates in different surveillance settings, i.e. 2x2 and 3x3 screen systems are comparable with the integration of the intent recognition into the system. This reinforces our hypothesis that the intent recognition reduces the cognitive burden of watching multiple screens and results in a system independent surveillance application.

With the ground works of the intent recognition mechanism tested in this project, potential future directions for this study expand over a number of possible areas. The assistive technologies are prime field for the expansion of this work. The intent recognition may be applied to the human computer interaction and graphics user interfaces to help individuals with physical challenges interact with computers in a more efficient manner.

Moreover, this technique can be applied to detect emergent patterns from a vast set of data. This may lead the way to detect potential disease causing genes and human-pathogen inter-genomic interactions.

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FINITE ELEMENT ANALYSIS OF ADHESIVELY BONDED TONGUE AND GROOVE GEOMETRY OF THICK COMPOSITE STRUCTURES

Mine USLU
Department of Mechanical Engineering, Yildiz Technical University,
34349, Besiktas, Istanbul, Turkey

ABSTRACT

This study focuses on investigating of parameters which effect the bonding and strength on thick composite sandwich structure models. The joint model is consisting of thick woven E-glass/vinyl ester laminates joined together with tongue and groove geometry. A finite element analysis was used to calculate the shear and peeling stresses generated by longitudinal tensile loads, analysis incorporating the adhesive behavior was performed to accurately estimate the mechanical stresses in the adhesive. The joint strength was estimated by three criteria, tongue length, pre-stress and using different tongue made of steel/aluminum, composite. The distributions of shear and peeling stresses were investigated for various critical ranges. Finite element analysis further confirms that longitudinal tensile loads were applied to the joints, resulting in large concentrated shear and peel stresses near the free edges of bondlines and also stresses values was compared in critic zone for obtain the failure behavior in adhesively joined geometry. The effect of applying the transverse pre-stress on joint strength was also taken into consideration. The results indicate that joint strength increases significantly by applying the transverse pre-stress and it can reverse the sign of the peel stress in the adhesive layer. The joint strength can be significantly improved by selecting appropriate the design parameter values and by using the finite element model, failure behaviors with distributions of stress can be defined obviously.

Keywords: thick composites, sandwich structures, adhesive bonding, design tensile strength, tongue and groove geometry, finite element analysis

1. INTRODUCTION

Adhesive bonding techniques are being used in an increasing number of composite materials as more metal materials. This technique has been widely used in construction as an alternative to conventional joint techniques particularly in composites. When the adhesive bonding is compared to traditional joining techniques, it can offer significant benefit. These benefits are including high performance under the static and dynamic loading, fatigue resistant, crack retardant etc. They distribute the load over a larger area than mechanical joints and do not require holes, resulting in a reduction of the stress concentration and an increase the strength of the joint. In addition to adhesive technology is simple, fast, efficient, and inexpensive, this technology can also bond connection can not connect a number of other materials or structures, such as metal and non-metallic bonding to achieve In this paper the joint to behavior caused by material as using different tongue made of steel/aluminum, composite have an effect on the joint strength. So, the strength of joint was investigated in accordance with three criteria, tongue length, pre-stress and using different tongue made of steel/aluminum, composite.

Touch on the subject which is tongue and groove geometry joint technique, in the past years, many joints technique have described in the literature, [1-5] such as scarf and strap joints, including single-and double-lap joints. Also single-lap joints have been most commonly used. Many literature mentions about effort of these type joints and their results. Commonly in results high stress concentration exists in the adhesive layer, especially at the free edges, thus limiting the strength of the whole joined structures. Also, because of the load is transferred from one adherend to another one through the adhesively bonded outer surface with overlaps, joint strength is generally limited by stress intension in the adhesive and adherends at the leading edges of the doublers, and by the often low peel strengths of the adhesive and laminated adherends. As different joint technique in this study, a design called tongue and groove geometry [6] is used. After the relevant experimental had been done, described the process that is the basis of genetic algorithm (GA), in developing tensile strength estimation of adhesively bonded thick woven E-glass/vinyl ester laminates [7]. Non-linear estimation models were developed using GA in the other part of studying. A genetic algorithm tensile strength estimation model (GATSEM) was developed to estimate the strength of adhesively bonded tongue and groove joints [7]. Author present the part of finite elements analysis to study in this paper. A finite element analysis (FEA) was used to in model calculate the shear and peeling stresses generated by longitudinal tensile loads, analysis incorporating the adhesive behavior was performed to accurately estimate the mechanical stresses in the adhesive. The joint strength was impressed by factors such as, tongue length, pre-stress and using different tongue made of steel/aluminum, composite. The distributions of shear and peeling stresses were investigated for various critical ranges.

2. GEOMETRY AND FINITE ELEMENT MODEL

At the start the finite element models were developed based on real size joint specimen configuration as shown in Fig.1. Pre-stress was applied along the entire length of the adhesive bond, each bolt was tightened with a preload value (one of parameters) to generate total compressive pre-stress commercial FEA software package ANSYS [11.1] was used to build the finite element models Fig.2.

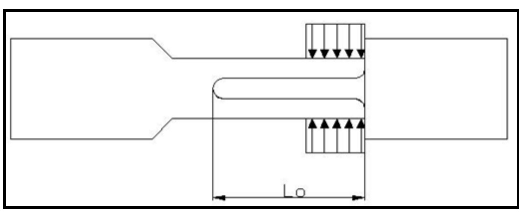


Fig. 1 Geometry of groove and tongue with pre-stress

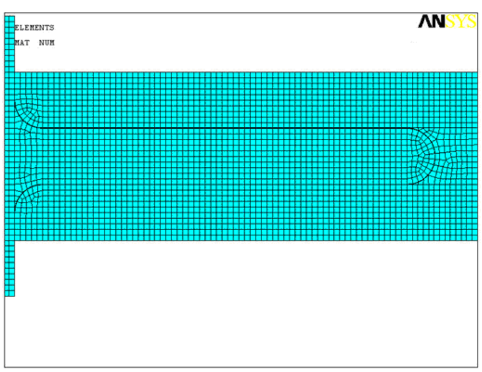


Fig. 2 Model with meshing

The material properties used in the analysis are the same data described in Table 1-3. The E-glass/vinyl ester laminate used in the study was manufactured at a unique company in Turkey and in the construction of woven roving; the warp directions were rotated in 0º, 90º, +45º, and -45º directions to compose a more nearly balanced quasi-isotropic lay-up. The specific laminate was fabricated using 24 plies with lay-up of [0/+45/90/-45].The adhesive used in this study is Loctite-Hysol 9464, which was used with proper curing temperature and time specified by the manufacturer (minimum 4 days at room temperature) and its shear strength 22 MPa and peeling strength is 10.5 MPa. The other side St-37-2 steel has estimated yield stress of 235 N/mm^2. We assured this limit was not exceeded in our experiment.

Table 1 Material properties of composite materials (Woven E-Glass/ Vinyl Ester)

Modulus of Elasticity (GPa)		
E_{11}	E_{22}	E_{33}
22	22	9
Shear Modulus (GPa)		
G_{12}	G_{23}	G_{13}
5.3	3.1	3.1
Poisson’s ratio		
ν_{xy}	ν_{yz}	ν_{xz}
0.27	0.38	0.38

Table 2 Material properties of adhesive

	Modulus of Elasticity (GPa)	Poisson’s ratio
Adhesive Loctite 9464	1.78	0.37

Table 3 Material properties of steel and aluminum

	Modulus of Elasticity (GPa)	Poisson’s ratio
Steel St37-2	210	0.3
Aluminum 5083	70	0.3

3. RESULTS AND DISCUSSION

Finite element analysis further confirms that longitudinal tensile loads were applied to the joints, resulting in large concentrated shear and peel stresses near the free edges of bondlines and also stresses values was compared in critic zone for obtain the failure behavior in adhesively joined geometry. For compare the stress attribute, value of stress were given to specific path and points (Fig. 3-4). For example; eight critical paths are shown in Fig 3.

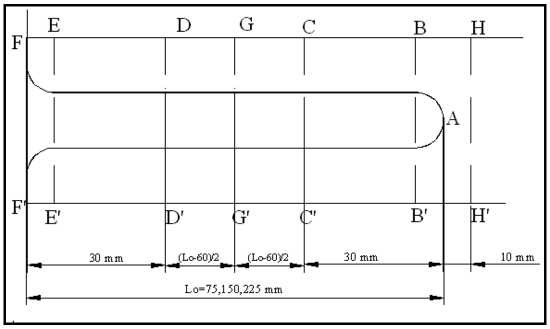


Fig. 3 Critical paths on the geometry

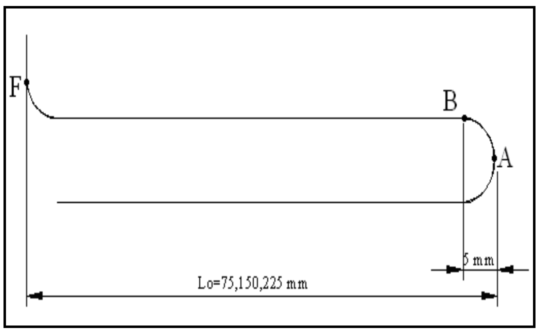


Fig. 4 Critical points on geometry

Von-Misses stresses were analyzed in the chosen paths, stated value of stress was continue on the groove material and at the 10.1mm where adhesive material zone, the stress increased. Therefore H-H path hasn't got adhesive zone, the stress curve is going to unless increase (Fig. 5). Also symmetry is shown the figure.

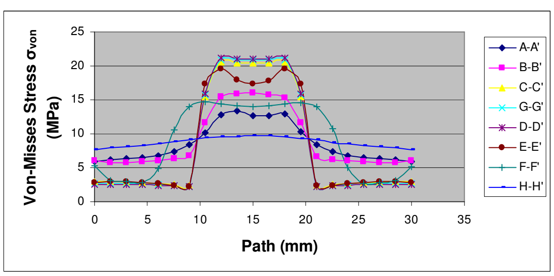


Fig. 5 Comparison of the Von Misses stress unprestressed steel tongue-composite groove joint specimens with recessed bond lined of 75 mm

A, B, F points location are on the adhesive material and taking from stress value at that points are given us failure behaviors. Parameter of study can compare with graph, for example Fig 6 is show compare of materials in the different stress which are Von Misses stress, shear stress and peel stress. Strength of material is steel, aluminum, composite respectively. Shear stress is symmetry in reference to x axes and it changes signature. Maximum points of peel stress are on the adhesive zone.

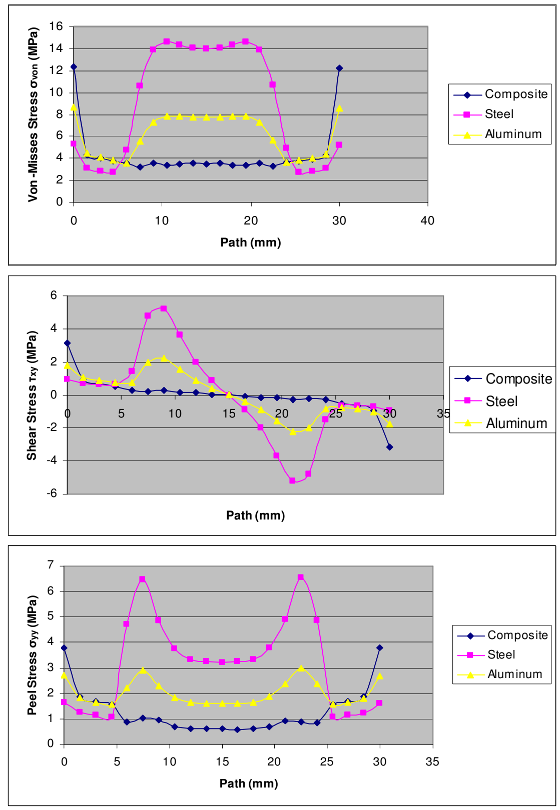


Fig. 6 Comparison of the material, unprestressed specimens with recessed bond lined of 75 mm according to F path

For the access value of von-misses stress, shear stress and peel stress, the path is drawn from A point to the B points in adhesive material model (Fig.7).

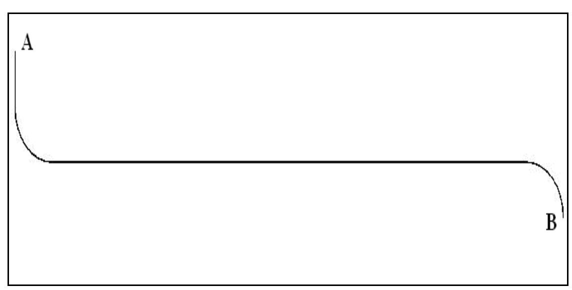
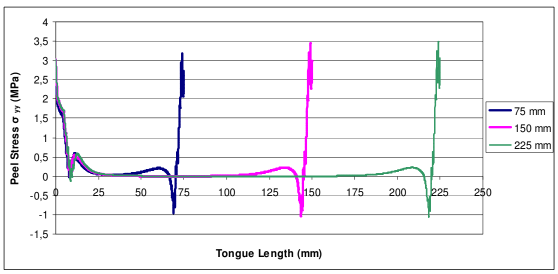


Fig. 7 A-B path

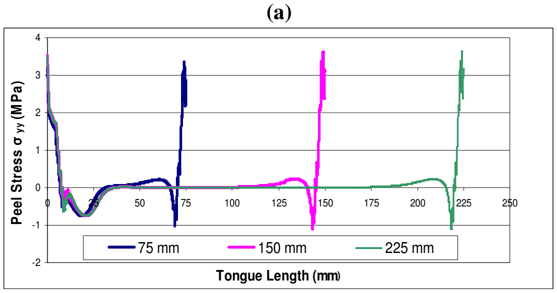
The effect of applying the transverse pre-stress on joint strength was also taken into consideration. The results indicate that joint strength increases significantly by applying the transverse pre-stress and it can reverse the sign of the peel stress in the adhesive layer. This effect can be seen in Fig. 8

clearly. Unprestressed and prestressed stations are presented for aluminum tongue and composite groove joint specimens in Fig. 8a and Fig. 8b, respectively. Also both all tongue lengths and prestress and unprestress stations, the maximum points are seen in the begin and end of A-B path. Finite element analysis further confirms that joint strength increases significantly by applying the transverse pre-stress.

Finally the joint strength can be significantly improved by selecting appropriate the design parameter values and by using the finite element model, failure behaviors with distributions of stress can be defined obviously.



(a)



(b)

Fig. 8 Comparison of the tongue length, for aluminum tongue and composite groove joints specimen according to peel stress **a)** unprestress station **b)** prestress station

4. CONCLUSION

In this study, Finite Elements Model was used to estimate the strength of adhesively bonded tongue and groove joints in accordance with design parameters such as overlap length, pre-stress on near the free edges of the bondline and material type of joining parts. The following conclusion may be drawn from the results of the present study:

- Experimental study show that all of failures are mainly the delamination of the top layer of laminated adherent and also FEA revealed that the high stress concentrations located in the adhesive leading edges where the failure may initial.
- The FEA results are comparable well with the experimental data.
- Application of transverse pre-stress can efficaciously minimize even reverse the sing of the peel stress and leads to maximize on the joint strength for all specimens.
- The results from finite elements model show that significant inter-relation among the bonding strength design parameters.
- This method can be use those joints which are tent to peel stress and inclined to delimitation, beneficially.

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Modeling of Worsening

Kalman Ziha
University of Zagreb
Faculty of Mechanical Engineering and Naval Architecture
Department of Naval Architecture and Ocean Engineering
Zagreb, Croatia

ABSTRACT

This paper aims to add impetus to understanding of worsening phenomena and prevention of their consequences. The introductory notes outline the uncertainty, the empirical character and the subjective meaning of the term “worsening”. The underlying hypothesis takes up the idea of omnipresent general causality in order to reveal the cause-effect interaction concept of worsening. The empirical concept of worsening is analytically modeled as an accumulation of effects in permanent interaction with causes. The mathematical formulation of the worsening is applied to examples of common engineering problems of material plasticity, structural fatigue and corrosion.

Keywords: causal relations, causality, interaction, system feedback, cumulative causation, fatigue, plasticity, corrosion.

1. INTRODUCTION

Things do not only happen, they also worsen!
Moreover, they frequently worsen faster than it is anticipated or expected in their lifetime. Worsening has a direct influence and impact on material objects and live beings - on physical, chemical, biological, technical, and social processes and properties, both natural and those created by people. Worsening also inevitably affects engineering objects, structures and operations, and sometimes very badly. It is an expected phenomenon in the experience of reality; however its resulting consequences are not always predictable with certainty.

Worsening is normally perceived as an accumulation phenomenon of progressive unfavorable but hopefully finite effects due to inescapable causes. The idealized hope that the mechanism by which the cause induces the worsening must be understood is not always sufficient to explain causal relation in which the worsening can retroactively affect the cause.

Sometimes, worsening can be distinguished timely to prevent any disadvantageous effects, but more frequently it can be noticed only after the apparent detectable consequences. In many disastrous situations the sudden consequences of worsening cannot be stopped or prevented. For this reason it is vital to have worsening under control, at least until a warning that an urgent preventive action must be taken or considered. Inspections and maintenance actions carried out to reduce the lifetime worsening are usually time consuming and expensive. Repairing of damages can be even more expensive. Any uncontrolled worsening may cause failures, damages, collapses, breaks, devastations and, in the worst case, disasters with possible catastrophic consequences for human life and goods.

2. WORSENING

Worsening has a general connotation of an empirical causality or fatality, sometimes with supernatural and mystical prejudices since it cannot be always explained and accepted just as a simple cause-effect relation. Worsening involves various factors, sometimes those that cannot be accurately measured or reliably identified; this fact makes it more intricate or fearful and therefore requiring the engagement of intuition, experience and sophisticated rationalization. The experiences in modeling of worsening reveal that cause and effect interactions stay behind earlier concepts such as the “positive feedback” or "cumulative causation" where some effect causes more of itself resulting with the amplification of changes. In contrast, negative feedback and negative accumulative causation opposes changes resulting in attenuation of effects. Positive refers to the direction of change rather than to the consequences of the causation.

The very concept of worsening has important practical character and subjective meaning. The common empirical truth is that the world is constantly changing. Generally, the effects of changes can be described from different viewpoints. One of such viewpoints is the qualitative and quantitative assessment of consequences of changes, which - if they are experienced as bad, harmful, dangerous, undesired or destructive - can be considered as worsening, sometimes declared as punishment.

Worsening is also commonly experienced as a relative phenomenon with respect to some predefined constant or uniform reference condition. Such relative changes are sometimes explicated as weakening, yielding, and ageing or fatigue. Yet another observable consequence of worsening is the life shortening with respect to the expected lifetime.

There is no general model of worsening but there are some rather particular or interdisciplinary views on different problems of worsening. Many processes in sciences and engineering are too complex, and mathematical approximations in practice are often not accurate enough for the appropriate modeling of the multifaceted worsening phenomena.

Causality is commonly considered as a relationship between an event (the *cause*) provoked by an outer action and some second event (the *effect*), where the second event is taken as a consequence of the first one - evident to conscious observers. The above reasons are why this paper focuses on worsening and intends to argue for a concept of worsening as a more general idea within the empirical context of causality. The causal relationship is a widely adopted concept for the understanding of physical reality at micro and macroscopic levels. The paper looks for a more general mental and analytical comprehension of worsening in the context of empirical causality and in the experience of the causal accumulation and positive feedback.

3. HYPOTHESIS OF WORSENING

This study is inspired by the fourth David Hume's [1] statement from 1896 on the judging whether two things are in a cause-effect relation:

> *"The same cause always produces the same effect, and the same effect never arises but from the same cause. This principle we derive from experience, and is the source of most of philosophical reasoning."*

Statements about causality in this study are critically revisited from practicality point of view following the inspiring intuition that causes and effects in reality are of definite and finite character. Once initiated, the cause and the effect can continue to interact with intensity appropriately to their internal causal property not necessarily affected by the external influences. However, the notion of finite cause and effect are substantially dependent on the observable start and on the definite end. The study discusses the thesis that the general causality implies the cause-effect relation and the finite interaction between causes and effects. Internal properties of a relation might affect the dependence of the progression on current and previous initial or input characteristics. Here, the cause-effect interaction concept links to the Wiener's idea of positive feedback from 1948 [2].

Consequently, the paper introduces a slightly more general concept of the finite cause-effect interaction in its preliminary primitive deterministic form. The proposal considers a plausibly practical involvement of the general concept of interactions between causes and effects into the empirical analysis of either time invariant or time variant worsening problems. The uncomplicated mathematical formulation of the interaction concept in the sequel uses the thesis put forward in this study that seemingly complex causal relations are analytically decomposable into simple causal relation and into a cause-effect interaction. The thesis then continues to elaborate that the roots of worsening lie in the realistic cause-effect interactions which are affecting the primarily assumed properties or the expected outcomes of assumingly ideal relations in which the possibilities of cause and effect meddling are not accounted for.

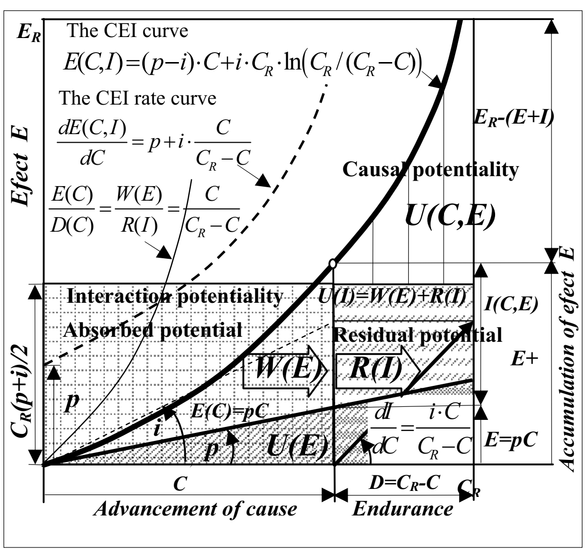

Figure 1. The general concept of cause-effect interactions

The paper, first of all, reminds us how significant the empirical causal relations in sciences and engineering are (e.g. Woodward in 2003 [3] and Pearl in 2009 [4].

4. INTERACTION CONCEPT OF WORSENING

The study at the beginning resumes the concept of a general relation between the constant single Cause (C) and the consequential uniform accumulation of a single Effect $E(C)$ at rate p without external or internal limits that is analytically presentable by the integral up to the ongoing cause C, as shown:

$$E(C)=\int_0^C p\,dC = p\cdot C \qquad (1)$$

In ideal Cause-Effect (CE) relations with undefined terminal conditions the cause produces the effect $C \Rightarrow E$ or the effect is hold up by the cause $E \Leftarrow C$ but the effect cannot change the cause $E \not\Rightarrow C$. However, for the finite CE relations in reality the finite cause C_R induces the finite effect E_R as $C_R \Rightarrow E_R$. Interactions between cause and effect then can occur due to the influence of the terminal conditions on the causal relationship. The Cause-Effect Interaction (CEI) concept admits that the effect E induced by the cause in turn can affect the subsequent cause C itself $E \Rightarrow C$, symbolically in both directions as $C \Leftrightarrow E$ and $E \Leftrightarrow C$.

The steering thought of the general CEI concept exposed in the study is that the resulting overall effect $E(C,I)=E(C)+I(C,E)$ is decomposable into an observable primary CE causal effect $E(C)=p\cdot C$ as in Eq. (1) unaffected by terminal conditions and into less apparent secondary CEI effect $I(C,E)$.

The source of the CEI is in continuous tire out of the residual causal durance D (Fig. 1) at a constant rate $1/i$ in Eq. (2), as a consequence of the escalation of the finite cause C_R until reaching the finite effect E_R, defined as follows below:

$$D(C)=\frac{1}{i}\int_{C_R-C}^{C_R} dC = C_R - C \qquad (2)$$

The interaction rate is the ratio between the effect E in Eq. (1) and the residual causal effect D (the durance) in Eq. (2) as:

$$\frac{dI(C,E)}{dC}=i\cdot\frac{E(C)}{D(C)}=i\cdot\frac{C}{C_R-C}=i\cdot\frac{c}{1-c} \qquad (3)$$

The deterministic parameter i is introduced in Eq. (2) and Eq. (3) to represent the CEI intensity of a CE relation.

The resulting overall rate E' of change is then the combination of the simple CE rate Eq. (1) and added CEI rate Eq. (3) as:

$$E'==p+i\frac{E(C)}{D(C)}=p+i\frac{C}{C_R-C}=p+i\frac{c}{1-c} \qquad (4)$$

The deterministic parameter p in Eq. (4) represents the initial propensity to interaction: for $c\to 0$ in (4) $p=dE/dC$.

The standardized cause $c=C/C_R$ and effect $e=E/E_R$ represent the CE relation with respect to the reference cause C_R and reference effect E_R in the 0-1 space. The interaction rate $E(C)/D(C)$ in Eq. (3) enlightens the CEI concept: the cause C (in the nominator) upholds the CE relation $E(C)$ as in Eq. (1) but simultaneously reduces the endurance $D=C_R-C$ Eq. (2) (in the denominator). Thus, C, D and E jointly induce the CEI. The formulation Eq. (3) enlightens the meaning of the amplifier or final gain in the positive feedback as a consequence of the CEI.

The second derivative of Eq. (4) is the overall sensitivity, that is, the rate of the interaction rate, as it is put down next:

$$E''=\frac{dE'}{dC}=\frac{d^2E}{dC^2}=i\cdot\frac{C_R}{(C_R-C)^2}=\frac{i}{C_R}\cdot\frac{1}{(1-c)^2} \qquad (5)$$

The overall rate of interaction E' in Eq. (4) geometrically represents the slope of the tangent on the CE curve (Fig. 1).
The accumulation of CEI effects $I(C,E)$ during the CE relation starting from a basic effect E_o, is determined as the integral (available from l handbooks) of the interaction rate Eq. (4):

$$E(C,I) = E_o + (p-i)\cdot C + i\cdot C_R \cdot \ln\frac{C_R}{C_R - C} \qquad (6a)$$

Or, rewritten in the standardized c-e (0-1) space (6a) as shown:

$$e(C,I) = e_o + (p-i)\cdot c - i\cdot \ln(1-c) \qquad (6b)$$

The overall effect E in Eq. (6) is then the superposition of the linear and of the logarithmic part. Note that in Eqns. (6a) and (6b) intensity i affects propensity p.
The cause C is not simply separable from Eq. (6). Due to CE interaction C appears on the both sides of the equation:

$$C = C_R \cdot (1 - e^{\frac{1}{iC_R}[(p-i)\cdot C-(E-E_o)]}) \qquad (6c)$$

Only for $p=i$, the resulting exponential term in Eq. (6c) (Fig. 1) for pure CEI without the linear part $C = C_R \cdot (1 - e^{-\frac{E-E_o}{i\cdot C_R}})$ represents the exponential low (Fig. 2) that often characterizes the cumulative causation and positive feedback systems.
The inherent power of a CE relation, its state of being capacitive and capable for interaction represents the CEI potentiality denoted U. The CEI potentiality is evident from the area under the $E-C$ curves above the C axis which can be derived by integration of Eq. (6) (Fig. 1), as shown:

$$U(C,E) = \int_0^C E(C,I)dC =$$

$$= \frac{p-i}{2}C^2 + i\cdot C_R \cdot \left[(C_R - C)\cdot\left(\ln\frac{C_R - C}{C_R} - 1\right) + C_R \right] = (7)$$

$$= C_R^2\left\{(p-i)\cdot c^2/2 + i\cdot[(1-c)\cdot\ln(1-c)+c]\right\}$$

Here, according Eq. (6) (Fig. 1), the CEI can also be interpreted as the uniform tire out the residual causal potentiality *R(I)* of the finite overall causal potentiality *U(C,I)* due to the progressive effect absorption *W(E)* of ongoing interactions at average exhaust rate C_R^2(p+1)/2 Eq. (6).

5. INTERACTION PARAMETERS

The parameter p is introduced in Eq. (1) to represent the initial propensity to interaction. It is normally evident from the interaction rate E' Eq. (4) attainable from the empirically observable CE starting conditions as shown:
For c→0 in (4) (the starting condition) *p=E'*.
The intensity parameter i introduced in Eq. (2) can be preliminary assessed from the e observed starting rate of the rate of change E'' Eq. (5) and from the terminal cause C_R.
For c→0 in (5) (the starting condition) *i= C_R E''*.
The interaction parameter i can be more appropriately determined from potentiality *U(C,E)* Eq. (7) (for example by numerical integration of observed CE diagram), as follows:

$$i = \frac{U(C,E)/C_R^2 - pc^2/2}{(1-c)\ln(1-c) + c - c^2/2} \qquad (8)$$

For $c\to 1$ in (7) (the end condition) it is $U=C_R^2\,(p+i)/2$.
For $c\to 1$ in (8) (the end condition) it fis $i=2U/C_R^2 - p$.

6. EXAMPLES

The first example presents the standardized CEI curves (6b) with different interaction parameters p and i (Fig. 2) $e = (p-i)\cdot c - i\cdot\ln(1-c)$ indicating levels of worsening. For the reference CE relation is p=1 and i=0 what implies simple CE relation $E \Leftarrow C$ without worsening due to interaction. Increase of the interaction parameter $i>>0$ for any value of propensity parameter $p>0$ indicates additional worsening because of the CEI, symbolically $E \Leftrightarrow C$ (Fig. 2).

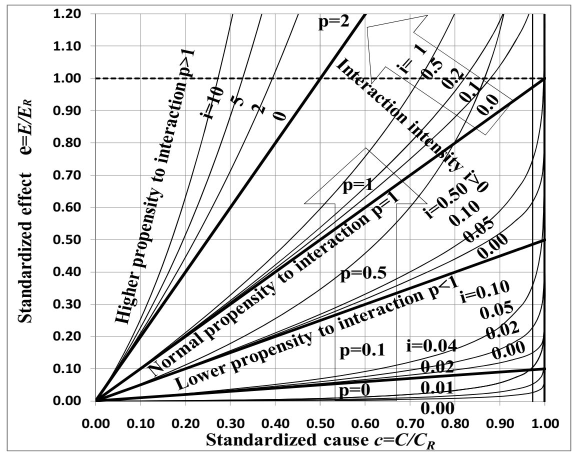

Figure 2. CEI curves $e=(p-i)\cdot c-i\cdot\ln(1-c)$

Following examples investigate can some common problems in engineering be comprehended as CEI phenomena.

6.1. Material yielding and plasticity

The first case study considers material plasticity (e.g. Ramberg and Osgood in 1943 [5], Van Vlack in 1985 [6] and Rees in 2006 [7]) as a possible CEI model. The materials under external loads undergo rearrangements of the internal structure within which the particles are being moved to new positions of internal energy equilibrium. The yielding and plasticity imply mobility of particles which occur as a result of dislocation motion in crystalline materials. The consequences of the progression of dislocations in materials at the micro-structural level triggered by sequential internal bond breaking and bond reforming are frequently explicated as interactions. The example applies the CEI concept to investigate the interaction character of plasticity. The Hook's elastic Stress-Strain (SS) law $\varepsilon(\sigma) = \sigma / E$ is a typical ideal CE relation as in Eq. (1) $\varepsilon \Leftarrow \sigma$.
Experiments confirm that escalation of accumulating material strains ε affects the advancement rate of changes of stresses $\varepsilon \Leftrightarrow \sigma$ resulting in yielding and plasticity. Following the general CEI concept the study investigates the Stress-Strain Interaction thesis (SSI) of plasticity that the overall strain is decomposable into primary linear strain $\varepsilon_P = \varepsilon_P(\sigma)$ as in Eq. (1) and into accumulation of strains $\varepsilon_I = \varepsilon_I(\sigma,\varepsilon)$ resulting from interactions of strains and stresses (Fig. 1) as in Eq. (6).
The overall SSI rate combines the primary strain rate and the interaction rate as in Eq. (4) summarized below:

$$\varepsilon' = p + i\frac{s}{1-s} \qquad (9)$$

The sensitivity of the interaction rate is as in Eq. (5) (Fig. 4):

$$\varepsilon'' = \frac{d\varepsilon'}{d\sigma} = i \cdot \frac{\sigma_R}{(\sigma_R - \sigma)^2} = i \cdot \frac{1}{\sigma_R} \frac{1}{(1-s)^2} \tag{10}$$

The resulting overall strain ε after Eq. (6a) is then as follows:

$$\varepsilon = \sigma_R \cdot \left[\left(\frac{1}{E} - \frac{1}{Y} \right) \cdot s - \frac{1}{Y} \cdot \ln(1-s) \right] \tag{11}$$

The elastic modulus in (11) is E=1/ε'=1/p. The plasticity modulus in (11) is Y=1/(σ_R ε'')=1/i, (Fig. 3) and (Fig. 4)

Numerical example of plasticity of metallic materials

The numerical example makes use of the tension test data for Steel A36 (e.g. Atlas of Stress-Strain Curves from Tamarin in 2002 [8]). Reference values in the plasticity zone are $\sigma_R = 160\ Mpa$ and $\varepsilon_R = 0.1$ (σ_R /ε_R=1600), (Fig. 4).

The Yield strength and strain are σ_Y=250 MPa and ε_Y=0.012.
The elastic and the plastic modulus are directly attainable from at least three carefully determined test points as close as possible to the start of yielding (Fig. 3).
The elastic modulus amounts to E=1/ε'=1/p=7500 *MPa* .
The plasticity modulus is attainable from test data and amounts to Y=1/(σ_R ε'')=1/i=11000 *MPa* (Fig. 3).

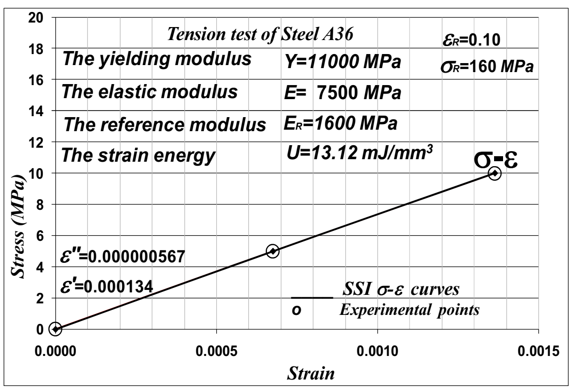

Figure 3. CEI parameters from initial tensile test (Fig. 4) A36

The strain energy is obtained by integration of the experimental SS curve (Fig. 4) and amounts to 13.12 *mJ/mm*^{3}. The causal potentiality is then the complementary strain energy and amounts to U=2.88 *mJ/mm*^{3}. Interaction intensity can be obtained from Eq. (7) as $i=2U/C_R^2-p=1/Y=9.17\ 10^{-5}\ MPa^{-1}$. It is the same value as obtained earlier for s=0 in Eq. (9) (Fig. 4).
The parameters of the Ramberg-Osgud's (RO) [5] power law:

$$\varepsilon = \int_0^\sigma \frac{d\varepsilon}{d\sigma} d\sigma = \frac{\sigma}{E} + K \cdot \left(\frac{\sigma}{E} \right)^n \tag{12}$$

are obtained from tension test data by least squares method:
K=10^5 and n=3.92 (Fig. 4).
It is commonly recognized that plastic strains in materials have smaller impacts at lower stresses but become greater at higher stress levels, which, in most cases, cannot be described appropriately by the Ramberg-Osgood power law Eq. (12).
The example with steel suggest that the SSI model based on CEI concept using interaction parameters form experimental data can model material yielding properties. Moreover, CEI has potentials to define the full plasticity under higher stresses. The CEI concept applied to material properties indicates how more plasticity adds to the yielding rate and induces further plasticity.

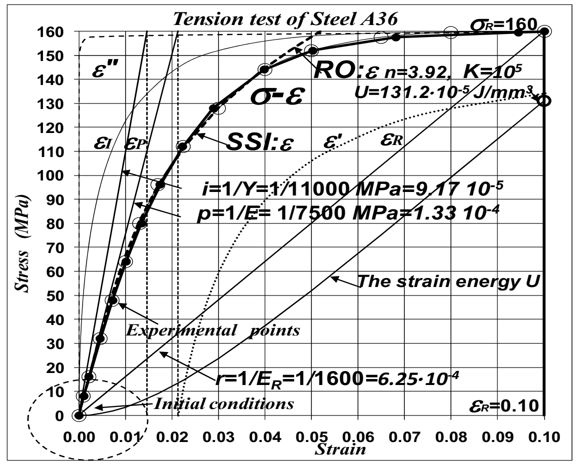

Figure 4. The SSI and RO parameters for steel A36

6.2. Lifetime shortening due to fatigue yield

The next case investigates could the CEI be the reason for additional fatigue life time shortening relative the Palmgren-Miner's linear fatigue damage accumulation rule (LD) e.g. [9], observed in ship operations [10]. The LD model sums up the formerly accumulated fatigue damage fractions $D_{j/i}$ under j^{th} loading block for i^{th} stress amplitude for the measure of fatigue:

$$W_j = \sum_{i=1}^{j-1} D_{j/i} = D(j-1) \tag{13}$$

The CEI concept of fatigue yielding (FY) [11] admits that the life shortens due to y accumulated fatigue W Eq. (13) that affects the residual fatigue strength denoted as the endurance:

$$R_j = 1 - D_i(j-1) \tag{14}$$

The FY rate [11] relates the strength worsening W_j (the cause C) Eq. (13) to the endurance R_j (the effect E) Eq. (14) for each j^{th} loading block patterned after the CEI rate Eq. (4) as:

$$\frac{dY_j}{dD} = \frac{W_j}{R_j} = p + i \cdot \frac{D_i(j-1)}{1 - D_i(j-1)} \tag{15}$$

Thus for infinitesimally small amounts of damage progressions *D,* the integral of Eq. (15) represents the CEI relation Eq. (5) and indicates the logarithmic and the linear components of the FY denoted *Y(D)* [11] as it is put down next:

$$Y(D) = \int_0^D \frac{dY}{dD} dD = (p - i) \cdot D - i \cdot \ln(1 - D) \tag{16}$$

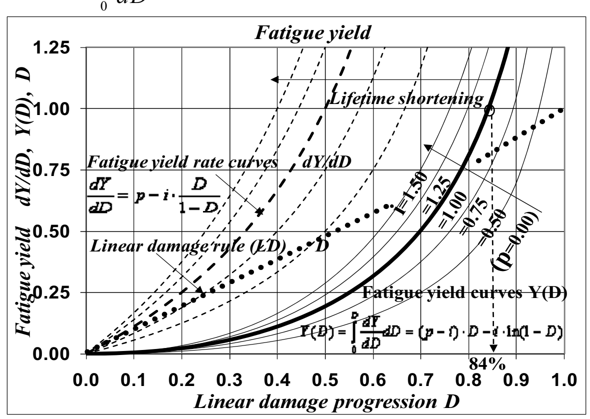

Figure 5. Fatigue lifetime shortening due to fatigue yield

The theoretical fatigue yield curve Eq. (14) can be adjusted to experimental damage progression results [11] by setting the fatigue yield intensity factor *i* and the initial propensity to yielding *p* at appropriate values [12] as it is the case with *p* and *i* parameters of the general CEI relation Eq. (4-6).
The theoretical fatigue yield rate ***D*/(1-*D*)** demonstrates how the endurance reduction (the effect E) **(1-*D*)** influences the damage progression ***D*** (the cause C). The study indicates that the fatigue life due to yielding becomes shorter since the formerly accumulated damages reduce endurance, e.g. for *i*=1, and *p*=0, the fatigue lifetime shortens at 86% of the expected (Fig. 5).

6.3. Corrosion wastage

The last case investigates the corrosion wastage as a possible consequence of the CEI. Corrosion is commonly described as a macro-structural material interaction with the surrounding environment induced by micro-structural electrochemical reactions and interactions, e.g. [13]. The example applies the CEI concept to the theoretical model of time variant corrosion rate *R(t)* (Fig. 6) by Sun & Guedes Soares in 2006 [14]:

$$R(t) = R_s\,(1 - e^{-\frac{t-T_i}{T_t}}) \tag{16}$$

The models describe corrosion in three phases (Fig. 6):

- The corrosion protection system is effective (up to time T_i)
- The failure of corrosion protection initiation (to time T_t)
- The corrosion rate R_s tends to be constant (after time T_s).

By integration of equation Eq. (1), the corrosion depth in time *d(t)* can be obtained as:

$$d(t) = R_s\left[\,t - (T_i + T_t) + T_t \cdot e^{-\frac{t-T_i}{T_t}}\right] \tag{17}$$

The choice of parameters in corrosion model depends on many factors, such as for example coating properties, surrounding properties, temperature and maintenance practice.

The study employs the CEI in the standardized 0-1 space *r-w* (Fig. 6) to explore how the increase of the corrosion wastage *w*(*r*) induces higher corrosion rate $r(t)=R/R_s$ due to interaction.
The corrosion wastage rate with respect to the simple CE relation *w(r)*=*r* and to what is left over after the ongoing wastage progression denoted as $o(r)=(R_s-R)/R_s=1-r$ Eq. (3), is as follows:

$$w''(r) = p + i \cdot w(r) / o(r) = p + i \cdot r / (1 - r) \tag{18}$$

The corrosion wastage rate *w'(r)* in terms of the CEI model Eq. (4) deepening on the corrosion rate *r* is the integral of Eq. (18):

$$w'(r) = w'_0 + (p - i) \cdot r - i \cdot \ln(1 - r) \tag{19}$$

The relative corrosion wastage in depth *w(r)* induced by the relative corrosion rate *r(t)* (Fig. 6) in the CEI interpretation of Eq. (7) is the integral of Eq. (19) as it follows:

$$w(r) = (w' - w_o) \cdot r - (p - i) \cdot r^2 / 2 - i \cdot r - i \cdot (1 - r) \cdot \ln(1 - r) \tag{20}$$

The total corrosion wastage in depth in Eq. (20) (Fig. 7) is:

$$W(r) = T_s \cdot R_s \cdot w(r) \tag{21}$$

The time to achieve corrosion wastage *W* at corrosion rate *r* in Eq. (21) (Fig. 7) is as follows:

$$t(r) = T_s \cdot w'(r) \tag{22}$$

The CEI parameters according the Eqns. (1, 5 and 8) are:

$$p = i = T_t / T_s \tag{23}$$

Numerical example of corrosion wastage

For mean values of corrosion wastage of main deck plates in cargo tanks of a tanker, [15], reasonable agreement with measurements were achieved with the following parameters of non-linear long-term corrosion propagation model: R_s=0.14 *mm/year*, $T_i = T_t$ =5 *years* and T_s =38 *years* in Eqns. (16-21).
The parameters for the CEI model Eq. (18-21) are as follows:
$p = i = w'_o = T_t / T_s = 5 / 38 = 0.131$ (Figs. 6 and 7).
These parameters define the corrosion wastage *w* with respect to the corrosion rate *r* (Fig. 6) as well as the of corrosion wastage (depth) in time, (Fig. 7).

For the special case when *i*=*p* in Eq. (22) the corrosion wastage rate *w'* in the time domain represents the time *t* to get the corrosion rate *r(t)* as follows:

$$t(r) = T_s \cdot w'(r) = T_i - T_t \cdot \ln\left[1 - r(t) / r_s\right] \tag{24}$$

The corrosion rate from equation Eq. (24) is equal to the theoretical model of time variant corrosion rate *R(t)* in Eq. (16):

$$r(t) = (1 - e^{-\frac{t-T_i}{T_t}}) \tag{25}$$

The Eq. (25) indicates that the theoretical model in Eq. (16) represents pure CEI interaction without the linear part Eq. (6).

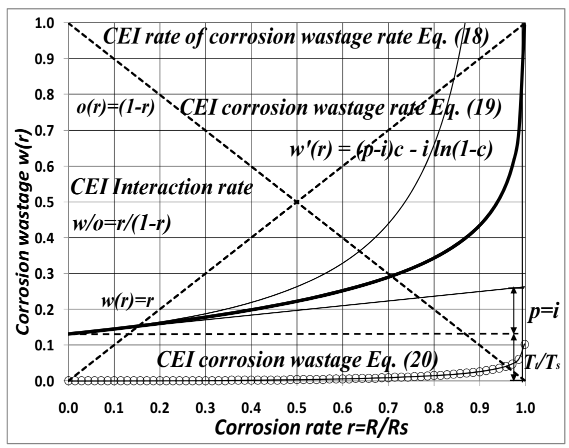

Figure 6. The corrosion wastage

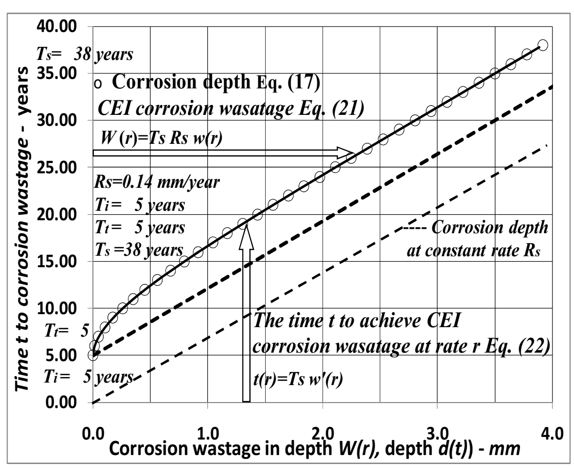

Figure 7. The corrosion depth

7. CONCLUSION

Worsening is a human interpretation of natural and social threatening phenomena whose consequences might be the loss of required or desired operational and existential efficiency. Worsening causes possible breakdown of anticipated individual, personal or general systemic functions and shortening of expected lifetime. Experience of worsening has roots in nature but the worsening itself should not be taken as a natural phenomenon. The judgments of the effects of natural processes are beyond local and temporal human criteria of quality. Worsening is to be accepted as a subjective attribution that expresses human expectations of their safety and wellbeing.

The Cause-Effect Interaction (CEI) concept revealed in the paper describes how things worsen with respect to the idealized Cause-Effect relation (CE). It also clarifies s why they in reality worsen faster of anticipated rate due to the negligence or mistreatment of the CEI. The CEI as an inseparable element of the omnipresent CE concept is also an omnipresent experience. The CEI also enlightens that the concepts of cumulative causation and of the positive feedback in systemic behavior have roots in causal interactions. The analytical settings of the CEI concept synthetically account for the joint accumulation of changes due to CE progression and CE interaction.

The analytical model takes for granted the encouraging prejudice without proof that there is no endless worsening; worsening promisingly must have an observable initiation and a definite end. Therefore, the concept of CEI is to be accepted rather as another empirical interpretation of observations about worsening phenomena that are valid as long as they can be verified, just as it is the case with the general causality lows. The straightforward mathematical formulation of the cause and effect interaction model indicates that the worsening, although omnipresent and threatening, itself is a simple phenomenon.

The examples demonstrate how material plasticity, fatigue and corrosion can be represented by CEI models. The study in general supports that the CEI concept might be a rational approach to an alternative comprehension of worsening, simple and accurate enough to tackle some engineering problems.

The future research of causal relations should consider some other forms of non-linear or non-uniform deterministic and probabilistic CE relations as well as the CEI models with correlated multiple causes and effects.

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CHALLENGES AND SUCCESSES IN MODELING WATERSHEDS

Peter E. Black
Distinguished Teaching Professor of Water and Related Land Resources, Emeritus,
SUNY ESF, Syracuse, NY 13210 315-470-6571; peblack@esf.edu

ABSTRACT

This paper describes the establishment, operations, materials and challenges to successful modeling of real world phenomena, including rainfall simulation, and adaptation of new electronic equipment to produce usable hydrographic records. The paper is more about the nature of the project than it is about the findings (the individual studies are published elsewhere and listed in the "Publications" of this paper). Resolution of the basic question concerned with whether project results could even be derived from the testing, output, and analysis of *watershed models* or *small watersheds*, was of prime importance in the utility of the project results. Ultimately, the response raises the more fundamental question: "What can we learn from models that will be useful for real world watershed management?" The response to these questions provide context for this report, but the project also had to include consideration of underlying questions concerning how to go about detecting and utilizing research results obtained in the process of constructing, operating, and interpreting the results of simulated rainfall events on iconic watershed models in a rainfall simulator. Do the *watershed models* accurately represent real world watersheds? Should they thus be classified as *small watersheds*? What materials to use to mimic real world watershed components? What sets of models to duplicate with ranges of physical characteristics of real world data sets? Which precipitation and physical watershed characteristics that impact storm runoff behavior should be evaluated? How scale precipitation depth on a three-square foot model? What constitutes a peak flow on a model? What should be the dimensions of soils? What is the best way to model storage behavior, infiltration, and percolation processes along with an experimental rainfall simulator's operations and characteristics? Emulating hydrologic monitoring field devices required reliable equipment for comparison of model and prototype runoff characteristics was also a challenge. As a research facility, the project was a boon to educational goals and understanding hydrologic processes. It also provided the challenge of creating more than "look-alike" physical models: they had to be capable of undergoing rigorous rainfall events coupled with model runoff monitoring equipment for analysis of a wide range of models and real-world watersheds. Eight project-specific papers from specific studies have been published, and many of the concepts, principles, and issues related to model/prototype challenges and solutions have been put to practical use, as well as become important information in the classroom. An educational film was also produced. While the project equipment has been disassembled, many of the concepts that were the subjects of study are products of the project. Recent cogitation by the author on several ramifications of similitude issues prompted this (very) post-project paper. Its educational value in a variety of watershed management situations also remains pertinent.

INTRODUCTION

The primary purpose of this project and its series of studies, was to reliably evaluate the relationship between watershed characteristics – size, shape, slope, elevation range, drainage pattern, and soil characteristics – and storm hydrograph characteristics such as <u>maximum peak flow</u> and <u>time of concentration</u>, characteristics of the post-peak hydrograph. An early goal was to derive a reliable determination of the time between start of rainfall and occurrence of the resultant storm hydrograph peak because how water flows from different parts of a watershed defy understanding how the time of concentration had been formulated. The simulator also provided the opportunity to evaluate surface and subsurface water movement over a variety of drainage patterns.

Armed with support and rainfall simulator plans and design from Professor Ven Te Chow (who had an impressive rainfall simulator that made the cover of *Life Magazine*), a variety of model drainages were created and tested under an extensive range of rainfall events. Runoff in the form of storm hydrographs and declining drainage characteristics were generated by a state-of-the-art electronic system that produced outflow storm hydrographs for analysis of time and other parameters, providing the data for evaluation.

An added project purpose emerged when the question of applicability arose following literature review of the several similitude challenges. The principal issues involved obstacles of hydraulic and hydrological similitude and the challenge of working with a new generation of electronic equipment. Finally, there was the challenge to model the soil. That turned out to be the keystone to the entire project.

PROJECT DESCRIPTION

The project provided a valuable instructional laboratory in addition to a time-lapse educational film about watershed management, published reports and conference-presentations; and much hands-on instruction. Being able to visually inspect and assess the runoff process on a scaled-down watershed was a wonderful learning tool. Like any model study, this one also fed a grown kid's intrigue and fun; it still does.

EQUIPMENT

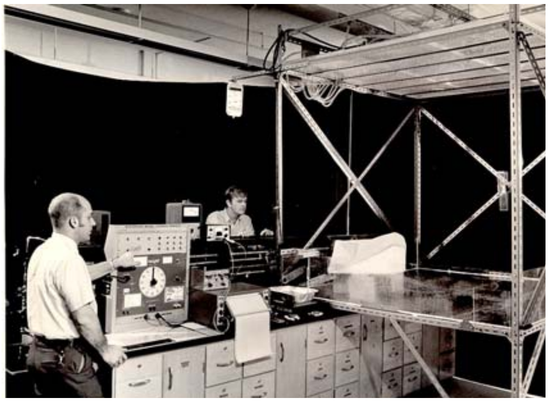

Figure1. Rainfall simulator. Author at control panel, and Graduate Student James Cronn.

Rainfall Simulator: Nine 2-by2-foot artificial rain "clouds" were constructed of Plexiglas© each 2 inches high and arrayed on a 9x9 foot metal framework. 5,184 Holes were drilled at one-inch intervals on the lower surface and fitted with short fine plastic tubes (commonly used for artery replacement in animal surgery). These one-inch-long plastic tubes were secured with clear plastic cement. The discharge ends of the tubes required hand-pick-cleaning every few weeks to preclude blockage as the slightly contaminated evaporating distilled water left miniscule deposits of dissolved solids. Each cloud's variable water pressure was controlled by a separate electric switch within the operator's reach and all the clouds' water pressure was reflected in a truck mirror that allowed monitoring the nine cloud pressure gages without moving from the control station, necessary because even minute local personnel movements was detected by the extremely sensitive platform transducer and thus recorded as "noise" on the storm hydrograph plot. Consequently, all research runs occurred on a Saturday when no one else was in the building. The discharge hydrograph of the model being tested was generated by an electronic discharge integrator that converted the increasing weight on an early and excellent platform transducer. This custom electronic equipment differentiated the input signal, and sent the trace, now an out-flow hydrograph, to a chart recorder (Figure 1).

Figure 2: Principal models showing different triplets of shape, outlet location, drainage pattern, and elevation ranges.

Models: The models were constructed from ½-inch slabs of Styrofoam© according to a contour map of the model watershed. The first set of models were each 3-square feet with varying shape, drainage pattern, location of the watershed outlet, and topped with one or two layers of artificial sponge material to model soil. For each watershed combination of size, slope, elevation range, and drainage pattern, a model was constructed and exposed to two or three rainfall events following the initial wetting run (and a constant pre-research-run period allowing drainage to establish consistent *antecedent moisture conditions*. Several topographic features were duplicated on larger models (some two and three times as large) to further evaluate effects of size on runoff characteristics.

Soil: A lengthy search for model "soil" material resulted in selecting an artificial car-washing sponge that had the following essential characteristics:

(1) should not change dimensions regardless of water content, that

(2) had a variety of interconnected pores

(3) of varying size, and

(5) exhibited retention storage of 25 to 30 percent, about that of a natural loam.

Fortuitously, the sponge material also came in 12x12" layers 3/8ths of an inch thick (marketed to dairy farms as pre-milking medicated udder-wiping cloths) and when rinsed, met all the requirements of the modeled soil material. Sufficient sponge was purchased from the same manufacturing batch to assure equivalent soil properties on all the models. The sponge lasted about 16 years before disintegrating, leading to the termination of the project.)

Soil layers were put in place and held together by drops of non-reacting glue at about one-inch intervals along the seam, thus water in the soil could readily flow between sponge pieces. For several of the models, multiple layers allowed doubling or tripling the soil depth for evaluation of storage effects on runoff. An important natural feature of the soil, of course, is to in part delay the arrival of the runoff from the watershed: thus deeper soils reduce peak flows more than shallow soils as one might expect. The amount of detention capacity (non capillary pores, thus temporary storage) of the soil is also reflected in the *decay time*, the time from the occurrence of peak storm runoff until the rate of flow decreases to one half of the peak value, therefore a measure of soil storage capacity. This characteristic from the field of electronics was suggested as a viable and easily measured storm runoff characteristic by collaborator Lee P. Herrington.

OTHER RESEARCH FACILITIES

Numerous educational and government agency experiment stations around the United States and in Europe and Africa pondered and conducted research on these questions. Real-world experimentation on watersheds is, of course, limited by the ability to produce rainfall (or snowmelt) replications that could be provided for establishment of impacts of the several parameters (listed above) on storm hydrograph characteristics, in particular. In the mid 1960s, studies were in progress at the University of California at Davis, Utah State University at Logan, University of Illinois Champaign/Urbana, Massachusetts Institute of Technology, and State University of New York at Binghamton. Only the latter project attempted to model the soil, in this case with cheesecloth. The Utah installation had real soil on the watershed models, and since that had to be replaced with each run, comparing watershed characteristics was not possible. All other studies used smooth plastic or polished clay surfaces with, of course, no storage-emulating soil, proxy, or stand-in. A study in London, England was not visited, but was correspondence reported able to create duplicate "storms" for analyses.

OPERATIONS

Preliminary: Every time a watershed model was placed in the simulator for a test run, it was subjected to a "wetting run" and allowed to drain for a short regulated period to ensure similar antecedent moisture conditions. Variation was never a problem.

Environmental conditions: all the research runs were done on a Saturday to avoid "noise" caused by the operator moving around or by visitors and/or regular building users. That also assured constant, notably humidity and temperature conditions. Thus, uncertainty concerning what atmospheric conditions existed that might adversely impact instrumental operational stability was controlled and variability was limited.

PRINCIPAL FINDINGS

The myriad references in the literature to the relationship between watershed drainage pattern, shape, size, and slope, provided the primary foci of the Watershed Model Studies Project. Watershed managers and hydrologists had been challenged to understand and apply knowledge derived from research to practical field questions. Knowing how field practices may include land clearing, distribution of various land uses, how to work productively with stream channels, and how effective were soils – and vegetation – in modifying runoff for specific areal and/or temporal behavior, among other questions, often unique to the experimental site. Attempts to limit some of these variables were sought as a reasonable benefit of the project.

The lengthy questions raised by the apparent relationship between watershed models' behavior and real world watersheds was not resolved until fifteen years after the project was shut down in 1984. That prompted preparation of a PowerPoint© presentation and this paper.

THE PRIMARY CHALLENGE

Similitude The difficulty with research of this type is the broad challenge of hydraulic similitude. This is often a challenge on iconic – look-alike – models where it is essential to have the model accurately represent the real world, or prototype. The challenge here is inherent in that several physical features of watershed landscapes where hydraulic and hydrologic elements, properties, and processes such as soil water sequestration, channel, surface and subsurface runoff, etc. may be readily quantified and therefore modeled using well-known and verified proxies or a formulated relationship to represent the well-known process or physical feature. *But one cannot model the primary substance of interest: water.* Therein lies the challenge. The solution in the ideal situation is to show that the model does in fact mimic – behave like – the prototype. That requires a model that is in fact, a small prototype.

For a project such as this one, the problem focused on the observation that there are well-established proxies and/or formulated representations of hydrologic processes that may appropriately help understand and evaluate model and prototype. Ideally, the model and prototype would be identical, but since it is not normal nor in most cases even possible to model the water, some degree of translation between model and prototype becomes necessary, thereby increasing the probability of errors of interpretation between the model and prototype. The best alternative is to have model and prototype affected by the feature of interest in the same way, thereby establishing similitude between the two realms. Simply put, if the watershed model behaves like the real world watershed, there is in fact hydrologic similitude. And, of course, the behavior of a rainfall amount should bear some similarity to both model and prototype.

<u>Watershed Models or Small Watersheds?:</u> After establishing the operational equipment facility, a consulting visit from Professor T. E Harbaugh, Hydrologist (formerly a student of Professor V. T. Chow who was the primary assistant on the U of I modeling project) accepted an invitation to visit the simulator and models. Upon reviewing standard operations and inspection of all the equipment that operationally made up the simulator and its output results, Dr. Harbaugh was asked the question: "**Are these *watershed models* or *small watersheds*?**" After some discussion, deliberation, and further analysis and consideration on his part, he asserted that they were "small watersheds". The focus on modeling the soil: the carefully selected sponge material properly represented – mimicked – soil storage and runoff relations in real world watersheds. Since behavioral characteristics of models and prototypes fit analytically, certain conclusions about the modeling process could be verified as legitimately representing real world watersheds. ("The proof of the pudding is in the eating.")

<u>The Big Remaining Issue:</u> Under what connection and authority then can one reliably transfer the nature – perhaps even some numbers – representing results of this research to the real world? How might use of what is learned in the laboratory be reliably used in watershed planning, for example? Toward the end of the 1967-to-1984 life of the simulator, models, and sponge (soil) this particular question emerged as an interesting, challenging, and fundamental issue. The essential element in the entire project, once the mechanical, hydraulic, electrical, and electronic features of the simulator were established, was the adequacy of the sponge used to represent the soil, selected based on accurately mimicking real soil properties and behavior.

The issue focuses on interpretation of the relationships between several sets of the three size models. The *exponents* and coefficients of the equation representing the relationship between peak runoff on three palmate models are almost identical to similar exponents and coefficients determined for simultaneous peak flows from real storms that occurred on all three sets of real-world watersheds similarly related based on runoff records from the Coweeta Hydrologic Laboratory in the mountains of North Carolina. The same is true for a similar trio of watersheds with similar size ratios at the Coshocton (Ohio) Experiment station watersheds. All the experiment station summer storms were intense, short-lived, probably thunderstorms. And the 3,000 square-mile Eel River watershed in California, with monitored sub-watersheds of nearly the same size ratios, was subjected to 50 inches of rain in nine days (1964). An operational set of (hand-drawn) straight lines shown connecting the four sets of comparable peak flows may be considerably different from that shown. In fact, the four sets of three comparable watersheds (including the models!) are shown here over ***ten orders of magnitude*** of drainage area (Figure 3). The graph also dimly shows runoff data for additional gages that do ***not*** fit the pattern (but are not far off!) Having pondered this challenging puzzle for more than a decade, it seemed that something was impacting their natural flow. It turns out that it is in fact, not surprising, as they all have flood control and/or hydroelectric power projects on the streams. In other words, their flow is regulated by dams or levees, especially at high flows!

Simply, the experimental models satisfactorily mimic real world watersheds, effectively assuring the validity of the models in representing the prototypes. And, the observation of Professor Harbaugh's judgment that the models are, in fact, small watersheds, enhances the project's specifications, operations, and findings and suggests possible extension of the research findings to a much wider spectrum of natural watersheds.

SUMMARY

The key to this project's success in at least understanding concepts if not producing actual management tools was that the overall similitude question sets up the project summation. This dataset is, of course, neither conclusive nor comprehensive, but it appears certainly worthy of further examination for its' potential value in understanding and, perhaps, managing watersheds. The possibilities are intriguing.

Further, the similitude question on a watershed scale may be resolved by accurately modeling the soil: it is the single most important, indeed critical environmental feature of the watershed. Without storage, stormwater runoff rapidly gets to the channel. Without storage of water on the watershed and subsequent access to vegetation's transpiration (and evaporation) is lost. What better explanation is there than this that affirms the soundness and validity of the entire project? Extending its results to real world management opportunities will certainly require further exploration in laboratory and field.

The broad curve-suggesting hand-emplaced three straight lines shown connecting the four sets of comparable peak flows may be considerably different from that shown. In fact, the four sets of three comparable watersheds (including the models!) likely is different from that shown here over *ten orders of magnitude* of drainage area; but that degree of similarity is amazing by itself, and suggests opportunities for further research. The graph also dimly shows runoff data for additional sets of gages that do *not* fit the pattern (but are not far off!).

Simply, the experimental models satisfactorily mimic real world watersheds, effectively assuring the validity of the models in representing the prototypes. And, the observation of Professor Harbaugh's judgment that the models are, in fact, small watersheds, enhances the project's specifications, operations, and findings and suggests possible extension of the research findings to a much wider spectrum of natural watersheds.

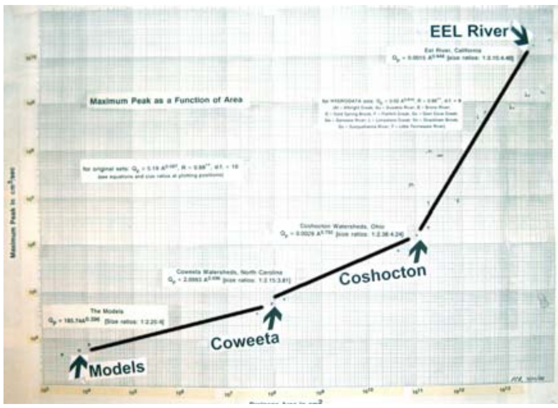

Figure 3: Ten orders of magnitude (from about 3 square feet to 3,000 square miles for four threesomes of watersheds exposed to separate rainfall events unique to each set of three suggest relationship, here drawn by hand as a reminder that this curve might best be used as the next-to-the-end product of further research into runoff behavior on the spectrum of watershed features to-the-end product of further research into runoff behavior on the spectrum of watershed features.

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PUBLICATIONS

[Note: All relevant citations used in the preparation of the following publications and references used in the creation of the Watershed Model Studies Project may be found in the following works that are products of the Watershed Model Studies Research Project. Anyone who wishes to get more and more detailed information will benefit from the project notebook, which would have to be copied or studied here in Syracuse.]

"Watershed Models for Instructional Films" 1970, Peter E. Black & Raymond E. Leonard, *USDA Forest Service Research Note NE* 113

"The Watershed in Principle", 1970 *Water Resources Bulletin* 6(2):153

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"A laboratory catchment study of a watershed parameter" James W. Cronn, Masters Thesis, SUNY ESF, 1971

"Hydrograph Responses to Geomorphic Model Characteristics and Precipitation Variables." Peter E. Black, 1972. *Journal of Hydrology* 17:309

"Flood Peaks as modified by Dam Size and Location." 1972, Peter E. Black, *Water Resources Bulletin* 8(4):780

"Hydrograph Responses to Watershed Model Size and Similitude Relations", 1975. Peter E. Black, *Journal of Hydrology* 26(255).

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Institutional Modeling of Iranian Public Policy Evaluation

Razieh EMAMI MAYBODI

Political Science Department, University of Tehran, Tehran, Iran

and

Kioomars ASHTARIAN

Political Science Department, University of Tehran, Tehran, Iran

Abstract

This article uses an institutional approach to design a model for evaluating the Iranian public policy. The proposed model is based on the institutional characteristics of Iranian political system, and is therefore called an institutional modeling. An institutional model is considered a multi-approach and multi-method model which takes a systematic approach. The main components of this model are: 1- Evaluation Goals: this component determines definition, types, stakeholders and functions of evaluation. 2- Policy Areas: This component identifies the right weighting of the five criteria and the limitations of evaluation. 3- Legislative Duties: This component identifies the level of policies and the purpose of the organization for the evaluation. 4- Organizational Characteristics: This component specifies applicable evaluation models according to the role, quality and quantity of expert personnel, quality of reporting and the internality or externality of it. The institutional model tends toward the division of labour, but applies it based on the evaluation being internal or external. In addition, by emphasizing on the complex relationship between stakeholder institutions and the necessity of managing that relationship, it considers the evaluation of policies as a coordinating and policy making tool.

Key Words: Policy Evaluation, Institutional Approach, Institutional Model, Iran.

1- Introduction

Today, the ever complicating management of public affairs has turned the evaluation of policies to an inevitable necessity for governments. A successful political regime tries to obtain feedback from the implementation of policies, and considers the applied changes. Then takes advantage of the results to continuation, revise, or modify the policies. In the absence of such a process, policymakers inevitably rely on personal experience, scattered data and advisory opinion which are not necessarily based on documented evidence and systematic information.

With the beginning of Development Plans in Iran, various attempts for evaluation took place. Verity and complexity of these plans lead us to necessity of coordination and coherence. The important issue facing Iran's policy system of evaluation is the question of how to consider monitoring and evaluating simultaneously. The public policy making system in Iran starts from General Policies at the highest levels of the system and extends to micro level Executive Activities. Figure one shows Iran's public policy making system.

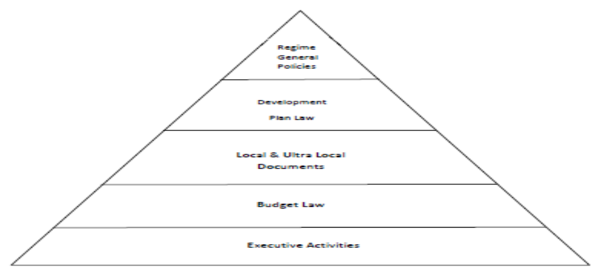

Figure 1: Public policy making system in Iran

Policy making process in the above pyramid is a sequential order while developed and implemented in relation to each other. The General Policies of this system are, at the first step, elaborated by the Expediency Council. Then, after approval of the Leader of the Islamic Republic they can become Law by the National Assembly to be, finally, executed by the government. These policies usually have a strategic nature and define the main orientations of the system in different fields. The General Policies should be applied in the Five Year Development Plan which is developed by the government and ratified by the parliament. Planning policies become operational within the framework of Official Sectoral Documents and should be implemented within the annual financial planning known as the Budget Law. The government annually develops the budget bill and offers it to the parliament for its approval. After its ratification, local and national executive agencies design and run the enforced activities. The process of public policy making, thus, involves the Leader, the Expediency Council, the Executive and the Legislative powers. Hence, the evaluation of policies should encompass different layers of policy making and provide each level with the necessary information and evidence. To be consistent and coherent, formal evaluation requires the development of a standard framework and a written guideline which has the ability to be utilized in the relevant institution.

However different models have different features and their corresponding methods have different areas of application. Therefore it is necessary to consider the situation in which evaluation model or method is most appropriate for providing the relevant institutions with the right policy information. In addition, the distribution of evaluative tasks among various institutions requires that these models be used in coordination with each other and give coherence to dispersed evaluations in different institutions. This process calls for a comprehensive model with the ability to integrate various parts. Model designing requires knowledge of the local context on the one hand and theoretical issues on the other. Therefore the present article tries to propose a policy evaluation model for the Iranian public policy system by covering these requirements within the framework of an analytical-explorative research through the utilization of an institutional approach. In this regard, the first part of the article reviews the literature of evaluation, and the second part portrays the current policy evaluation situation in Iran. Then in the final section the designed model for the improvement of policy evaluation in Iran is proposed.

2-Methodology

This study is among the analytical-explorative researches and applied through a focused synthesis method. The data collection method used was documentation and in-depth interview. Expert opinion was also used to assess the findings and adapt the basic model. It should be mentioned that this article is written within the framework of an institutional approach and with regards to the Islamic Republic Constitution and Iranian Administrative Law. The research literature review and the evaluation of the administrative and political system in Iran were also done accordingly. Therefore this article has defined the study of institutions, rules, procedures, and their mutual influence as its departure point; hence having a normative-prescriptive nature.

3- The Institutional Approach

For us, an institute is the "method" to arrange or regulate human-social "relationships". Institutional approach in the political sciences considers the constitution as the main arranger of political relations. Classic interpretation of the institutional approach, considers the official institutions in public policy as the unit of analysis.[1] On the other hand we cannot consider organizations as individual units in performing their tasks. Administrative-social institutions have a network of roles and are each responsible for a specific task while having a systematic approach in their performance. This is what is referred to as a policy network theory. The policy network theory has adopted a "state-based" approach in public policy and focuses on specific management tools and actions.

Among the many approaches in modeling, the functional modeling identifies the important and influential variables, and their relation while also benefiting from the decision-making variables. This feature makes functional modeling the right tool for public policy based on decision-making. In functional modeling all the involved factors including economic factors, human resources, financial factors, legal, and so on are investigated and accounted for in the model. One of the positive features of this modeling is that it prevents a waste of expenses and clears the decision-making arena. Accordingly we will benefit from functional modeling within the framework of the institutional approach and the policy network theory in order to optimize the use of policy evaluation capacities in the country.

4- Literature Review: Theoretical Components

There are many ways to evaluate policies whether focused on impact or process or both. In their classic study Guba and Lincoln have mentioned the four generations of measurement, description, judgment, and constructivism in evaluation.[2] Dunn has divided policy evaluation approaches into the three groups of Pseudo-evaluation, Official evaluation, and Decision –Theoric.[3] In the latest edition of his book in 2007, he has revised the titles of policy evaluation approaches into Causal Evaluation, Official Evaluation, and Participative Evaluation. Foss Hansen places the evaluation models in the six categories of results models, process models, system models, economic models, actor models and program theory models.[4] Stufflebeam has identified 22 different approaches in the evaluation monograph based on the design and the implementation of the evaluation. He places the mentioned approaches in the four major levels of pseudo evaluations, the Questions/Methods-Oriented approaches, Improvement/Accountability- Oriented approaches, and the Social Agenda/Advocacy Approaches.[5] The delicacies of models increase the number of approaches. Hanberger differentiates between three democratic approaches: discursive democratic evaluation; elitist democratic evaluation, and participatory democratic evaluation.[6] Or Taylor claims that his value centered approach is different from other evaluation approaches.[7] The Cross-Cultural Evaluation which focuses on the interaction between different cultures in evaluation seems almost independent of other models.[8] Recently feminist approaches of evaluation have also emerged which focus on the promotion of social justice especially for women.[9] An ascending number of approaches which apply fresh delicacies especially in political and participatory approaches continue to emerge.

Despite the existing diversity Bovens et al discovered that policy evaluation approaches should be placed in the two categories of, rationalistic and argumentative according to the role they give to values, norms and power. The rationalistic school emphasizes on the unbiased process of producing information and a regulated application of research procedures in social sciences. This school rises from the positivist perspective and claims that it's an unbiased way of judging with empirical data. The argumentative school on the other hand, by rejecting the separation of science and politics, states that scientific assumptions that define good and bad policies are influenced by power and politics; and emphasizes on reflecting the voice of different stakeholders in its evaluation. [10]

Each of the above mentioned models require the application of a set of research methodologies in social sciences and operation research, which are usually called the methods of evaluation. [11, 12]

Despite the remarkable diversity of evaluation methods and policy evaluation models, the literature in this field has not paid enough attention to choosing between these models. Foss Hansen has identified three major criteria for selecting evaluation models based on the conducted research: 1- the purpose of evaluation 2- the characteristics of the topic of evaluation 3- and the problem the evaluation deals with. [13]

Despite these shortcomings, the rich literature on evaluation about the different consisting elements of policy evaluation, models, and methods help us in extracting components of evaluation model selection. The next part covers the important components which should be taken into consideration in the selection of policy evaluation models.

Definitions and Types

The way policy evaluation is defined depends on its epistemological approach. When the definition of evaluation is specified, the evaluator then accordingly selects the policy evaluation model in the form of the rationalistic and argumentative schools. The definition of evaluation usually has other organizing elements within it.

Mark et al categorize the different definitions of evaluation in the two groups of performance-oriented and goal-oriented.[14] These definitions encompassed a variety of evaluations as sets of research methodologies to the process of social learning. An operational definition of policy evaluation should pay attention to both the methodological and political aspects of it while also having the ability to simultaneously cover its impact and process as well. In this context we rely on the definition provided by the British Bureau of Social Investigation, on policy evaluation which states that, "Policy evaluation uses a range of research methods to systematically investigate the effectiveness of policy interventions, implementation and processes, and to determine their merit, worth, or value in terms of improving the social and economic conditions of different stakeholders".[15] According to this definition policy evaluation seeks two goals: 1- measuring the results of the performance and the level of achievement in policy goals, which shows the objective, technical and quantitative aspect of the evaluation; 2- judgments about the success or failure of policies based on efficiency, effectiveness, impact and its sustainability; this shows the value and quality of the evaluation and emphasizes on improving the situation of the target population and the policy stakeholders.

The next step in the search for an evaluation model is determining the type of evaluation so that the required information can be identified. Evaluation research is done in the two main categories of summative (focused on the effects and results) and formative (focused on the process) evaluations. However, as noted by Stake the conjoined conduct of both in an evaluation research is not rare. [16]

Stakeholders

The stakeholders of the evaluation are individuals, institutions, and groups which have influenced or been influenced by the evaluation. [17] The nature of the evaluation stakeholders influences the design of the model. Internal stakeholders tend toward models that help improve the implementation of policies. In contrast external stakeholders focus more on accountability models. In addition the more the diversity of stakeholders in the evaluation, the more the evaluation model tilts toward participatory approaches. In contrast, limited stakeholders usually have specific demands which are more aligned with objective-oriented approaches.

Issues and Criteria

Overall, the policy evaluation criteria follow the definition of evaluation. Determining the evaluation criteria depends on the evaluator's approach and more than that on the desired issues of the client. Effectiveness (the amount or probability of achieving policy goals), and efficiency (the ratio of policy outputs to costs) are the most common evaluation criteria. International organizations have consensus on impact criteria (results and effects of the policy), sustainability (the institutional financial and environmental capabilities of the continuity of services and policy benefits), and relevance (the permanent communication of approach and policy goals with the needs, problems and priorities) in addition to the above mentioned criteria.[18,19,20] The mentioned criteria were use in different countries and proven their efficiency in comprehensive policy evaluations and programs. Depending on the evaluation model, the amount of attention paid to them differs. A comprehensive evaluation model should have the five criteria.

Functions and Constraints

The expected function from the evaluation is another major factor in the design and selection of the evaluation model. The main functions of the evaluation can be summarized into: 1- learning, performance improvement and helping in making a conscious decision, 2- accountability, efficiency and legitimacy, and 3- transparency and the criticism of values.[21,22,23,24] The learning function recommends participatory models while the accountability model tends towards strongly programmed models. The decision-making function demands a combination of these models. Finally the value transparency function requires explorative models.

The limitations of the evaluation model should be taken into consideration in the design and selection of it. Meanwhile the dynamic nature of policy is one of the main issues that should be considered. Knowledge of the relativity of the evaluation, diversity of policies and their implementation process, the existence of various stakeholders and the numerous existing methodological challenges, make the evaluator take into consideration the timing, reliability, operational needs and technical abilities in the design and selection of models. This makes the evaluation fair and enforceable. [25,26]

Based on the above topics, the main elements in determining evaluation models are: the definition of evaluation, evaluation types, evaluation stakeholders, evaluation criteria, evaluation functions and limitations. The mentioned item can be summed up in the following components: 1- Goals of evaluation: This component determines the appropriate definition, stakeholders; and the type and function of the evaluation. 2 - The nature of politics: this component specifies the relevant weighting of the five criteria and the limitations of the evaluation.

5- The Administrative-Political System of Policy Evaluation in Iran: Practical Components

According to the Constitution (Principles 55, 76, 89, 110, 126, 134, and 174) and ordinary laws (Public Audit Act, Law of civil service management, program and budget law, Majlis Research Center duties law, Supreme Audit Country Court Act, State General Inspection Organization Act) the role of evaluation is divided between the Supreme Leadership and the judiciary, executive, and the legislative branches. At macro-levels these institutions include the Expediency Council on behalf of the leadership, State Inspector General Organization, Supreme Audit Court, Majlis Research Center and the President Deputy Strategic Planning and Control. Here we will have an overview of the legal context and the relevant institutions involved.

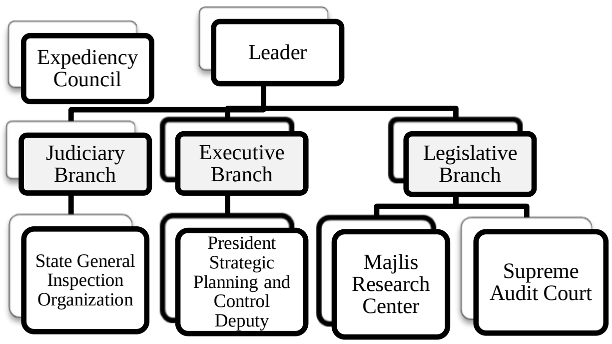

Figure 2: Macro Institutions Associated with Policy Evaluation in Iran: the Status Quo

The Leader

According to article 110 of the constitution setting the general policies of the Islamic republic of Iran, after consultation with the Expediency Council is the leader's responsibility. Also one of the functions and powers of the leader, is supervising the overall implementation of the general policies of the regime. Moreover the leader has the right to delegate some of his duties and powers to another person. Accordingly, the leadership delegated the general policies of the Third Development Plan, the first series of the general policies of the regime in the year 2000, and the monitoring of the implementation of general policies of the regime to the Expediency Council. Monitoring takes place in during the phases of "before action", "while running" and "after running". Monitoring before the implementation of the Expediency Council includes adapting the material of the development plan and the annual budget bills with the ongoing general policies by the government, reviewing it in the parliamentary commission, passing it at the House floor, and approving it by the guardian council. This mainly takes place in the form of a comparative study which is only considered a type of monitoring and not evaluation. Monitoring during and after the implementation of policies and during which evaluation is inevitable. In this regards the main focus of the secretariat is on gathering indexes and indexing for the purpose of monitoring. In addition case evaluations of the realization of general policies take place in form of legislative monitoring. It seems like the above mentioned evaluations are only conducted in order to inform the leader. In fact, evaluation in this case has a advisory-expertise role and its main mission is to assist wise decision-makings at macro levels.[27]

President Strategic Planning and Control Deputy

The “President Strategic Planning and Control Deputy” was established following the merge of the Management and Planning Organization with all the functions and powers of the presidential institute in 2007.

Article 5 of the budget planning law requires the Management and Planning Organization to constantly monitor the implementation of plans and their annual progress, and evaluate the performance of executive organizations and report to the president. This is done through visits and inspections from the activities and projects of executive organizations and then preparing six- month, annual, and five-year reports. Executive organizations are obliged to cooperate with this organization and provide it with the necessary information. This is emphasized on in articles 81 to 83 of the Law of civil service management. The activities of the Deputy are categorized into three groups: 1- a system of monitoring on civil national projects in the form of information management systems, which monitors the physical progress of projects and their financial situation with a technical-civil approach. 2- Reports on the performance of institutions which evaluates the amount of work done through specific indexes. 3- Financial reports and monitoring on the performance of development plans which measures the annual progress of development plans according to legal provisions, policies, measures, indicators and qualitative goals; and offers recommendations for improving the advancement of projects. Achieving legal and approved objectives is considered the desirable performance criteria. In fact, the performance of organizations in achieving their objectives is monitored. Reforms in budgeting and activities aimed at changing the approach of the organization to budgeting, which started in 1999, can increase the level of attention to program and policy evaluations, if combined with a change in its executive-oriented approach to a result-oriented approach.[28]

Majlis Research Center

Paragraph C of article 2 of the Duties Act of the Parliament Research Center states that one of the tasks of this center is to study and investigate the fine implementation of laws and offer expert recommendations for removing obstacles and problems. When this task is put besides the Centers’’ other task of providing information to the parliament commissions and representatives and establishing an information system- according to paragraph D of the same Article- the inevitability of policy evaluation studies in this center becomes evident. Since according to the Article 76 of the Constitution the parliament has the right to investigate all affairs of the country, the Research Center has a wide range of activities to conduct policy evaluations. The MRC evaluations are cross-sectional ones which usually conduct legislative monitoring and have a wide variety in terms of their content. Experts have various ways in conducting them, which include documentation and interviews.[29]

Supreme Audit Court

Article 55 of the Constitution defines adaptive computing as the general framework of activities for the Supreme Audit Court. From the perspective of policy evaluation, this level of activity could be considered as part of the policy process evaluation. According to paragraph E of Article 23 of the Supreme Audit Court Act the advisory board of the court can not only investigate and issue binding votes in cases “resulting from abuse, neglect and compliance of public property, documents and funds” but also “ any wrong decision or spending that results in wasting or violating public funds”. If the crime is proved the board can accordingly issue votes that condemn and punish the violators. Also the case is submitted to courts through the Supreme Audit Court. During the course of time the court has passed its financial computing duties and moved on to comparative computing, and is now in its early stages of changing its approach to function computing. The main activities within the Supreme Audit Court Audit is carried within the framework of comparative computing which focuses on financial monitoring.[30]

State Inspector General Organization

Under Article 174 of the Constitution, the State Inspector General Organization monitors the well conduct of affairs and the correct implementation of laws in administrative organizations. The well conduct of affairs and the correct implementation of laws mean a set of continuous, systematic, and targeted activities in order to gather necessary information on the stages before, during and after the practices of the subject organizations; the analysis and adjustment of the performance of these organizations with their goals and legal duties, and offer of recommendations on for a smoother conduct of affairs. According to Articles 8 to 10 of the State Inspector General Organization law, institutes are not only obliged to aid this organization in its inspection duty but have to act upon the suggestions made for the improvement of affairs by this organization. Not acting upon the legal recommendations of the organization without any legal excuse will receive punishment according to Article 576 of the Islamic Penal Code. The extensive inspections of the State Inspector General Organization include reviews of projects, programs and policies and provide a retrospective and evaluation of the ongoing and post implementation of policies. [31]

Expert information shows that the recommendations of inspectors do not focus on the technical improvement of the project from a learning approach but rather take care of the correct implementation of laws and the elimination of errors. Moreover, according to the local regulations of the organization, the inspectors only mention the drawbacks and have no say in the decision-making. The State Inspector General Organization acts and decides based on the report given by the inspectors. [32] Therefore the State Inspector General Organization has the right to decide and intervene in macro issues where the executers might escape the right enforcement of actions.

Therefore the above mentioned institutions are different in terms of their legal obligations, the basis of their evaluation, the type of policy under evaluation, their organizational role, the purpose behind their evaluation, their expertise facilities, and the possibility of debriefing. The mentioned elements can be combined in the following components: 1-legal duties: legal documents are the basis of evaluation, type of policies, and the purpose of the organization from evaluation. 2- Organizational characteristics: Organizational characteristics include roles, the quality and number of expert forces, the quality of possible debriefing, and its being internal or external identify the possible evaluation models for implementation.

6- Conclusion: The Formulation of the Institutional Model

The current situation of evaluation in Iran can be compared to a number of dispersed islands of monitoring institutions. The lack of a clear law about policy evaluation on the one hand and the extensibility of the current laws on the other hand have created a maximized overlapped and repeated interpretations of evaluating tasks. Although due to the necessity that mandates an evaluation to be either internal or external, using similar approaches are inevitable but they should be done in compliance with coherence, and coordination and effective communication among institutions in order to prevent extra costs. Considering the focus of institutions on legislative monitoring, the dominant approach is to use evaluation as a monitoring tool rather than a coordinating and policy making one. In addition, policy evaluation reports need to be more competent in terms of technical issues. They often use documentation, interview and expert opinions and are reluctant to the capacities of other approaches. Yet, starting reforms in the administrative system, such as changing approaches to functional budgeting and performance computing have created an opportunity to promote and institutionalize policy evaluation in the administrative system and also create an opportunity for producing local policy knowledge and knowledge-based decision making. The optimal use of these capacities requires a model that chooses the right approach and method in accordance with the requirements and limitations of the relevant institutions. We propose the institutional model for the design of this structure.

Institutional modeling is based on the legal-official characteristics of Iran, and is therefore called institutional. This model is a multi-approach, multi-methodology model which combines theoretical components with administrative-political ones in order to choose the right model. Institutional policy modeling considers both the impact and the process and is able to cover different micro, intermediate and macro levels of policy. The institutional model has the ability to implement performance guarantee for evaluation and considers the necessity of public responsiveness and the existence of independent evaluation institutions. This model is based on the coordinated participation of relevant institutions in policy evaluation and considers evaluation as tool for coordination and policy. The logical flow of the institutional model is as follows:

- Evaluation tasks are divided among different institutions in Iran
- The purpose of all supervisory institutions is not the identical in performing the evaluation
- The overlap of evaluations by different institutions should be based on the evaluation being internal or external
- Organizational characteristics of different institutions have created limitations in the evaluation approach
- A specific approach cannot be used for policy evaluation at different levels
- The focus of each institution on one or more evaluation approaches according to their legal and administrative capacities will increase evaluation capacities in the country

Thus the institutional policy evaluation model is divided into the four main components of Evaluation goals, Policy areas, organizational characteristics, and Legislative duties. The first two components were extracted from a theoretical analysis and the next two from the analysis of Iran's administrative-political system. These components provide us with the possibility of choosing the right approach.

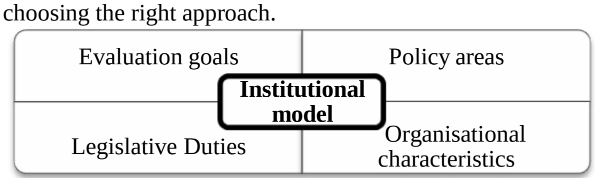

Figure 3: The Institutional Policy Evaluation Model

The main organizing element of the institutional model is the institution which aims to evaluate policies. This is the main difference between the institutional model and other policy evaluation models. The institutional model has the ability to be used in different national contexts. This model has become operational in the context of Iran in table 1. According to table 1 relevant institutions have divided tasks among them and evaluation reports are formed in connection to each other. The MRC has focused on the impacts and results of policies before and after their implementation; and as for the responsiveness of the government it considers legislative monitoring. To improve their performance, executive agencies conduct internal policy evaluations, and the planning and strategic deputy continuously monitors their performance and ties it to it budgeting plans. It also calculates the general indexes of the economic-social situation of the country for decision-making purposes at macro levels. The reliability of the reports by the executive branch in regards to operational policies mentioned in the budget law is investigated by the operational review of the Supreme Audit Court. Due to its legislative nature, the State General Inspection Organization avoids evaluation in order to evade from overlapping duties with the executive branch; this organization spends all its time and energy on supervision and combating corruption which is its main responsibility. The Expediency Council evaluates the general policies by concluding the reports of the relevant institutions, benefiting from expert opinion and the evaluations of private institutions and hands in the final report to the Leader. In addition to the Expediency Council, executive agencies and the MRC can also order the evaluation of private institutions. The MRC and Supreme Audit Court reports have to be publicly released to inform people of their contents. The order and institutionalism of this process not only adds to the efficiency and coordination of the policy system but also strengthens public trust and provides it with a rich social capital.

Institution	Model Variables				Model Recommendations	
	Legislative obligations	***Objective of Evaluation***	***organizational characteristics***	***Policy areas***	***Preferable Approaches***	***Applicable Methods***
Executive Agencies	Article 81 of The State Service Management Law	Decision-Making Learning	1.Mainly Provincial organizations 2. Permanent Experts 3.Internal/External and Annual Reporting	variable	1.Decision/accountability-oriented 2. Consumer-oriented 3.Accreditation/certification 4.Client-centered studies (responsive evaluation)	Different types of qualitative and quantitative methods
President Strategic Planning and Control Deputy	1. Article 82 of The State Service Management Law 2. Article 5 of The Planning and Budgeting Law	Accountability Decision-making	1. Staff Organizations 2. Permanent Experts 3.Internal/External and Annual Reporting	variable	1.Management Information Systems 2.Accountability, particularly payment by results 3. Social System Accounting	1.program input, process, output databases 2. Program Planning and Budgeting System (PPBS) 3.Management by Objectives (MBO) 4. Social Indicators
Supreme Audit Court	Article 23 of The Supreme Audit Court Law	Accountability	1. Provincial Organizations 2. Permanent Experts 3. External and Annual Reporting	variable	Benefit-cost analysis	1. performance audit 2. cost-efficiency analysis 3. cost-effectiveness analysis
Majlis Research Center	Article 2 of The Research Centre of Parliament Obligations Law	Accountability Decision-making	1. Staff Organizations 2. Permanent and Temporary Researchers 3. External and Sporadic Reporting	variable	Pre-implementation: 1.Experiment 2.Benefit-cost analysis 3.Desicion-Theoric Post Implementation: 1.Case study 2.Objective-based	1. a wide range of qualitative and quantitative methods 2. experiment and quasi-experiment
Expediency Council	Article 110 of The Constitution	Accountability Decision-making	1. Staff Organizations 2. Permanent and Temporary Experts 3. External and Sporadic Reporting	variable	1. Objective-based 2. Criticism and connoisseurship	1.systematic review 2. experts' opinions
Private Sector	According to Private Sector Rules	Decision-making Value-Clarification	1. Private Structure 2. Researchers and Scholars	variable	1. Dependent to Employer Order 2. for Independent Evaluations: -Constructivist - Deliberative democratic	Appropriate for Given Approach

Table 1: The Implementation of the Institutional Model in Iran

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Brownian Dynamics for modeling the evolution of double emulsions

Laura A. IBARRA-BRACAMONTES[1], Gonzalo VIRAMONTES-GAMBOA[2], Amadeo SANCHEZ[1]
[1]Faculty of Mechanical Engineering, [2]Faculty of Physical-Mathematical Sciences
Universidad Michoacana de San Nicolas de Hidalgo
Morelia, Michoacan, Mexico

and

Martín CHAVEZ-PAEZ
Institute of Physics, Universidad Autonoma de San Luis Potosi
San Luis Potosi, SLP, Mexico

ABSTRACT

In this work we present a numerical model for the evolution of double emulsions using Brownian Dynamics formalism. The coalescence process was modeled as a simple stochastic process. A double emulsion globule was modeled as a system whith droplets initially confined in a spherical cavity. The droplets encapsulated are allowed to coalesce between them inside the cavity and to coalesce toward the exterior with specific probabilities. We found that our model reproduces qualitatively trends observed in experimental results.

Keywords: coalescence, emulsion, globule, simulation, Brownian Dynamics

1. INTRODUCTION

Coalescence is one of the primary mechanism through which emulsions evolve. In one emulsion, for example water in oil (W/O), the system evolves continuously from the initial preparation state towards equilibrium driven by processes such as coalescence between the water droplets. In water-in-oil-in-water double emulsions (W/O/W), coalescence is also one of the most important driving forces of their evolution [1]. For these type of systems, experimental evidences [2] have shown that double emulsions can evolve following two types of coalescence processes: (a) internal coalescence between water-water droplets in the oil phase leading to the grow of large internal water droplets, and (b) external coalescence between water droplets and the external water phase. In those experimental results have been showed that the evolution of the double emulsions is due to the escape of water droplets from the globule by measuring their time dependent size. However, the rate of which water leaves the globule is affected by the evolution of the droplets in the globule. In other words, the dynamics of the globule size depends on the coalescence between droplets in the globule and the external coalescence. The experiments can not tell how these two mechanisms combine to yield the experimental data observed. Thus, in this paper we performed numerical simulations in a model system that allows to determine the influence of these two types of coalescence processes.

The coalescence process in a real system is very complex. In principle, it depends on several parameters as temperature, size of the globule, van der Waals type interactions, charge on the surfactants, elasticity of the membranes, etc. To include all these factors in an atomistic simulation is beyond the capabilities of nowadays computers. In others works some efforts to simulate coalescence process has been made in which atomistic models have been substituted by coarse grained approaches [3, 4]. In those simulations, for example, the coalescence of interacting droplets is simulated by assuming that the droplets interact through an effective pair potential that takes into account, in a simplified manner, the van der Waals and electrostatic interactions. Others works have even included the elasticity and deformation of the droplets [5]. Besides the pair potential between droplets, those models incorporate the coalescence between droplets through an overlaping criteria [4]. Similar criteria have been used in the past for simulations of aggregation phenomena by others authors [6]. In our work, the basic idea assumed is that coalescence only takes place when two particles overlap, reaching a condition where the energy between the droplets surpass an stabilizing energy barrier. When this condition is satisfied, the simulation algorithm simply creates a new droplet out of those two original droplets.

2. METHODOLOGY

The goal in this work is to determine the effects of internal and external coalescence in the evolution of a double emulsion globule. For this purpose a simple approach to model the coalescence process was adopted. The system in study is a W/O/W double emulsion as those experimentally investigated and reported in literaty [2, 7]. Figure 1 shows a schematic representation of the evolution with time of a double emulsion globule.

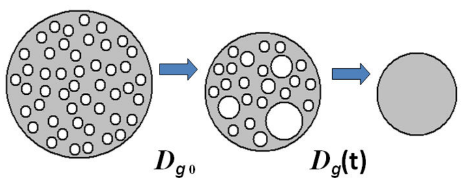

Figure 1. Schematic drawing of the evolution of a double emulsion globule.

In our model, we consider a single spherical cavity (the oil phase) containing particles (the water droplets) that interact through short range repulsive potentials. The positions of the droplets are changed using Brownian Dynamics. In Brownian Dynamics simulations [8], the equation of motion for particles is given by

$$\boldsymbol{r_i}(t+\Delta t) = \boldsymbol{r_i}(t) + \beta D_{0i}\boldsymbol{F_i}(t)\Delta t + \boldsymbol{R_i}\ , \qquad (1)$$

where $\beta = (\kappa T)^{-1}$ is the inverse of thermal energy. $\boldsymbol{r_i}$, D_{0i} and $\boldsymbol{F_i}$, are the position, diffusion coeficient and total force acting on particle *i*; respectively. The total force could include the interactions with other particles, the confining wall, and the gravity field. $\boldsymbol{R_i}$ is a random displacement with a Gaussian distribution whose average value is zero and $\langle \boldsymbol{R_i} \cdot \boldsymbol{R_j} \rangle = 2D_0\Delta t\delta_{ij}$.

Particles in the cavity can coalesce with either other particles (internal coalescence) or with continuos external water phase (external coalescence). A stochastic coalescence criteria was assumed when particle-particle or wall-particle overlappings are produced. If two droplets do overlap, say particles i and j, these two particles are destroyed and a new particle is created with probability P_p [4, 6]. The new particle is created at the center of mass of the coalescent particles and its size is determined from the volume conservation condition, i.e, the size of the new particle is given by

$$\sigma_{new} = \left(\sigma_i^3 + \sigma_j^3\right)^{1/3}, \qquad (2)$$

where σ_i and σ_j are the diameters of the coalescent droplets.

But if a droplet overlaps with the wall, this particle is destroyed with a probability P_w. In this case, the droplet simply disappears from the group of particles in the simulation and the size of the globule is calculated again.

When the coalescence parameters P_p and P_w were varied, different trends were obtained in the evolution of the globule. The size of the globule $D_g(t)$ and the number of droplets in the cavity $N_p(t)$ were calculated as a function of time. We focus on quantities that can be determined experimentally such as the evolution of the globules' size.

To perform the simulations, N_p indentical particles of initial diameter σ_0 are initially placed randomly at the beggining over the entire volume inside the spherical cavity and then allowed to equilibrate for several thousand cycles before allowing particles to coalesce. The initial number of particles $N_{p0} = N_p(\mathrm{t}=0)$ is determined from the volume fraction ϕ_v and the initial size of the globule $D_{g0} = D_g(t=0)$ of the cavity as

$$N_{p0} = \phi_v\left(D_{g0}/\sigma_0\right)^3\ . \qquad (3)$$

The simulations were performed using the thermal energy κT as the energy scale, with $\epsilon = \kappa$T. The time step, $\Delta t^* = 5\times10^{-5}$, is defined in units of $t_0 = \sigma_0^2/D_0$, where σ_0 and D_0 are the initial size and diffusion coefficient of particles before coalescence is allowed. The value of these parameters were taken from experimental conditions [2] $D_0 = 1.5848\times10^{-12}\ m^2/s^2$ and $t_0 = 2.524\times10^{-2}s$.

Note that the diffusion coefficient is a parameter that changes as particles coalesce. For a newly created particle, its new diffusion coefficient is estimated through the relation

$$D_{new} = \kappa\mathrm{T}/(3\pi\ \eta_{\mathrm{oil}}\ \sigma_{new})\ , \qquad (4)$$

where η_{oil} is the experimental viscosity of the oil phase. The force due to gravity is calculated through the relation

$$F_g = \Delta\rho\ g\left(\pi\ \sigma_{\mathrm{p}}^3/6\right)\ , \qquad (5)$$

where $\Delta\rho$ is the density difference between the oil and water phases, g is the magnitude of the gravity field, and σ_{p} is the diameter of the particle.

3. RESULTS

The higher the value of the probabilities either P_p or P_w, the more likely particles will coalesce. As limiting cases we have $P_p = 0$ when particles are not allowed to coalesce internally, and $P_p = 1$ when any overlap between particles will produce immediately a new particle. Similarly, if $P_w = 0$ then the particles are not allowed to leave the cavity, and if $P_w = 1$ then any collision with the cavity's wall will allow the colliding particle to escape and a reduction of the cavity's volume is obtained.

Thus, within this model we can simulate pure internal coalescence ($P_w = 0$), pure external coalescence ($P_p = 0$), or the combination of both processes ($P_p \neq 0$ and $P_w \neq 0$). The evolution of the system will depend on the competing effects introduced by these coalescence parameters. We will present results for all these cases, for different values of the parameters P_p and P_w to illustrate the effect that these parameters have on the behavior of our model system.

The results correspond to cavities' size of 10 times the initial diameter of particles ($D_{g0} = 10\,\sigma_0$).

External Coalescence

The results for the time evolution of the cavity's size $D_g(t)$ when only external coalescence is allowed are analized. To simulate external coalescence the parameter $P_p = 0$ is set. Under this constrain the particles cannot coalesce between them and therefore the initial size of the particles σ_0 remains constant. As indicated before, in this case particles that overlap with the wall have a finite probability P_w to leave the globule. When that happens, the concentration of particles and the globule's diameter decrease. If at a given time n droplets coalesce with the wall, the number of particles in the cavity is calculated again and the new diameter of the confining sphere is determined by the relation

$$D_g^{new} = \left[D_g^3 - n\,\sigma_0^3\right]^{1/3} . \quad (6)$$

Figure 2 shows the results for $D_g(t)$ at several values of P_w in a system with a volume fraction of $\phi = 0{,}4$ and $D_{g0} = 10\,\sigma_0$. As we see from the Figure 2, in all the curves the size of the globule decreases monotonically as time increases. When P_w is large ($P_w = 1, 10^{-1}, 10^{-2}$), we observe that $D_g(t)$ exhibits first a very rapid decrease in a very short time and then a slower decreasing rate. This is expected because at small times there are many particles near the wall and the collision rate with the wall is high. Since P_w is high, these two mechanisms combine to produce a large number of particles leaving the cavity at short times. As the number of particles decreases the average time to reach the wall increases, which translates into a slower decreasing rate of the cavity size. When P_w is smaller (for example $P_w = 10^{-3}, 10^{-4}, 10^{-5}, 10^{-6}$) the initial decreasing rate slows down since particles (especially near the the wall) have now a longer life time in the cavity, and thus more time to diffuse away from the wall.

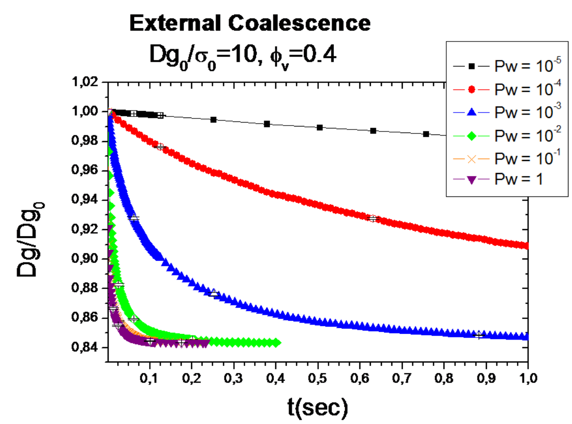

Figure 2. Cavity's size normalized with the initial globule diameter for several values of the parameter P_w, with $\phi_v = 0.4$ and $D_{g0} = 10\,\sigma_0$.

Internal Coalescence

Here we now consider the process of internal coalescence. To achieve this the constrain $P_w = 0$ is imposed. Since this restriction keeps the size of the cavity constant, we follow the evolution of the globule through the total number of particles into the cavity. This means that the simulations started with an initial number of particles $N_{p0} = N_p(\mathrm{t} = 0)$ of the same size σ_0, and they were stopped until only one particle remains into the cavity. For internal coalescence the monodispersity of the system is not preserved. Instead, the system evolves as an aggregation process where the coalescence of particles form larger particles. Thus, we can define the state of aggregation of a particle by taking into account the effective number of original droplets it is made of. Thus, if particle k is the result of the fusion of n monomers, its size would be

$$\sigma_k^n = n^{1/3}\,\sigma_0 . \quad (7)$$

With this definition in mind, we can say that droplets with $n = 1$ are monomers, droplets with $n = 2$ are dimers, etc. Thus, the size of a new particle that results from the collision of another two can be written as

$$\sigma_p^{new} = \sigma_0[n + m]^{1/3} , \quad (8)$$

where n and m correspond to the aggregation state of the colliding particles.

Figure 3 shows the simulation results for the number of particles in the cavity as a function of time for several values of P_p and for a system with small radius and high volume fraction ($D_{g0} = 10\,\sigma_0$ and $\phi = 0{,}4$). As can be seen from Figure 3, the initial stage of the simulation is characterized by a rapid decrease in the number of particles in the cavity, until eventually only one big particles remains. Note that the curves shift to the right as the parameter of coalescence decreases, all forming a characteristic curve, i.e, a curve with initial rapid decrease, and then a slower rate of decrease in the number of particles.

The initial coalescence rate of particles in the first stages is due to the fact that the average distance between particles is initially small, and therefore chances of collisions are high. As the number of particles decrease, the mean distance between particles increase and the collisions are less frequent.

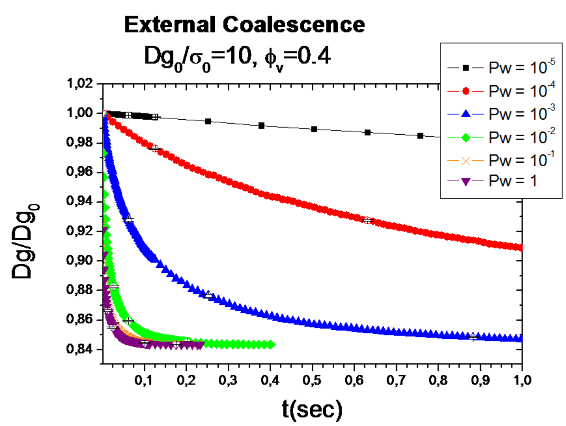

Figure 3. Number of particles in the cavity as a function of time for several values of the parameter P_p, with $\phi_v = 0.4$ and $D_{g0} = 10\,\sigma_0$. This case corresponds to a initial configuration of 400 particles into the cavity.

Internal and External Coalescences

In the previous cases we saw that when only external coalescence is allowed the size of the cavity evolves in a smooth manner due to the releasing of monodisperse droplets to the exterior. In the case of pure internal coalescence, however, droplets of different sizes develop inside the cavity. Thus, when both mechanisms are present we expect to have different trends in the evolution of the system due to the competition of the two mechanisms. The combination of external and internal coalescence processes of the encapsulated particles allows to get closer to the behavior of the experimental systems of double emulsions as reported previously [2]. Clearly the resulting properties will depend on the competition of these parameters that control each type of coalescence. Due to this, here we will present how these parameters modulate the properties of the systems.

When the coalescence parameters P_p and P_w are varied, different behaviors can be appreciated in the evolution of the globule, as illustrated in Figure 4.

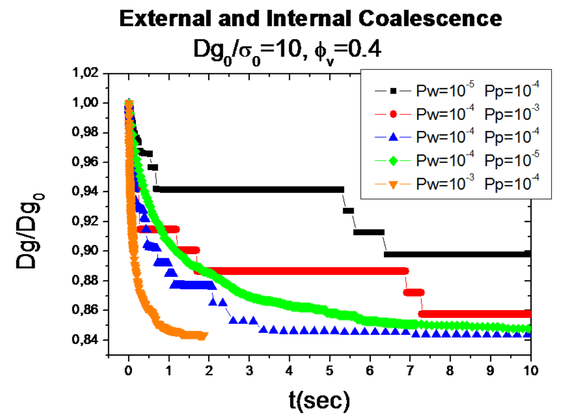

Figure 4. Evolution of the globule's size for several combinations of the parameters P_w and P_p, in a system with $\phi_v = 0.4$ and $D_{g0} = 10\,\sigma_0$.

All the curves in Figure 4 show an initial pronounced slope, which, as mentioned earlier, is due to an initial internal pressure of the systems that induce a fast release of particles, a process that is controlled by the parameter P_w. We observe, however, that for some combination of the coalescence parameters $D_g(t)$ exhibits a smooth behavior, whereas for other combination of parameters the curves of $D_g(t)$ are discontinuous.

The formation of flat regions in the evolution of the size of the globule, followed by a sharp decrease of $D_g(t)$ are manifestations of large particles that grow in the cavity. The release of these big particles produces large changes in the total volume of the system, producing the steps observed as well as experimental level [2]. This behavior is observed when the condition $P_p \geq P_w$ is met, i.e., when the internal coalescence dominates over the external coalescence. These last results show a surprising similarity with the trends observed experimentally in double emulsion systems. This suggests that this mechanism is responsible for the sudden changes in globule size observed in experiments.

Besides, where the condition $P_p < P_w$ is met, i.e., when the dominant mechanism is the coalescence to the exterior of the cavity, the evolution of $D_g(t)$ is smooth and continuous. This allows us to conclude that, for these conditions, the system does not present the formation of large particles.

4. CONCLUSIONS

Brownian Dynamics has shown to be an useful technique to model the evolution of double emulsion systems. Overlapping criteria driven by stochastic processes has let include two kind of coalescence mechanisms in confined systems as observed in experiments with double emulsion globules. These coalescence mechanisms were controled by two parameters, P_p for internal coalescence, and P_w for external coalescence.

When the dominant mechanism in the evolution of globule's size is the coalescence to the exterior of the cavity, i.e. $P_p < P_w$, then $D_g(t)$ shows a curve smooth and continuous. This indicates that the system does not present the formation of large particles of significant size confined into the globule. It leads a gradual delivery of encapsulated material.

And when the internal coalescence dominates over the external coalescence in a double emulsion system, i.e. $P_p \geq P_w$, abrupt changes in $D_g(t)$ are observed. This indicates the growing and release of large particles from the cavity as it was observed in experiments.

To our knowledge, these mechanism have not been previously reported, and our results constitute the first evidence, at numerical level, that present two coalescence processes in confined systems.

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A NEW SLIP-LINE FIELD MODELING OF ORTHOGONAL MACHINING FOR A WORN TOOL

Alper UYSAL
Department of Mechanical Engineering, Yildiz Technical University
34349, Besiktas, Istanbul, Turkey

and

Erhan ALTAN
Department of Mechanical Engineering, Yildiz Technical University
34349, Besiktas, Istanbul, Turkey

ABSTRACT

The importance of quantitatively estimating the technological performance of machining operations such as tool life, forces, power and surface finish attracts growing attention due to ever increasing applications of machining technologies in a wide variety of modern industries. This performance information is required for the selection and design of machine tools and cutting tools, as well as the optimization of cutting conditions. The machining performance is known to vary significantly with the progression of tool wear. This is because the tool wear formed at different tool faces changes the original tool geometry/configuration thus resulting in unexpected machining performance. In all types of tool wear, the flank wear has attracted maximum attention, since the amount of flank wear is often used in determining the tool life. A new slip-line model for orthogonal machining for a worn tool with flank wear and its associated hodograph are developed in this study. The entire slip-line field consists of 11 sub-regions, five slip-line angles (θ_1, θ_2, δ_2, η and ψ) and two angles of vertices (α_1 and α_2). Mathematical formulation of the model is established based on Dewhurst and Collins's matrix technique. The new model predicts the cutting force, thrust force, ploughing force, chip up-curl radius, chip thickness and thickness of the primary shear zone.

Keywords: slip-line, worn tool, orthogonal machining

Nomenclature

$\boldsymbol{c}$	column vector representing a unit circle
$\boldsymbol{F}$	resultant force
$\boldsymbol{F_c}$	cutting force
$\boldsymbol{F_t}$	thrust force
$\boldsymbol{F_x}$, $\boldsymbol{F_y}$	two force components acting at point *I*
$\boldsymbol{f_1}$, $\boldsymbol{f_2}$, $\boldsymbol{f_3}$	names of three non-linear functions
G, P, P*, Q, Q*, R	members of a set of basic operators defined by Dewhurst and Collins
$\boldsymbol{k}$	material shear flow stress
$\boldsymbol{l_f}$	length of flank wear land
$\boldsymbol{M}$	bending moment acting at point *I*
$\boldsymbol{P}$	ploughing force
$\boldsymbol{P_A}$	hydrostatic pressure at point *A*
$\boldsymbol{P_H}$	hydrostatic pressure at point *H*
$\boldsymbol{R_u}$	chip up-curl radius
$\boldsymbol{R_{ui}}$	intermediate variable
$\boldsymbol{t_1}$	undeformed chip thickness
$\boldsymbol{t_2}$	chip thickness
$\boldsymbol{V}$	cutting speed
$\boldsymbol{V_h}$	magnitude of chip velocity at point *H*
$\boldsymbol{w}$	width of cut
$\boldsymbol{\alpha_1}$	angle between the slip-line KB with the free surface of work material
$\boldsymbol{\alpha_2}$	angle between the slip-line KB with the free surface of chip material
$\boldsymbol{\delta_1}$	angle between the straight boundary AK and the cutting speed
$\boldsymbol{\gamma}$	tool rake angle

θ_1, θ_2, η, δ_2, ψ	five slip-lines angles
ρ	total velocity jump across the slip-lines
ρ'	velocity jump across the slip-line KBCDEFP
σ_1, σ_2	radii of curvature of two base slip-lines HL and LJ
τ_1, τ_2, τ_3	tool-chip frictional shear stresses
ω	angular velocity of the primary shear zone
ΔS	thickness of the primary shear zone
ζ_1, ζ_2, ζ_3	factors for tool-chip friction

1. INTRODUCTION

Some studies concerned with worn tool have been carried out both analytical and FEM techniques. Elenayar and Shin developed a procedure to model the ploughing forces by accounting for the change in geometry with flank wear. The procedure uses the indentation models along with values of tool and work piece material constants to determine the indentation force [1]. Wang et al. presented a mechanics of cutting analysis for orthogonal cutting with tool flank wear based on an experimental investigation. Researchers proposed an orthogonal cutting force model which makes full use of the classical thin shear zone analysis for "sharp" tools [2]. Li and Liang developed a predictive model for the cutting forces in near dry machining and the predicted variables of flow stress, contact length, and shear angle obtained from the model were used to predict the cutting forces due to the tool flank wear effect based on Waldorf's model. Researchers made comparisons between predicted and experimental cutting forces for sharp tools and worn tools in the cutting of AISI 1045 with uncoated carbide tools [3]. Fofana et al. made an integrated experimental and analytical study to examine changes in tool-wear with chatter instability for different cutting conditions and progressively worn cutting tools. Researchers have used the power function for the cutting force model [4]. Smithey et al. developed a worn tool force model for three-dimensional cutting operations. Developing model required a minimal number of sharp tool tests and only one worn tool test. An integral part of the worn tool force model was a contact model that was used to obtain the magnitude of the stresses on the flank of the tool. The force model was validated through comparison to data obtained from wear tests conducted over a range of cutting conditions and work piece materials [5]. Bao and Tansel studied about the cutting forces characteristics of the new and worn tools and an analytical model proposed to simulate the cutting forces of micro-end-milling operations at different usage levels. The simulated cutting forces of the proposed model were compared with experimental data of micro-end-milling operations and very good agreement was observed between the simulated and experimental cutting force [6]. Yen et al. developed a methodology to predict the tool wear evolution and tool life in orthogonal cutting using FEM simulations. To approach this goal, the methodology proposed has three different parts. In the first part, a tool wear model for the specified tool–work piece pair was developed via a calibration set of tool wear cutting tests in conjunction with cutting simulations. In the second part, modifications were made to the commercial FEM code used to allow tool wear calculation and tool geometry updating. The last part included the experimental validation of the developed methodology [7]. Calamaz et al. used smoothed particle hydrodynamics model (SPH model) as a numerical method in order to model the machining process with both new and worn tools. The predicted chip morphology and the cutting force evolution with respect to the tool wear were qualitatively compared with experimental results [8]. Muñoz-Sánchez et al. developed a numerical model to analyze the tool wear effect in machining induced residual stresses. Differences between predicted and measured values of tensile residual stresses were reasonably values for this application [9].

Slip-line field solution for orthogonal cutting for a worn tool with flank wear has also been proposed. Shi and Ramlingam developed a slip-line model for orthogonal cutting with chip breaker and flank wear. The model predicted a linear relationship between flank wear and cutting force components [10]. Dundur and Das suggested two slip-line field models for orthogonal machining with a worn tool with a finite flank wear land. Researchers accepted to occur an angle between flank wear land and work material on developing models [11]. But in literature [12, 13], evaluating of the flank wear land was parallel to work material.

In the present study, a new slip-line model for orthogonal machining for a worn tool with flank wear and its associated hodograph are proposed (Figs.1 and 2). Fang's [14, 15] studies are followed to obtain new slip-line model. The scope of this paper is limited to orthogonal cutting with continuous chip formation. First, it is shown that the entire slip-line field consists of 11 sub-regions, five slip-line angles (θ_1, θ_2, δ_2, η and ψ) and two angles of vertices (α_1 and α_2). The angle α_1 is between the straight slip-line KB and the free surface of work material. The angle α_2 is between the curved slip-line AI and the free surface of chip material. The model also involves the angle δ_1 between the straight boundary AK and the cutting speed V as shown in Fig. 1. In addition, the region SNIJM disappears if the slip-line angle ψ=0. Mathematical formulation of the model is established based on Dewhurst and Collins's [16] matrix technique for numerically solving slip-line problems. In Fig. 1, point S is a stagnation point of the flow of material. It is also referred to as a separation point in some machining literature.

The new slip-line model developed according to two traditional assumptions of the classic slip-line theory:

- The deformation of work material is under plane-strain conditions. For this reason, the model applies only to orthogonal metal cutting with continuous chip formation.
- The work material is rigid plastic.

2. MATHEMATICAL FORMULATION OF THE NEW SLIP-LINE MODEL

2.1 Determination of the Tool-Chip Friction

The tool–chip friction occurs on the tool rake face and below the flank wear land of the tool. It is determined by

$$\zeta_1 = \frac{1}{2}cos^{-1}(\tau_1/k) \quad (1)$$
$$\zeta_2 = \frac{1}{2}cos^{-1}(\tau_2/k) \quad (2)$$
$$\zeta_3 = \frac{1}{2}cos^{-1}(\tau_3/k) \quad (3)$$

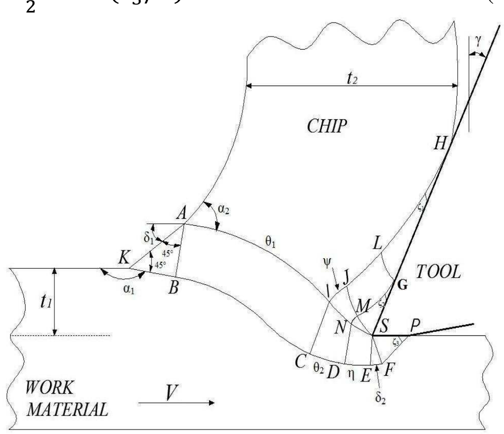

Fig. 1 Schematic diagram of the new slip-line model for a worn tool

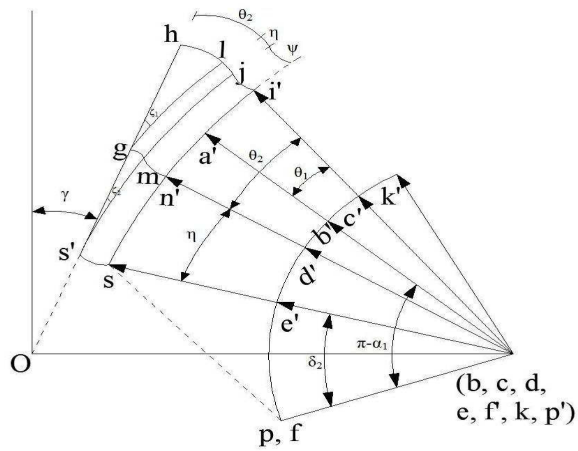

Fig. 2 Hodograph of the new slip-line model for a worn tool

2.2 Determination of the Slip-Lines in the Secondary Shear Zone

The slip-lines HL and LJ shown in Fig. 1 are taken as two base slip-lines. Column vectors σ_1 and σ_2 denote their radii of curvature, respectively. In the following equations, P, P*, Q, Q*, R and G are members of a set of basic matrix operators defined by Dewhurst and Collins [16].

2.2.1 Relationships among the slip-lines in the physical plane in Fig. 1

In the slip-line region HLG,

$$GL = G_{\zeta_1}.\sigma_1 \quad (4)$$
$$LG = R_{\theta_2}.GL \quad (5)$$

In the slip-line region LJMG,

$$CM = P^*_{\theta_2}.\sigma_2 + Q^*_{\theta_2}.LG \quad (6)$$
$$JM = P^*_{\eta}.LG + Q^*_{\eta}.\sigma_2 \quad (7)$$

In the slip-line region GMS,

$$SM = G_{\zeta_2}.GM \quad (8)$$

In the slip-line region MNS,

$$NS = P_{\eta\psi}.SM \quad (9)$$
$$NM = Q_{\eta\psi}.SM \quad (10)$$

In the slip-line region JINM,

$$MJ = R_{\theta_2}.JM \quad (11)$$
$$MN = R_{\psi}.NM \quad (12)$$
$$IJ = P_{\psi\eta}.MN - Q_{\eta\psi}.MJ \quad (13)$$
$$IN = P_{\eta\psi}.MJ - Q_{\psi\eta}.MN \quad (14)$$

The convex slip-line IA is determined by

$$IA = (\rho/\omega).c \quad (15)$$

2.2.2 Relationships among the slip-line images in the hodograph in Fig. 2

The following equations is occurred in determining the slip-lines according to Green [17],

$i'n' = \rho.c$ (16)
$i'a' = \omega.IA$ (17)
$i'j = \omega.IJ$ (18)
$lj = \omega.\sigma_2$ (19)
$hl = \omega.\sigma_1$ (20)
In the slip-line region i′jmn′
$jm = P^*_{\psi}.i'n' + Q^*_{\psi}.i'j$ (21)
$n'm = P^*_{\theta_2}.i'j + Q^*_{\theta_2}.i'n'$ (22)
In the slip-line region n′ms′s,
$n's = \rho.c$ (23)
$ms' = P^*_{\psi}.n's + Q^*_{\psi}n'm$ (24)
$ss' = P^*_{\eta}.n'm + Q^*_{\eta}.n's$ (25)
$s'm = R_{\eta}.ms'$ (26)
In the slip-line region mgs′,
$gm = G_{\zeta_2}.s'm$ (27)
In the slip-line region gmjl,
$mj = R_{\theta_2}.jm$ (28)
$mg = R_{\eta}.gm$ (29)
$lg = P_{\theta_2\eta}.mj + Q_{\eta\theta_2}.mg$ (30)
$lj = P_{\eta\theta_2}.mj + Q_{\theta_2\eta}.mg$ (31)
Finally, the slip-line region hgl,
$gl = R_{\theta_2}.lg$ (32)
$hl = G_{\zeta_1}.gl$ (33)

All the equations listed above, i.e., Eqs. (1)-(33), have been employed to determine two base slip-lines HL and LJ. Then all other slip-lines can be determined.

2.3 Determination of the Slip-Lines in the Primary and Tertiary Shear Zones

The slip-lines in the secondary shear zone are known, the slip-lines in the primary and tertiary shear zones can be determined from following equations. The slip-lines KB and FB are straight. The curved slip-lines CB, CD, DE and EF are calculated as

$CB = \frac{\rho'}{\rho}.IA$ (34)
$CD = \frac{\rho}{\rho'}.IN$ (35)
$DE = \frac{\rho}{\rho'}.NS$ (36)
$EF = \Delta S.c$ (37)

2.4 Solutions to Non-Linear Equations

The forces and the bending moments transmitted across the slip-lines IA, IJ, LJ and HL are resolved at point I. To provide the requirements of equilibriums of the force and bending moment, the following equations must be satisfied:

$f_1 = \sum F_x = 0$ (38)
$f_2 = \sum F_y = 0$ (39)
$f_3 = \sum M = 0$ (40)

where the variables f_1, f_2 and f_3 symbolized three non-linear functions. Powell's [18] algorithm of non-linear optimization has been used to solve the above three non-linear equations. The requirement of a force-free chip is achieved if the following inequality is provided:

$$\left(\frac{f_1}{kt_1w}\right)^2 + \left(\frac{f_2}{kt_1w}\right)^2 + \left(\frac{f_3}{kt_1^2w}\right)^2 \leq 10^{-10} \qquad (41)$$

3. DETERMINATION OF MAJOR MACHINING PARAMETERS

3.1 Determination of the Cutting Forces (F_c/kt_1w and F_t/kt_1w) and the Ploughing Force (P/kt_1w)

If the forces transmitted across the slip-lines KB, CB, CD, DE, EF and FP are denoted by vectors F_{KB}, F_{CB}, F_{CD}, F_{DE}, F_{EF} and F_{FP}. The resultant force F is obtained from following equation:

$$\frac{F}{kt_1w} = \frac{F_{KB}}{kt_1w} + \frac{F_{CB}}{kt_1w} + \frac{F_{CD}}{kt_1w} + \frac{F_{DE}}{kt_1w} + \frac{F_{EF}}{kt_1w} + \frac{F_{FP}}{kt_1w} \qquad (42)$$

The cutting force F_c/kt_1w and the thrust force F_t/kt_1w are determined by decomposing the resultant cutting force F/kt_1w in two perpendicular directions, i.e., parallel and normal to the cutting velocity V.

The ploughing force (P/kt_1w) is calculated as

$$\frac{P}{kt_1w} = \frac{F_{EF}}{kt_1w} + \frac{F_{FP}}{kt_1w} \qquad (43)$$

3.2 Determination of the Chip Up-Curl Radius (R_u)

The chip up-curl radius Ru is expressed as

$$R_u = \frac{R_{ui}}{2} + \frac{V_h}{2\omega} \qquad (44)$$

$$R_{ui} = \sqrt{\left(\frac{V}{\omega}\right)^2 + \left(\frac{\rho}{\omega}\right)^2 + 2.\frac{V}{\omega}.\frac{\rho}{\omega}.cos(\alpha_1)} \qquad (45)$$

where α_1 is found from the hodograph in Fig. 2 and is expressed as

$$\alpha_1 = \frac{5}{4}\pi - \zeta_2 - \frac{\gamma_1}{2} - \eta - \theta_2 + \theta_1 - \delta_2 \qquad (46)$$

3.3 Determination of the Chip Thickness (t_2)

The chip thickness is determined as

$$t_2 = 2.\left(\frac{V_h}{\omega} - R_u\right) \qquad (47)$$

3.4 Chip Deformation in the Primary Shear Zone:

The thickness ΔS of the primary shear zone is expressed as

$$\Delta S = PS.\ \sin(\zeta_3) \qquad (48)$$

where PS is length of the flank wear land (l_f).

4. THE APLICABLE RANGE OF THE NEW SLIP-LINE MODEL

Due to the plane-strain assumption, the new slip-line model applies only to orthogonal metal cutting with continuous chip formation.

4.1 Constraints of Stresses

Based on Hill's [19,20] theory of the overstressing, the extension of a stress field into a rigid field is only possible over a limited range of solutions to the slip-line model for each value of the tool rake angle. For an acceptable solution, the two vertices, represented by the angles α_1 and α_2 between the slip-line and the free surface should not be overstressed. Mathematically, this condition is expressed as

$$\frac{\pi}{2} - 1 - 2\alpha_1 \leq \frac{P_A}{k} \leq 2\alpha_1 - \frac{3\pi}{2} + 1 \qquad (49)$$

$$2cos\left(\alpha_2 - \frac{\pi}{4}\right) - 1 \leq \frac{P_A}{k} \leq 1 + 2\left(\alpha_2 - \frac{\pi}{4}\right) \qquad (50)$$

The angle α_2 is determined by

$$\alpha_2 = sin^{-1}\left(\frac{V}{\omega}\frac{1}{R_{ui}} sin\alpha_1\right) \qquad (51)$$

4.2 Constraints of Slip-Line Angles

All the five slip-line angles (θ_1, θ_2, δ_2, η and ψ) must be positive in their numerical value.

4.3 Constraint of Normal Pressure on the Tool Rake Face

Chips are in contact with the tool rake face before curling away. Thus, the normal stress at point H should be compressive. This constraint is expressed as

$$P_H + k.\ \sin(2.\zeta_1) \geq 0 \qquad (52)$$

4.4 Non-Unique Nature of the Model

The angle δ_1 is represented by

$$\delta_1 = \alpha_1 - \frac{3\pi}{4} \qquad (53)$$

5. CONCLUSION

This paper presents a new slip-line model for orthogonal machining with worn tool. The proposed slip-line model simultaneously predicts as many as five groups of machining parameters:

(1) cutting force, thrust force, resultant force and the ratio of cutting force to thrust force,
(2) ploughing force,
(3) chip up-curl radius,
(4) chip thickness,
(5) thickness of the primary shear zone.

Previously developed slip-line models for a worn tool have shortcomings, i.e. accepting an angle between flank wear land and work material. The new model presents that the evaluating of the flank wear land is parallel to work material. Therefore, the new model is compatible machining applications with a worn tool.

6. ACKNOWLEDGEMENT

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IDENTIFICATION OF APPLICABILITY AREA OF MATHEMATICAL MODEL OF NETWORK CONTROL SYSTEM FUNCTIONING IN ASYNCHRONOUS MODE DURING DATA TRANSFER VIA MULTIPLE ACCESS CHANNEL

Abramov G.V., Emelianov, A.E., Ivashin A.L.
agw@vgta.vrn.ru, emaleg@yandex.ru, ivashin.alexei@gmail.com

Abstract: Theoretical bases for modelling a network control system with information transfer via the channel of multiple access are submitted. Experimental research of the given control systems is carried out.
Key words: network control system, Ethernet, CSMA/CD, modelling, region of stability.

1. INTRODUCTION

The increase of the information and equipment requirements unification amount make a change in the technologies used in automated systems. However in industry, energy, oil and gas industry, transport and industrial enterprises increasingly use the Ethernet technology. Network based on this technology attract low cost, simplicity of implementation and maximum efficiency. The use of Ethernet as a standard solution leads to a decrease in the number of interfaces does not require additional cost and knowledge, significantly reduces the duration of the projects.

In addition, industrial Ethernet has already received a number of protocols (ProfiNet, EtherCAT, Ethernet Powerlink, etc.) designed for real-time systems.Multiple access methods to communication channel which is based Ethernet introduces stochastic to time data transmission. When implementing information management systems must consider not only the uncertainty of time packet delivery, but also the loss of data.

To effectively use these technologies to develop a mathematical model to calculate the necessary characteristics of networked control systems (NCS).The overall objective is to create a universal model that does not depend on the characteristics of specific protocols. Initial data for the modeling process will be determined on the basis of the processes occurring in the multile access channel (MAC). The creation of such mathematical tools will determine the characteristics (region of stability and process parameters control) operation systems based both on the base protocol Ethernet, and on industry standards.

2. MODELLING

The article deals with mathematical simulated and experimental research of NCS with the information transmission via multiple access channel in asynchronous mode. As seen MAC network Ethernet implements the method of multiple access with carrier and collision detection (CSMA/CD).The peculiarity of this NCS is that if the data from the digital sensor (DS) were obtained by digital regulator (DR), then they should be taken into account when making regulatory impact at the next cycle. Otherwise, use the earlier data. Sending data via MAC is random. The time of transfer depends on the channel load, the number of collisions is characterized by the relevant law distribution of disintegrations $f(t)$.Due to asynchronous NCS, we think that the time of the regulatory impacts moments of (DR) behind the corresponding moments of reading data from the (DS) release of the object of regulation at the time τ in the refractive index of quantum-beat T_0. Considering the length of time $]kT_0,\ kT_0+\tau[$ where the vector process $Y(t)$ is continuous. The system at this point in time described by the following stochastic Eq. (1):

$$\dot{Y}(t) = Z(t) - A \cdot Y(t) + C \cdot V(t), \qquad (1)$$

where $Y(t)$ – phase vector, dimension n; $Z(t)$ – vector of regular exposure, dimension n; A – matrix of the system continuously part, dimension $n \times n$; $V(t)$ – vector of white noise, dimension n.

This multi-dimensional continuous Markov process has a probability density function $f(Y,t)$, satisfies the Fokker-Planck-Kolmogorov Eq. (2):

$$\dot{f}(Y,t) = -\left|\frac{\partial}{\partial Y}\right|^{T} \cdot \Pi(Y,t). \qquad (2)$$

In accordance with the structural scheme (Fig. 1) can be derived recurrence expression of the first and second moments of phase coordinates of the system.

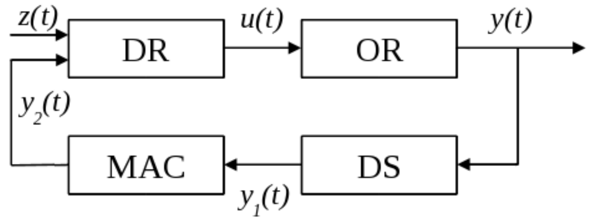

Fig. 1. General block diagram of the NCS

Mathematical model is solved with appropriate initial values of the moments and *S*[0], *Z*[0]. Figure 2 shows the experimental and calculated data obtained for the given NCS.

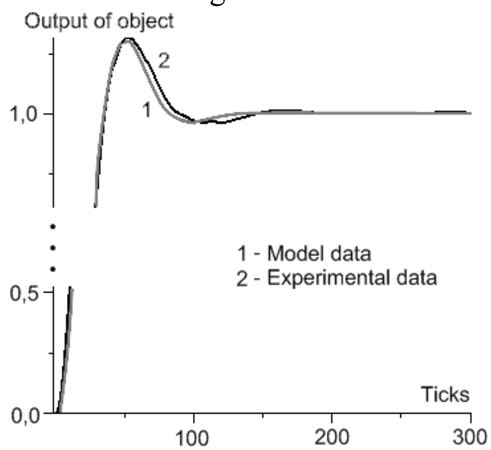

Fig. 2. Stable NCS process (point 2)

3. EXPERIMENTAL RESEARCH

Checking the adequacy of the model was carried out using the experimental facility block diagram is shown on Fig. 3.

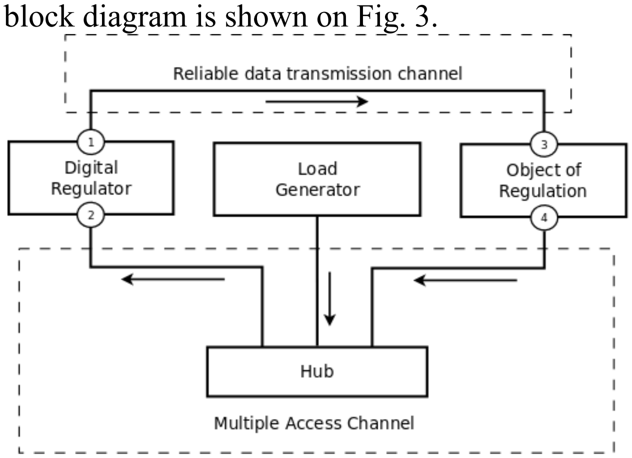

Fig. 3. General block diagram of the experiment facility

Consider the elements of the scheme. Regulator - computer equipped with two interfaces 1 and 2 for the transfer of regulatory impact and reception of data from the object of regulation, respectively. The object of regulation - a computer equipped with two network interfaces 3 and 4 for data output object and receive regulatory impact, respectively. Hub is networking equipment, providing packet data from the object to the controller. Load generator is a computer that regulates the loss coming in a multiple access channel. Interface 2, interface 4, a data link and transmission protocol without loss of form a secure channel for data transmission.

Hub interface 1, interface 3, a data link and communication protocol network devices form a multiple-access channel. Arrowed lines in Fig. 3. shows the direction of flow of information.

Element of the system, designated as control, using the developed software receives and validates the package with the regulatory influence of the interface 1.The validation process is carried out to filter out duplicate packets, or packets came late (containing irrelevant output value of the object of regulation). In the case of packet loss (absence during the stroke), the calculations are carried out with the base of the last valid output values of the object. Further, with a given beat, by the calculation of the new value of the regulatory impact on the design algorithms of management and transfer it into the channel without loss through the interface 2. Reception and transmission of packets from the output values of the object involved in independent asynchronous threads of execution. In each cycle of quantization Regulator is saving measure number, the current value of the regulatory impact and the output values of the object and on the basis of which the current exposure is calculated.

Element of the system, designated as the object of regulation, with the help of the developed software provides a reliable method of data transmission channel package from the regulatory influence of the interface 3.Further, with a given beat, calculates new output values of the object to design algorithms and broadcast it to multiple-channel output through the interface 4.It should be noted that the frequency quantization object of regulation and the regulator coincide. However, the moments of the quantization Object lag behind the corresponding moments of the quantization controller on some sets the amount.

Load generator is an element of experimental control systems, implementing change operating parameters of multiple-access channel. DR and RO are physically located on a single PC that allows you to accurately sync and allows you to collect statistics on utilization of the channel and to calculate the required probabilistic characteristics of the transfer of information.

Using the criterion of Jury for the resulting model can determine the stability region of the expectation. Figure 4 shows the product of the gain of the object and the controller $k_{obj} \cdot k_{reg}$ the ratio τ/T_0 of this system of governance at different T_{obj}/T_0.

For example, in Fig. 4 calculated region of stability, located under the curves A, B, C and D, describing the NCS with the ratio of T_{obj}/T_0 are respectively 4.0, 6.0, 10.0 and 14.0.

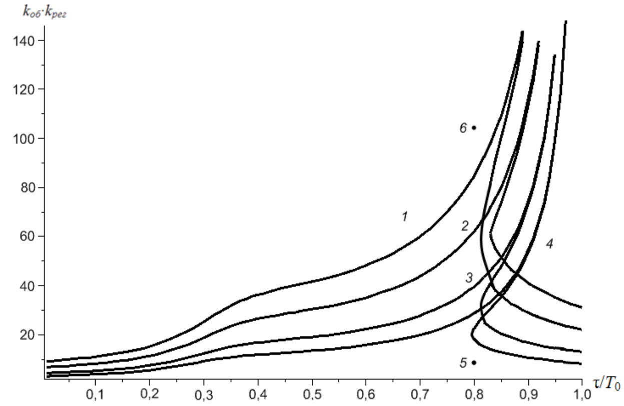

Fig.4. The stability region of NCS in the coordinates ($k_{obj} \cdot k_{reg}$, τ/T_0)

Consider the NCS with an area of stability of A. The mathematical and experimental research of NCS for points 1 and 2. Transient processes are shown for selected points are presented in figures 5 and 2.

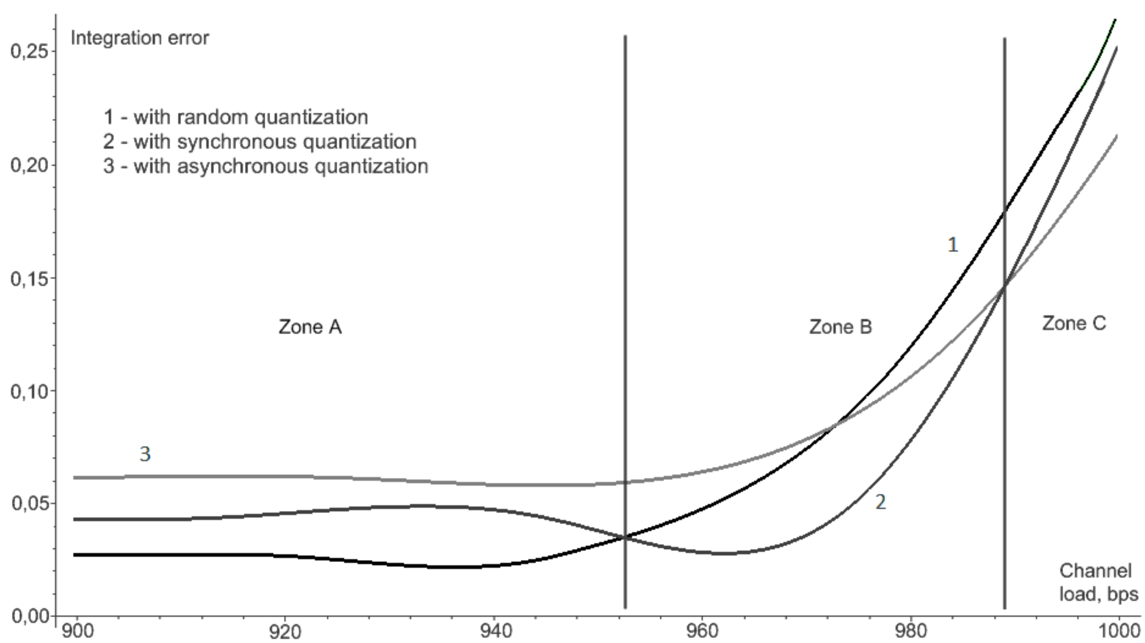

Fig. 5. Process of control system for point 1

Previously suggested other mathematical models of NCS, such as the presence of quantization on the controller at random times, when the sensor is quantized on a regular basis with a given tact [1]. There is a mathematical model of NCS, in which as the assumptions adopted by the synchronous operation of DS and DR [2] with a given tact quantization described in this work. After the research has made it possible to compare how well these mathematical models describe the behavior of real control systems. Comparison of the results (Fig. 7), obtained with the help of mathematical models with experimental produced by the integral of a quadratic-index $I=(y_m-y_e)^2$.

Figure 6 shows the dependence of the integrated-square error between model and experimental data from the boot of MAC. At different channel loading to improve the accuracy it makes sense to use different mathematical models, which will in each case a more precise description of system behavior.

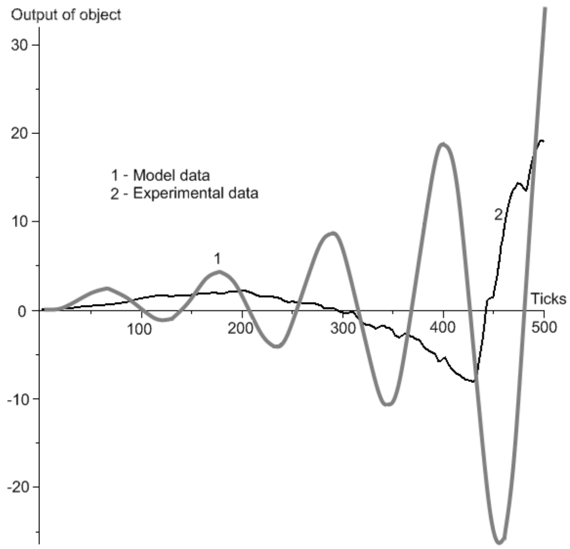

Fig. 6. Dependence of the integral-square error between model and experimental data from loading MAC

4. RESULTS AND CONCLUSION

The study has proposed a new approach to the description of NCS based on the MAC, taking into account the asynchronous data transmission and to identify areas of sustainability. This study developed and existing models showed that at low loads in the channel data transfer to (zone A) most accurately describes the process model built with the assumption of random quantization. In the region B shows a higher accuracy model, which provides synchronous quantization in the digital controller and the object. Under fairly heavy load on the multiple-access channel (zone C) is recommended to use the model with asynchronous quantization.

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Critical Factors in Schedule Reliability of Container Shipping Carriers

for MMMse 2011

Cheng-Chi CHUNG
Associate Professor
Shipping and Transportation Management
National Taiwan Ocean University
No. 2, Pei-Ning Road, Keelung
20224 Taiwan, ROC

And

Chao-Hung CHIANG
Ph.D.
Institute of Traffic and Transportation
National Chiao Tung University
3F, 118 Chung Hsiao W. Rd.,
Sec. 1,Taipei, Taiwan, ROC

ABSTRACT

In today's ever-increasing competitive environment, container shipping is a significant part in the supply chain. Schedule reliability of shipping carriers will affect the hinterland transport and customers. Thus, service quality of schedule reliability has a big influence on operational performance of shipping carriers. The main purpose of this study was to analyze and investigate the key influential factors of schedule reliability by using Fuzzy Analytic Hierarchy Process. Results indicated that the important object is 'process management in the shipping lines', and the important criteria were 'well-arranged time window,' 'transship arrangement,' 'planning the suitable ports,' and 'planning the berth and warehouse previously'.

Key words: Container shipping, Schedule reliability, Fuzzy AHP

1. INTRODUCTION

In today's highly competitive environment, container shipping carriers are facing several challenges. Shipping is not only a carrier but also a part of the supply chain; therefore, schedule reliability of container shipping carriers plays a key role in the global supply chain. It is the fact that schedule reliability might affect hinterland transport and logistics costs to the customers.

Although shipping lines operate on fixed-day weekly schedules, the survey of Drewry Shipping Consultants pointed that more than 40% of the vessels deployed on worldwide liner services delayed one or more days (Vernimmen *et al.*, 2007). Drewry (2007-2009) calculated the schedule reliability of global container shipping carriers from 2007 Q3 to 2009 Q2 as shown in Table1. It indicated that most of the carriers can not call the vessels on time.

Table 1 Statistics of global container shipping carriers' schedule reliability

Year /Quarter	No. of Calling Times	No. of Shipping Carriers	On-time Rate (%)	100	90	80	70	60	50	40	30	20	10	0
2007/Q3	2,237	66	No. of Shipping Carriers	0	7	3	2	12	18	8	8	6	1	1
2007/Q4	2,145	65		4	1	0	4	13	16	8	7	6	4	2
2008/Q1	2,130	66		0	1	3	6	11	19	10	8	2	3	3
2008/Q2	1,935	60		1	1	0	6	6	11	9	10	7	4	5
2008/Q3	1,891	58		1	1	2	4	14	11	11	3	6	1	4
2008/Q4	1,641	57		0	4	0	1	5	6	19	7	3	7	5
2009/Q1	1,633	54		0	2	1	3	7	18	4	5	7	2	5
2009/Q2	1,712	61		0	0	6	8	13	10	11	4	3	1	5

Source: Drewry (2007-2009).

This study began with literature reviews, followed by the conduction of the expert questionnaire survey to collect data required for the main purposes of exploring the influential factors on the schedule reliability. It is the fact that fuzziness and vagueness are common characteristics in many decision processes; thus, Fuzzy Delphi Method was used in this study. It was used to rank the critical factors by interviewing the shipping experts. And then, Fuzzy Analytic Hierarchy Process (FAHP) was applied to analyze the importance degree of each criterion to explore the significance of factors which added the concept of weight values. The survey also explored the different two routes, *i.e.*, Asia routes and American routes whether experts have different decisions to determine influential factors of schedule reliability.

The rest of the study was organized as follows: The relevant literature was surveyed in section 2. Section 3 described research design and methods. Section 4 presented empirical results, followed by conclusions and suggestions in section 5.

2. LITERATURE REVIEW

2.1 THE IMPACT OF SCHEDULE RELIABILITY ON SHIPPERS/CUSTOMERS

Due to low-cost trend, the transportation demand of container shipping is getting increasing recently. The system of container transportation is structured under time-tight schedules. Schedule reliability might be the reference for shippers when planning their supply chains with realistic expectations of delivery time and selecting liner carriers. Thus, delays might not only decrease the reliability of the liner service, but also increase logistics costs to the customer, such as additional inventory costs or additional production costs (*e.g.*, a production stop due to a late delivery of materials) (Notteboom, 2006).

2.2 INFLUENTIAL FACTORS ON SCHEDULE RELIABILITY

Carey (1999) claimed that measures of reliability and punctuality of scheduled services are important in planning, management, operating and marketing of the services. Schedule design is a strategic planning problem in shipping lines (Fagerholt, 2004), and it should meet customers' requirements in terms of frequency, transit time and price (Notteboom, 2006). Vernimmen *et al*. (2007) stated that low schedule reliability can be caused by a number of factors, and many of them beyond the control of shipping companies. For instance, vessel delay is the general reason due to bad weather, port congestion, and labor strikes and so on. Besides, two stages of schedule arrangement are port assignments and navigating by sea. Consequently, it divided into four aspects to explore influential factors of schedule reliability in this study.

(1) Operating strategy of shipping carriers

Shipping carriers master the schedule plan in most of time. Shipping lines could improve their efficiency of schedule reliability by performing different strategies, such as avoiding unreliable ports or using the chase strategy and so on. Shippers Today (2007) said that the unwillingness of carriers to make up for lost time by increasing vessel speed also affect schedule reliability. In addition, some shipping companies increase the control in the supply chain, reduce waiting times and guarantee the high vessel productivity by investing in port operating business, such as investing in dedicated facilities (Chiang and Hwang, 2009; Dynamar, 2005).

(2) Staff in shipping lines

Human factor is also the key component on schedule reliability, such as sense of mission in their own duty of every staff. For instance, the ports of Cape Town and Port Elizabeth have been closed on a number of occasions in the past due to employee strikes which caused further schedule unreliability (Vernimmen *et al*., 2007). With good coordination ability of market players (*ex*. port authority and custom) will be helpful to decrease waiting time and to increase efficiency.

(3) Process management in the shipping lines

Planning the berthing windows is an important design in shipping lines. Wang *et al*. (2010) also claimed that minimum average schedule missed hours of ships between the ship schedule departure time and the actual departure time will enhance the schedule reliability of ships. Well-arranged berthing windows can reduce the loss in customers and shipping lines; moreover, schedule reliability will increase. After one vessel arriving at port on time, it still has to wait in a queue and this will cause missing of berthing window. Drewry ever mentioned that most container carriers do not provide sufficient buffer time of their weekly schedules for contingencies, because some shipping lines think that buffer time is too expensive (Vernimmen *et al*., 2007). In addition, it also needs to take care of the transit time reliability. If a shipping line is behind the scheduled transit time which might shift containers to other vessels/ports, it will abolish the fixed schedule. Thus, the reliability of transit times between two ports also a key factor which will affect the further transport on time or not. Sözer and Dogan (2007) pointed that a good reputation of high schedule reliability also has high transit time reliability.

(4) Ports condition

Notteboom (2006) pointed that port congestion is one of the factors that can disrupt schedules, negatively affect schedule reliability. Thus, the increased port congestion and infrastructure constraints are some of the reasons which will compel the services of shipping lines. Drewry also agreed that the deterioration of liner schedule reliability was caused partly by port congestion (Shippers Today, 2007). Therefore, the characteristic of vessel schedules such as liners' schedule reliability is also an important factor of port selection (Lee et *al.*, 2007; Malchow and Kanafani, 2004). In addition, the schedule reliability also needed for efficient terminal planning, especially in those ports that are non-first port of call (Vernimmen *et al.*, 2007). Thus, berth allocation and terminal efficiency are important because these will cause the bad influence on the schedule of next ports.

3. RESEARCH DESIGN AND METHODOLOGY

Expert questionnaire is used to analyze the reliability of schedule. It has two stages to evaluate the importance of the factors in this study. The first stage utilizes Fuzzy Delphi Method to rank the critical factors by interviewing the shipping experts. In the second stage, Fuzzy Analytic Hierarchy Process is applied to analyze importance degree of each criterion to explore the significant of factors.

4. EMPIRICAL STUDY

4.1 HIERARCHY ARCHITECTURE OF THE STUDY

Reviewing relevant literatures about influential factors in schedule reliability of container shipping carriers, it can propose the hierarchy model of influential factors on schedule reliability as Table 3 according to the goal of influential factors on schedule reliability.

4.2 THE RESULTS OF FDM

According to the criteria in Table 3, fuzzy Delphi is applied to investigate the importance of the influence factors on schedule reliability as Table 4. The results show that the ranking of top five criteria from the overall respondents are planning the suitable ports (0.774), well-arranged the time window (0.774), transship arrangement (0.742), terminal efficiency (0.730), and planning the berth and warehouse previously (0.693). In Asia route, ranking of the top five criteria are planning the suitable ports (0.795), well-arranged the time window (0.757), transship arrangement (0.747), terminal efficiency (0.733), chase strategy (0.695) and planning the berth and warehouse previously (0.695). In American route, the top five criteria are well-arranged the time window (0.796), planning the suitable ports (0.748), terminal efficiency (0.725), transship arrangement (0.724), planning the berth and warehouse previously (0.712).

4.3 THE RESULTS OF FAHP

A general consensus among experts can establish a hierarchical structure. Using FAHP to calculate the importance of the influence factors on schedule reliability based on four objects and

12 criteria. The four objects are including operating strategy of shipping carriers, staff in shipping lines, process management in the shipping lines and ports condition. For overall respondents, the results showed that the process management in the shipping lines is the most important object as Table 5.

5. CONCLUSION AND SUGGESTION

(1) Schedule reliability is important for companies when addressing cargo activities. Delays will decrease the reliability of the liner service, cause a knock-on effect on the hinterland supply chain, and also add logistics costs to the customers. Thus, schedule reliability is important for each shipping line while handling cargo by sea.

(2) The result demonstrated that the 'process management in the shipping lines' is the main consideration in the evaluation process by using FAHP. 'Well-arranged time window' is the most important criterion from overall perspectives. Those results might be the direction for shipping companies to improve their reliability.

(3) Compare the Asia routes with American routes; the critical influential factors between them are not significantly different. It also implies that the critical factors of schedule reliability are almost the same, whether in short sea shipping lines or in deep sea shipping lines.

(4) To the shipping lines, it showed that the process management in the shipping lines is the most important, especially well-arranged the time window in the results of study. Thus, liner carriers should plan sufficient buffer time of their weekly schedules for unexpected situations such as bad weather and port congestion. In addition, shippers can also build more buffer time in their supply chains to cover the damage risk of variability in liner schedules.

(5) Service quality of schedule reliability might have a bigger influence on freight rate negotiations between carriers and shippers; meanwhile, it also will influence on performance of shipping lines. Therefore, it suggests that shippers can treat schedule reliability as a key performance indicator in the shipping lines.

Table 3 Influential factors in schedule reliability of container shipping carriers

Goal	Object	Criteria	Statement of Criteria
Influential Factors on Schedule Reliability	O1: Operating Strategy of Shipping Carriers	O11: Planning the suitable ports	Shipping carriers need to choose the suitable ports according to the port condition, cargo volume and so on.
		O12: Chase strategy	Whether shipping carriers execute the chase strategy or not.
		O13: Investing/specializing terminal	Shipping carriers has invested or specialized terminal.
	O2: Staff in Shipping Lines	O21: Staff's sense of mission	Every staff has strong sense of mission in their duty.
		O22: Coordination ability of staff with external relations	Staff should have good coordination ability with market players (ex. port authority and custom) to decrease waiting time and to increase efficiency.
		O23: Control and management staff in the terminal	The shipping carrier should control and manage the staff in the terminal effectively to avoid strike or slowness at works.
	O3: Process Management in the Shipping Lines	O31: Well-arranged the time window	Shipping lines should plan the time window appropriately.
		O32: Planning the berth and warehouse previously	Before arriving to the port, shipping lines should plan the berth and warehouse in advance.
		O33: Transship arrangement	Shipping lines should transship properly to avoid delay.
	O4: Ports Condition	O41: Freely flowing of ports' access roads	Access roads of a port are freely flowing.
		O42: Berth allocation	Berth allocation will influence on the operating time.
		O43: Terminal efficiency	Terminal efficiency will influence on the operating time.

Table 4 Defuzzied scores and ranking of criteria by using FDM

Criteria	Ranking		
	Overall	Asia Route	American Route
Planning the Suitable Ports	0.774(1)	0.795(1)	0.748(2)
Chase Strategy	0.677(8)	0.695(5)	0.642(9)
Invest/ Specialized Terminal	0.645(11)	0.647(11)	0.618(12)
Staff's Sense of Mission	0.661(10)	0.676(9)	0.630(11)
Coordination Ability of Staff with External Relations	0.677(8)	0.666(10)	0.666(7)
Control and Management Staff in the Terminal	0.688(6)	0.695(5)	0.700(6)
Well-arranged the Time Window	0.774(1)	0.757(2)	0.796(1)
Planning the berth and warehouse Previously	0.693(5)	0.695(5)	0.712(5)
Tranship Arrangement	0.742(3)	0.747(3)	0.724(4)
Freely Flowing of Ports' Access Roads	0.634(12)	0.609(12)	0.642(9)
Berth Allocation	0.678(7)	0.680(8)	0.651(8)
Terminal Efficiency	0.730(4)	0.733(4)	0.725(3)

Table5 Evaluation criteria weight of experts from different fields

Object	Weights			Criteria	Overall		Asia route		American route	
	Overall	Asia route	American route		Weights of Criteria in Each Object	Global Weight	Weights of Criteria in Each Object	Global Weight	Weights of Criteria in Each Object	Global Weight
O1	0.211 (2)	0.266 (2)	0.112 (2)	O11	0.735 (1)	0.155(3)	0.714(1)	0.196 (2)	0.739(1)	0.082(4)
				O12	0.189 (2)	0.040(7)	0.184(2)	0.050 (6)	0.164(2)	0.021(9)
				O13	0.075 (3)	0.016(10)	0.102(3)	0.020 (9)	0.098(3)	0.008(12)
O2	0.138 (3)	0.101 (3)	0.108 (4)	O21	0.174 (3)	0.024(9)	0.302(2)	0.018 (10)	0.084(3)	0.019(10)
				O22	0.302 (2)	0.042(6)	0.174(3)	0.031 (8)	0.327(2)	0.033(7)
				O23	0.524 (1)	0.072(5)	0.524(1)	0.053 (5)	0.589(1)	0.057(6)
O3	0.589 (1)	0.563 (1)	0.667 (1)	O31	0.544 (1)	0.320(1)	0.587(1)	0.306 (1)	0.650(1)	0.363(1)
				O32	0.126 (3)	0.074(4)	0.103(3)	0.071 (4)	0.098(3)	0.084(3)
				O33	0.330 (2)	0.194(2)	0.310(2)	0.186 (3)	0.252(2)	0.220(2)
O4	0.061 (4)	0.070 (4)	0.112 (2)	O41	0.144 (3)	0.009(12)	0.098(3)	0.010 (12)	0.236(2)	0.016(11)
				O42	0.237 (2)	0.014(11)	0.164(2)	0.017 (11)	0.116(3)	0.027(8)
				O43	0.619 (1)	0.038(8)	0.739(1)	0.043 (7)	0.648(1)	0.069(5)

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Validating Avionics Conceptual Architectures with Executable Specifications

Nils Fischer
Airbus Deutschland GmbH
Hamburg, Germany

and

Horst Salzwedel
MLDesign Technologies, Inc.
Palo Alto, California, USA

ABSTRACT

Today, specifications developed after conceptual avionics design is finished still carry a high degree of uncertainty. Since specifications are not validated early enough within the development process and no top-level executable model exists, system designers cannot evaluate the impact of their design decisions. At the end of the development process of complex systems, e. g. aircraft, an average of about 65 per cent of all specifications were changed because they were wrong, incomplete or poorly described. In this paper, a coupled model methodology in combination with a virtual test environment is used to make complex high level system specifications executable and testable during the very early stages of system design. An aircraft communication system and its system context was created to demonstrate the proposed early validation methodology. It enables system designers to couple functions, architecture elements, resources and performance parameters. As a result, a holistic executable specification on so called Early Conceptual Architecture Level is formed and used to determine the impact of different system architecture decisions on system behavior and overall performance.

Keywords: Civil Aircraft, Concept Validation, Coupled Model Design, Executable Specification, Top-Down Approach, Uncertainty Reduction, Virtual Test Bench

1. INTRODUCTION

For many years, the development of complex networked systems like aircraft, spacecraft or automobiles is characterized by a high risk and product uncertainty [1]. But complexity has always been a development challenge, especially for aircraft. In the early days of air flight, all attempts to develop an airplane failed. It was until the three Lilienthal siblings developed validated models of aerodynamics through observation of natural systems and rotating airfoil experiments [2].
Later, these models were further validated by wind tunnel experiments of the Wright brothers. Over time, progress in technology enabled engineers to form more and more complex aircraft. Aircraft crossed the sound barrier and needed to be equipped with stability augmentation systems for pilots. This dynamically coupled aerodynamics, aircraft structure and control. Again, many approaches failed to overcome the aero–servo–elasticity problems. It took some time until *System Control Technology (SCT)*, a division of *Science Applications International Corporation (SAIC)*, developed standardized mathematical descriptions for aerodynamics, structures and control and a common execution model which describes, simulates, and analyzes integrated coupled aircraft dynamics [3].

Today, we face the highest increase of new functionality and configuration diversity within networked systems of aircraft. Nearly all avionics and cabin related systems are affected, for instance in-flight entertainment or cabin communication networks to name just a few. Short lead times, a strong market competition and a complex design task which is realized by different divisions and groups of people are contributing to the overall risk. Several attempts, such as Requirement-based Engineering (RBE) and Concurrent Engineering (CE), have been made to handle the complexity as well as the development risk. Some model-based techniques, such as SysML/UML have been introduced in order to improve the quality of the design. However, all of these attempts have failed to deliver on their promise [4]. UML 2.0 is common practice for software development [5], but it is also capable to provide a base for integrated systems modeling and system architecture descriptions [6]. To derive consistent, complex and multi domain specifications however, its model elements and many different diagram types are often not strict enough and less formal than required to specify unambiguous and executable specifications. SysML, a language based on UML, enables modeling of system requirements and their evaluation [7]. It was created as a standardized expansion of UML to deliver a more specialized language for system designers. But since SysML specifications lack the combination of functional, non-functional, resource and mission criteria it is at the moment not suitable to develop complex system-of-systems simulations. Other well proven model driven methodologies like SystemC or Verilog operate on a completely different level of abstraction and are not intended to be used on complex overall system level [8]. Both, the level of abstraction and the combination of functional and architecture system components are currently hard to find in one of the established software tools. Another good example is MATLAB Simulink and similar software suite members, which are mainly used for control applications and less complex systems [9]. An executable design flow is also impossible to achieve. A specialized tool used for aircraft and military model based software design is SCADE [10]. This tool provides formal verification techniques, model test coverage and has gateways to many different tools. SCADE allows code generation certified for DO-178B. A key norm when it comes to aviation software. As mentioned before, SCADE is mainly used for software design at the moment and is not able to combine software, architecture and mission in one comprehensive and executable model for networked systems.

To be successful in the future, it is essential to provide a customer with the best solution for the intended application of a product. Therefore it is also necessary to be able to optimize a complex system on an overall system level. In order to achieve a good quality of system specifications we need to increase the level of validation early by means of executable concept specifications. Currently used design practices lack the ability to create and use such executable specifications during early design phases. Overall concept architectures and related written specifications are typically being developed using office applications according to DoDAF [11]. The resulting documents are not executable and complex system interactions cannot be validated. They cannot fill the gap between concept and specification which ultimately leads to component realization and integration. An executable concept specification must be derived which contains all relevant aspects of system design, i.e. behavior, architecture and performance parameters, often related to as non–functional parameter values. In other words to combine hardware, software, operational scenarios and aspects like weight, costs or timing constraints. Only then will early risk reduction and an overall architecture optimization be achievable early within the design process .

2. CIVIL AIRCRAFT AVIONIC SYSTEM

Two system models were developed to illustrate how a conceptual model based system design can be done. Therefore a simplified aircraft communication system and its extended system context, including other systems, an aircraft and a ground facility, were created. These two systems can be simulated and compared to choose a designated and validated design approach early in a project.

Modern civil aircraft are equipped with integrated communication systems that perform many different functions. While there are dedicated systems for voice communication between flight deck and air traffic control, the system considered here facilitates communication between different aircraft systems for the purpose of operation and maintenance [4]. Figure 1 shows the extended system context of one of two possible system architectures. The communication system is equipped with three main units which perform dedicated functions.

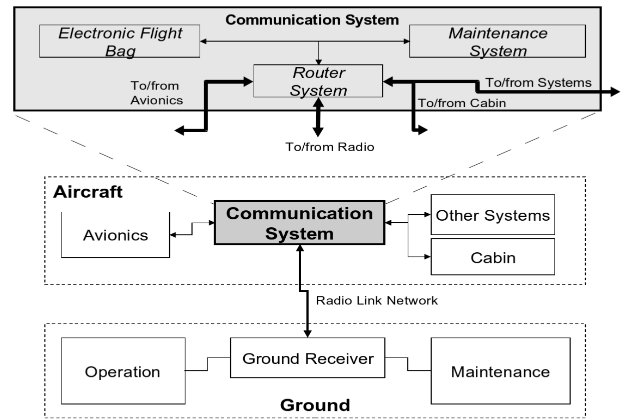

Figure 1: System level and extended system context with three dedicated system elements

An Electronic Flight Bag (EFB) is a system element that supports the flight crew when performing specific tasks related to flight operation such as the Aircraft Operation Manual (AOM), calculation of take-off and flight performance and weather data processing. Since nearly all modern aircraft use IP-based communication for non-critical systems, a router system element is required to provide a certain Quality of Service (QoS) for all connected systems. Civil aircraft use so called Built-in Test equipment (BITE) to constantly monitor connected components and report any unusual behavior to the Centralized Maintenance System (CMS). Most systems will also send part of the information about the state of other systems to the ground via a maintenance system element. A second possible system architecture is depicted in Figure 2.

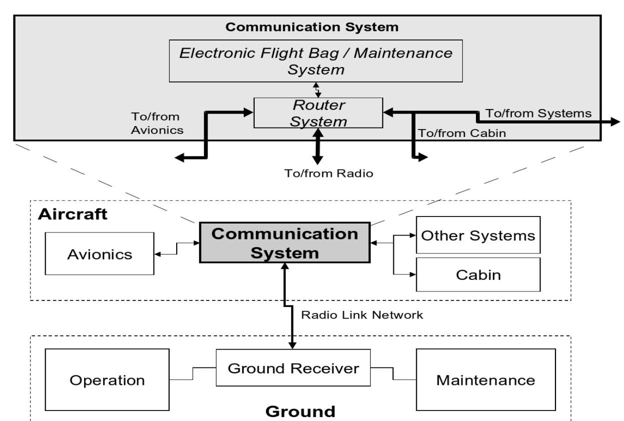

Figure 2: System level and extended system context with two dedicated system elements

Both system models represent identical functional behavior. All double arrowed lines in both pictures represent communication and data channels which are used to exchange data between connected entities. These communication lines are also considered as essential architecture elements of the system and its context. For more in depth information on aircraft related systems, design approaches and principles see references[12,13].

3. EARLY CONCEPTUAL MODEL BASED DESIGN

In current approaches of complex systems design such as aircraft, structured approaches are widely used. The design task is decomposed through various design stages until the remaining complexity permits to develop buildable solutions. All these buildable solutions need to be assembled into a complete system to solve the overall design problem. Dividing a complex design problem into a number of less complex problems and assembling these partial solutions is an approach widely accepted [14], [15], [16]. Usually, system and concept designers concentrate on operational and functional aspects of a system under design. Physical architecture, resource dimensioning and performance compliance is left to the implementer or an external supplier. However, concentration on a purely functional design without any reference to a reasonable architecture is not sufficient [17]. Also, a holistic design process needs to look at problems that may arise from system integration. An overall solution which is assembled from operative standalone sub-solutions may not work at all. Therefore it is necessary to begin conceptual design at aircraft level [18].

At an early stage of system design, a concept is generated. Most concepts are derived from top-level operational needs and customer inputs. While the concept is steadily decomposed into sub-concepts and top-level specifications are created, system and function designers assign a set of attributes to each derived function. Thus, the designer makes assumptions about a possible implementation of the function being defined. These assumptions may also be based on experience from previous projects and/or similar designs. Consequently, a design decision about a functional architecture is not based on functional aspects alone, but rather influenced by the implicit assumptions about the physical architecture that the designer made. The system specification however does not explicitly state these assumptions thus making it difficult to validate all requirements [4].

To overcome this validation gap, executable concept specifications of two possible civil aircraft communication systems have been created with the system design tool MLDesigner [19]. An executable concept specification binds logical behavior (Function), architecture (Elements) and performance aspects as well as specific resources in one combined multi-domain simulation. Simulations are used to validate the system design as early as possible, to solve integration problems during design and to reduce product uncertainty and therefore development risk earlier.

In a first step, a functional model without any reference to any architecture was created. This model is used as an operational base for the overall concept. General aspects of a function at conceptual level are depicted in Figure 3.

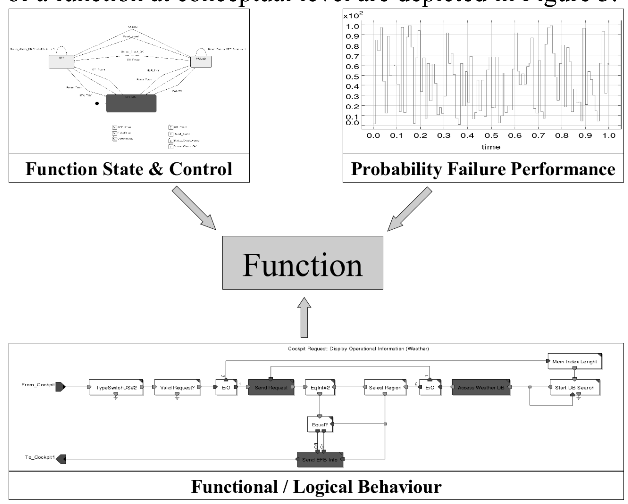

Figure 3: Functions within executable conceptual models

At conceptual level, functions do not only describe logical behavior but also contain a generic internal Finite State Machine (FSM) to represent several possible function states. For instance a function can be in normal mode, switched off or failed. Depending on its internal state, a model function can adjust its behavior during simulation, e.g. a function is deactivated or activated. To add long term probabilistic behavior and uncertainty, the state machine of a function can be linked to a failure inducing module that fails, enables or stimulates a function in a certain way with defined probability and a chosen probability distribution.

In the second step, an underlying conceptual architecture was introduced and functions were allocated. Both, functional and conceptual models are executable and include the extended context of the communication system which is the aircraft and a ground entity as depicted in Figure 1 and 2.

In addition to functions and communication links, the architectural layer includes concepts of several networks, a radio link as well as other performance relevant and execution elements, which include CPU and memory as well as network protocols. These concepts introduce additional model parameters, such as the average latency and the maximum bandwidth of a network, the number of instructions per second that a CPU can process and the capacity of involved memories.

A so called element is a container for model components representing architectural system features as mentioned above and functions. An element can also form a complete electronic control unit which can contain further elements. All functions of the functional model are allocated to elements. Just like functions, elements also contain a set of different features as shown in Figure 4. Several, often called non-functional or performance values, like cost and weight are also associated with elements.

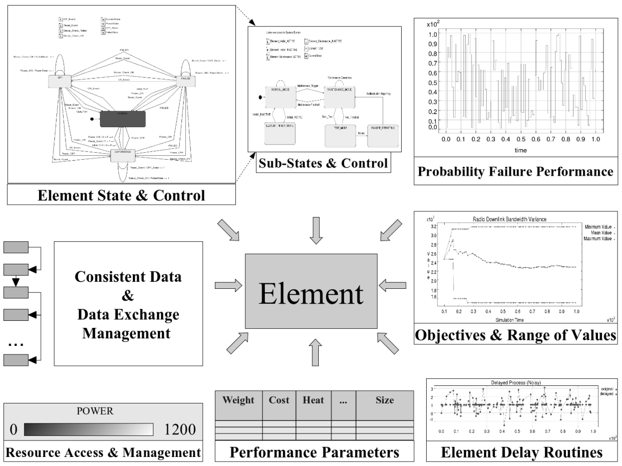

Figure 4: Elements within executable conceptual models

In order to be able to validate a design and determine the best possible architecture from a set of variants, so called objectives have been introduced. Objectives have to be met by the overall system or a sub-set of its elements and functions. Typical objectives given for aircraft are weight, cost or timing constraints for the completion of an important function or the *Mean Time To Restore (MTTR)*. Objectives are tuples of weighted parameter values and can be used for either system validation or as parameter inputs defining ranges instead of single values.

Objective = (value, lower bound, upper bound, weight)

Quantifiable and adjustable shared resources like power or bandwidth are directly coupled with element and function execution for all conceptual models. Elements and functions specify their individual need or range for certain resources. If a global or local resource like power is not available or does not fulfill the demand given by an element objective, the element will stop its execution and all of its allocated functions until all needed resources are available again.

Elements also have a generic FSM based internal state control. By default, but not limited to, an element has four states. Normal, Failed, Off and Unpowered. In combination with function states it is now possible to let an element behave normally, failed or partially failed. It can also be switched off through stimulation by other elements and functions if necessary. All generic states can be extended through hierarchical decomposition of its states. For instance the Normal state could host several sub-states like Maintenance or Test Mode. If, for example, an element or an entire system is in Test Mode, only specific functions are available to be performed. Probabilistic routines are used to emulate failures as they happen in real world Line Replaceable Units (LRUs).

Since all elements communicate through standardized data structures, it is possible to use specific delay routines within each element. These routines delay allocated functions and data generated or processed within an element. Possible delay values can depend on available bandwidth, cable length, CPU and memory execution delays to name just a few. In early design phases, when such time aspects are only vaguely known, system designers could use more abstract element and function delays to figure out the maximum amount of time which still enables an element or system to perform all functions while simultaneously fulfilling necessary time constraints or other objectives.

Both system architecture variants use identical functions. Variant 1 allocates EFB functions and maintenance functions to two dedicated elements within the communication system, while variant 2 uses one element to host all functions together. The same router element is used in both variants to host all routing functions. Accordingly, variant 1 uses five network elements and a radio link and variant 2 uses four network elements and a radio link to communicate with other systems. In variant 2 network traffic from the combined EFB and Maintenance System element is transmitted using the same network link, thus increasing the bandwidth demand. Additionally, the CPU and memory resources must be capable to satisfy the demand of both functions simultaneously.

4. VIRTUAL VALIDATION ENVIRONMENT

A global system application or mission is used to guarantee repeatable simulations for all models and to validate each model. To introduce features as depicted in Figures 3 and 4, it was necessary to:

(a) Implement an overall synchronicity method that controls and synchronizes all model components
(b) Develop and use a consistent data base and a standardized, coherent data exchange management between elements
(c) Use ranges instead of point values for parameters during simulation to include uncertainty

Several generic model components have been created to help system designers to form conceptual elements. These include several basic model components such as:

- Delay modules for calculation, execution and transmission behavior
- Probability driven failure generators
- Network components and predefined elements
- Objective iterators and test modules
- Resource management components

- Global and local system, element and function control modules
- Evaluation modules, showing statistics and value ranges
- Automation routines for maximum delay calculation and state based coverage testing

On extended system level a control module is used to manipulate system, element and function behavior directly during simulation. A prototypical graphical user

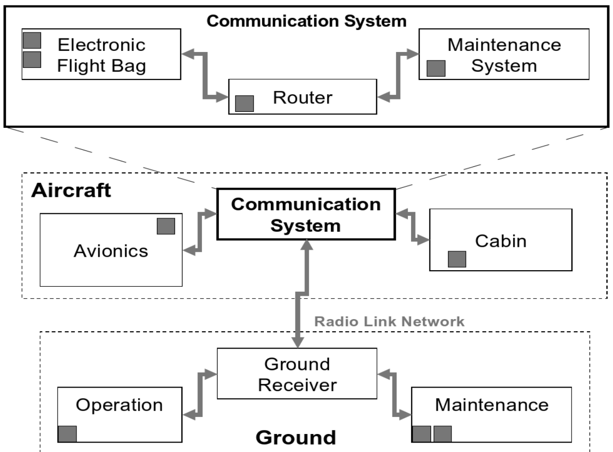

Figure 5: Impact of function / element deactivation on other system components during simulation

interface (GUI) was implemented to show and change the status of each system, element and function. Also, any function, element or sub-system failure is detected and shown. If for instance a whole subsystem is deactivated, all of its functions fail and elements will stop providing resources they normally would produce. Figure 5 depicts how a manipulation of one maintenance function and the EFB element via the created system control GUI dynamically affects several elements (LRUs, networks) as well as functions within other areas of the model during simulation. Small gray boxes represent impacted functions within other elements and systems and gray network connections, which are affected.

In addition, an auto simulation mode is available, which will automatically generate different state permutations during simulation for all generic FSMs of sub-systems, Functions and Elements. To find a maximum feasible delay value for all elements of a system, which still satisfies all given objectives, it is possible to auto iterate simulations. The system will adapt element delay parameters after each simulation until a given position after decimal point is reached. In the example system an over-sized periodic maintenance function could be determined immediately which was sending continuous data via the radio link network thus generating a constant over utilization. Because of this, the performance of other functions and elements of the system itself and related systems was reduced to a non acceptable degree. The periodic function was modified slightly to adjust to given system architecture parameters thus resolving the problem at a very early stage of design. Another important application for the simulation control features are safety and reliability critical aircraft systems. By activation / deactivation of functions, elements or systems one can determine the robustness of a given system architecture. Questions like "Will the system still work as required if one particular function or one element or a coupled system fails" or "Will all redundancy mechanisms work?" can now be checked during simulation before system integration has even started.

5. SIMULATION AND RESULTS

Since all concept specifications are executable, it is possible to draw conclusions from every model. The functional model alone however, can only be used to validate, if logical operational and functional aspects of the concept were implemented correctly. After both conceptual architecture simulations are completed, a table with all objective values is created and used to compare the results for the different architectures alternatives. Based on this data, a design decision can be made. Of course, this decision is strongly affected by the individual weight of each objective. However, a simple comparison is not enough when validating an architecture. Specific properties of an architecture, such as scalability and extensibility may also be used to find a decision. Furthermore, the resource utilization linked to a specific state of the system must be examined in order to validate the dynamic behavior of the system. Figure 8 compares the results of the simulations for data transmission to the ground via radio link for both variants. This result shows that the integration of several functions into a single element incurs a burden on the resources that are required to operate the system. The graph also shows that additional delays are introduced when using the same set of resources in one element and that using one shared network between different Elements increases delay for overall data transmission.

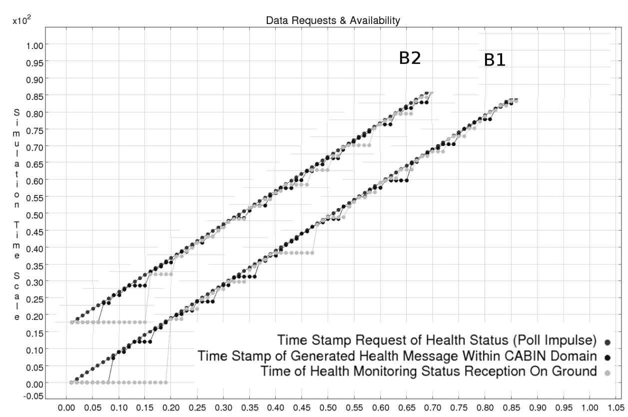

Figure 8: Simulation results for air to ground data transmission of variants B1 and B2

Power management and power-up behavior are important factors of nearly all electronic systems, especially in spacecraft and aircraft. Resource objectives like power could be calculated from all given element parameters without simulation. Nevertheless, this static calculation does not include dynamic processes which occur during system operation. Figure 11 shows how power usage changes over time during simulation of variant B1. The Power characteristic of a system is therefore another important factor which is to be considered when trying to find the right architecture to solve a given design task.

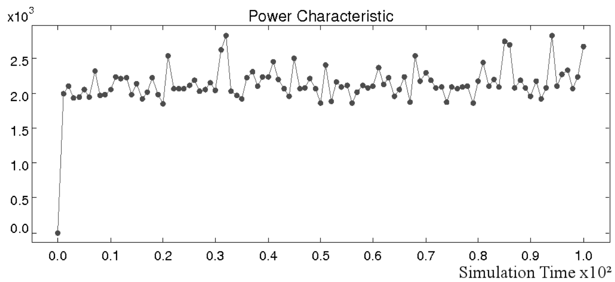

Figure 11: Power usage over time of variant B1

Such investigations can also contribute to find a design decision as well as to show and include uncertainties in design parameters at an early design stage. Once the design is elaborated, the uncertainties are expected to decrease.

6. SUMMARY

This paper identifies current challenges of complex systems design, especially for aircraft development. A set of model based tools and methodologies were considered to solve the demand for holistic and executable specifications for early system design levels. Executable models of two aircraft communication system variants were developed using the system design tool MLDesigner. These models include upper system context (aircraft, ground entities) as well as coupled functional, architecture and performance components. A virtual test environment was created to survey and manipulate the operational status of each model component. Since MLDesigner already uses Monte-Carlo-Simulation it is also possible to simulate over different parameter value ranges and therefore include model uncertainty. FSM based control structures embedded in functions, elements and sub-systems are used to simulate several different generic states which affect the overall system behavior and performance. These control structures also allow automated coverage analyses for all parts of a system model. An execution of several test scenarios or pre-defined test is possible via configuration files. It was shown how modeling and simulation at architecture performance level permits the creation of an executable concept specification for coupled systems. This virtual prototype can be used in early design stages to perform architecture comparison and validation of system requirements and thus significantly reducing the design space and product uncertainty. Different architecture alternatives can be used to optimize the system application before implementation and integration has started.

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Application of Analytic Hierarchy Process (AHP) for ANN model selection in streamflow prediction

Masengo Ilunga[a] and Ednah Onyari[a],
[a]Department of Civil Engineering,
University of South Africa,
Pretoria, South Africa.

ABSTRACT

The present article is a companion paper published recently in 2010 by the above-mentioned authors. Analytic Hierarchy Process (AHP) is applied for the selection of the best predicting rainfall-runoff models between Artificial Neural Network (ANN) techniques (alternatives), namely the M5P Model Tree and the multilayered perception (MLP) ANN. Both models were developed, trained using 66 % data set and verified for the predicted discharge at Luvuvhu River, Mhinga gauging station of the Limpopo province in South Africa. The AHP criteria included the Root Mean Square Error of Predictions, the Mean Absolute Error (MAE) and the correlation coefficient (CC). The weights obtained after the ranking of these three criteria were respectively 63 %, 26 % and 11 %. For each criterion, pairwise comparisons of the two ANN techniques were carried out. The M5P-Model performed better than the MLP ANN based on a consistent judgment through AHP process (i.e. consistency ratio of 7). The overall preferences for M5P and MLP techniques (alternatives or models) were estimated at 84% and 16% respectively.

Keywords: Analytic hierarchical process, model prediction, neural network

1. INTRODUCTION

Planning and management of water resources, requires reliable streamflow data. Sometime the records are not of sufficient length at the site where development such water structure design, etc can take place. Prediction models are commonly used to predict data, e.g. streamflow at that specific site. From the literature, the application of multilayered perception Artificial Neural Network MLP-ANN in several aspects of water resources and related fields has been reported to be successful, e.g. rainfall runoff modeling, infilling streamflow data problems, etc [1], [2], [3]. As tree based models with their leaves having multivariate linear models, M5 model tree has been reported to be relatively new in water resources but in the events it has been used it has been proved to be quite robust [1]. For more details, the referred is referred to [1].

The choice for a suitable technique is not always easy when considering several selection performance criteria, which could lead in some cases to subjective considerations. This challenge can be due to the high number performance criteria as well as the number of prediction models.

Currently, for hydrological modeling, specifically streamflow prediction, there are no universal criteria accepted in terms of technique or model performance evaluation. Hence the commonly criteria used in the literature are predominantly statistical, amongst others Root Mean Square Errors (RMSEp) of predictions, Relative Mean Error (RME), Absolute mean error (AME), Standard error (SE), correlation coefficient (CC), Nash-Sutcliffe (R^2), etc. The ranking of models is usually done by comparing the magnitude of each criterion for the different techniques. Conclusions are drawn through simple observation in terms of magnitudes of computed criteria. This way of ranking models becomes complicated when dealing with cases with many models and criteria. Hence AHP can be used to handle such cases. The use of AHP in water resources and related fields is very sparse. In particular, no study has shown the overall performance for streamflow predictions using AHP, hence allocation of weights using a pairwise comparison with respect to criteria and prediction technique or model. Only paired comparison of criteria or alternatives but not both will be dealt here. It has to be noted that the RMSEp can be expressed as another form of the sum squared errors (SSE) or the standard error (SE) of predictions.

In this paper the use of Analytic Hierarchy Process (AHP) mainly based on the results of a recent publication [1]. AHP is proposed for selection of the best streamflow prediction model based on a consistent judgment. In some way AHP process is normally based on subjective considerations which should yield to a consistent judgment. The AHP process is applied to results of streamflow predict flow at Mhinga station (gauge A9H012) while accounting for rainfall data from Thohoyandou station (07236646) and streamflow from Mutshindudi River (A9H025) and Nandoni dam outflows (A9H030) [1]. Hence the M5P and MLP ANN were the two models (alternatives) evaluated through AHP. In what follows, “model”, “technique” and “alternative” can be used interchangeably.

2. ANALYTIC HIERARCHY PROCESS: OVERVIEW

AHP is one of Multi Criteria decision making method that was originally developed by Prof. Thomas L. Saaty [10]. In short, it is a method to derive ratio scales from paired comparisons. The input can be obtained from actual measurement such as price, weight etc., or from subjective opinion such as satisfaction feelings and preference. AHP allow some small inconsistency in judgment because human is not always consistent [4]. This technique has been applied to numerous fields, amongst others manufacturing process selection [5]. Hydro-Spatial AHP, a method for sitting smaller water harvesting was developed to rank potential sites for such reservoirs based on reservoir suitability index [6]. The use of AHP in water resources and related fields is sparse. The use of AHP in engineering problems can be a powerful tool when comparing different alternatives.

AHP can be summarized in the following as re-iterated [5]:

1. Modeling of the problem as a hierarchy: The hierarchy contains a goal, the alternatives and the criteria for evaluating the alternatives.
2. Establishing priorities among the elements of the hierarchy: The pairwise comparisons of the criteria. During this comparison the importance of criteria is determined using the scale shown in Table 1. Intensities are allocated based on the judgments or experiences of individuals have on a particular topics
3. Determination of overall priorities for the hierarchy: The information obtained is consolidated in a comparison matrix.
4. Consistency checking: Consistency of decisions made in previous steps determined by computing a consistency ratio. This ratio should be less than 10%
5. Final decision: Based on the normalized principal priority vector (Eigen vector) obtained from a comparison as built matrix.

Table 1. Fundamental Scale for Pairwise Comparison [5]

Intensity of Importance	Definition	Explanation
1	Equal importance	Two elements are equal with regards to the objectives
3	Moderate importance	One element is slightly preferred over another
5	Strong importance	One element is strongly prefer over another
7	Very strong importance	One element is preferred very strongly over another.
9	Extreme importance	One element is dominantly preferred over another
Intensities of 2, 4, 6 and 8 can be used to express intermediate values		

3. IMPLEMENTATION OF AHP FOR STREAMFLOW MODEL PREDICTION

The implementation of AHP process was done as follows:

- Goal: Defining the best streamflow prediction model at Mhinga station (gauge A9H012) using flows at Mhinga, Mutshindudi, and Nandoni dam outflow.
- Criteria: Root Mean Squared Error of predictions (RMSEp), Mean Absolute Error (MAE), Correlation Coefficient (CC)
- Alternatives: M5P Model Tree and MLP used in our previous publication is used [1].

One should note that RMSEp for streamflow prediction can be considered to be used more than the rest of criteria. For instance, some authors made clearly this choice or preference [2], [7]. Hence the first preference could be given to RMSEp (which can be derived from sum squared errors-SSE between the actual and the predicted data). Other publications made the use of RMSEp criterion indirectly through other criteria like standard error [2], [8], while some make through SSE criterion [9]. The correlation coefficient has been commonly used for goodness-of-fit statistic; however it is only a measure of linear association between variables [2]. Hence in the case of non-linearity, it wouldn't be recommended, e.g. case of ANNs. Other criteria are used like MAE, etc. Hence preference can be given first to RMSEp, then to MAE and lastly CC since this one is thought more suitable for linear cases. Table 2 shows the results extracted from a previous publication where streamflow data at Mhinga station (gauge A9H012) were predicted using flows at Mhinga, Mutshindudi, and Nandoni dam outflow for a period of 3 years [1]. M5P and MLP-ANN models were used for streamflow prediction. For more details, the reader is referred to [1].

Table 2 Criteria values (RMSEp, MAE, CC)

Model training set (66%)	RMSEp	MAE	CC
MLP	3.43	1.96	0.82
M5P	2.67	1.23	0.89

4. PAIRWISE COMPARISON OF CRITERIA

Table 3 depicts the criteria pairwise comparison with the corresponding importance allocation intensity. Based on a subjective consideration or preference (as outlined in the previous paragraph), the RMSE can be considered to have a strong importance than the rest of criteria. MAE could be moderately important than CC since MAE is thought to adjust better to non-linearity cases, e.g. case of ANNs. The subjective consideration holds only when the consistency ratio during AHP process is less than 10%, otherwise it has to be rejected and seek for other considerations.

Table 3. Pairwise comparison of criteria

A	B	Importance	Intensity
RMSEp	MAE	A	3
RMSEp	CC	A	5
MAE	CC	A	3

5. ALTERNATIVES COMPARISON

Table 4 depicts the pairwise comparison between MLP ANN and M5P with regards to each criterion considered: RMSE, MAE and CC. According to the previous publication, the results in Table 2 showed that ML5 performed better than MLP. The conclusion on the performance was based only on observing/comparing the magnitudes of criteria. However no weight was given to the criteria as well as the models (alternatives). Hence to check the consistency of the judgment/decision about models or alternatives, preference intensity equal to 5 was used.

Table 4. Pairwise comparison between MLP and M5P with respect to criteria

Criteria	MLP	M5P	Intensity
RMSEp		X	5
MAE		X	5
CC		X	5

6. RESULTS AND DISCUSSION

Table 5 shows the weights of the three criteria considered. Appendix A gives details of weight calculations. The results showed that 63% of the goal weight is on RMSE, 26 % of the goal on MAE and 11 % on CC. The consistency ratio was found to be 7 %, which is less than 10 %. This could imply that preferences in AHP process were logical and hence yield to a consistent judgment.

Table 5. Criterion weights

	RMSEp	MAE	CC	Average
RMSEp	0.65	0.69	0.56	0.63
MAE	0.22	0.23	0.33	0.26
CC	0.13	0.076	0.11	0.11

Table 6 depicts the weights of the two alternatives with regards to each criterion. Mathematical calculations are given in Appendix A of this paper. From this table, it is seen that for M5P has a preference of 83 % for a given criterion while MLP has 17% for the same criterion.

Table 6. Weights of alternatives

	MLP	M5P
RMSEp	0.17	0.83
MAE	0.17	0.83
CC	0.17	0.83

The overall preferences for the two alternatives MLP ANN and M5P have been determined in Appendix C. Table 7 shows that the overall performance is 84 % and 16 % for MLP and M5P respectively. The consistency ratio as computed is 7 %, which gives a consistent judgment.

Table 7. Determination of overall weights of alternatives

Appendix A	Appendix B data				
A	B	C	D	E	F
Criteria weights	Alternatives weights				
		MLP	M5P	MLP	M5P
0.634	RMSEp	0.17	0.83	0.16	0.53
0.260	MAE	0.17	0.83	0.043	0.26
0.106	CC	0.17	0.83	0.0177	0.088
				0.157	**0.838**

The overall preferences obtained could be explained by the fact that the RMSEp was ranked higher than the rest of criteria. This ranking is specific to the application of discharge prediction problem at Luvuvhu River, Mhinga gauging station of the Limpopo province in South Africa. The RMSEp is critical in defining the accuracy of the streamflow predictions between observed and predicted values. However, the RMSE might not be necessarily the most preferred criteria for other techniques or other applications where for example there is strong linearity between variables. M5P scored higher for the high ranking criteria compare to the MLP according to the results obtained from the previous study [1].

7. CONCLUSIONS

It was shown that AHP can be applied and explained logically for the selection of two ANN techniques used for streamflow predictions. Through mathematical formulations, the choice was made logically. A better and transparent understanding in the choice of the best technique was made. AHP does not rely on a rule of thumb. However one of its limitations is that the final results very much depend on the human inputs in the rankings of criteria. One can make sure that the input is logical by computing the consistency ratio. The power of AHP is shown when the number of criteria and alternatives increase in a given problem. The application in this study is a relatively simple case but useful in illustrating the AHP methodology to the selection of hydrological modeling techniques. Further work may include the application of AHP for the selection of ANN with various alternatives and criteria as well as testing AHP to other models/techniques.

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9. APPENDICES

Appendix A: Criterion Weights

Table 1. Preference on criteria

	RMSEp	MAE	CC
RMSEp	1	3	5
MAE	0.33	1	3
CC	0.2	0.33	1
	1.53	4.33	9

Table 2. Weights on criteria

	RMSEp	MAE	CC	Average
RMSEp	0.655	0.692	0.556	0.634
MAE	0.216	0.231	0.333	0.260
CC	0.131	0.076	0.111	0.106

Each element in Table 2 (weights on criteria) is obtained by dividing the entry in Table 1 (preference on criteria) by the sum of the column it appears in. Values in the Average column are obtained by averaging values in the different rows. The Average column represents the weights of criteria.

Appendix B: Determination of alternative Weights

Step 1: Weights of alternatives with regards to each criterion

Table 1a. Comparison of models(alternatives/techniques) on RMSEp

	MLP	M5P
MLP	1	0.2
M5P	5	1
	6	1.2

Table 1b. Weights of alternatives with regards RMSEp

	MLP	M5P	Average
MLP	0.17	0.17	0.17
M5P	0.83	0.83	0.83

Table 2a. Comparison of alternatives with regards to MAE

	MLP	M5P
MLP	1	0.2
M5P	5	1
	6	1.2

Table 2b. Weights of alternatives with regards to MAE

	MLP	M5P	Average
MLP	0.17	0.17	0.17
M5P	0.83	0.83	0.83

Table 3a. Comparison of alternatives with regards to CC

	MLP	M5P
MLP	1	0.2
M5P	5	1
	6	1.2

Table 3b. Weights of alternatives with regards to CC

	MLP	M5P	Average
MLP	0.17	0.17	0.17
M5P	0.83	0.83	0.83

Step 2 Weights of alternatives

Table 5. Weights of Alternatives

	MLP	M5P
RMSEp	0.17	0.83
MAE	0.17	0.83
CC	0.17	0.83

Values in Table 5 rows are obtained from Average column in Appendix C

Appendix C: Determination of overall Weights

Table 1. Determination of overall weights of alternatives

Appendix A	Appendix B data				
A	B	C	D	E	F
Criteria weights	Alternatives weights				
		MLP	M5P	MLP	M5P
0.634	RMSEp	0.17	0.83	0.16	0.53
0.260	MAE	0.17	0.83	0.043	0.26
0.106	CC	0.17	0.83	0.0177	0.088
				0.157	**0.838**

Values in columns E and F are obtained by multiplying A by C and A by D respectively. The overall weights are summing values in columns E and F

Creative teamwork in quick and long term project development, 24 hours of innovation

Luz-Maria Jiménez-Narvaez
ÉTS, École de Technologie Supérieure
Montréal, Québec, Canada H3C 1K3

and

Simon Desrosiers
ÉTS, École de Technologie Supérieure
Montréal, Québec, Canada H3C 1K3

and

Mickaël Gardoni
INSA de Strasbourg,
Strasbourg, France, 67000
/
ÉTS, École de Technologie Supérieure
Montréal, Québec, Canada H3C 1K3

ABSTRACT

The charette is “an intensive, concentrated and deadline oriented group confrontation and discussion technique applied to identify, analyze, evaluate and solve educational, organizational and community problems and needs” [3]. In this paper, we are interested in comparing the charrette with the long project development, in the analysis of creative activities. From the charrette, several issues are questioned, such as the importance of the group maturity and the skills of the participants. About industrial project development inside a competitive world, there are some questions about the Quick Projects Development QPD and also for the long periods of developing. We consider that our research could clarify four discussion topics regarding creative teamwork in charrette in the particular context of 24h charette duration: a) team building and the idea development into the 24h, b) an analysis of the issues presented in the innovative projects and the response of the team, as well as, c) the use of time in work sessions and d) the role of the leader in the team creative performance. These answers are important for the planning of teamwork in the PD activities of technological projects. This comparative study was carried out within the context of the Fourth Edition of the 24 Hours (24H) of Innovation international competition and a project of 3 months.

Keywords - Quick projects development, Long-term project development, creative work, collaboration in design, designing for innovation

1 INTRODUCTION

The 24 Hours of Innovation (24H) is an international competition created by the École Supérieure des Technologies Industrielles Avancées (ESTIA, France) with the purpose of developing innovative solutions. The competition is set in the time frame of 24 consecutive hours and crafted to address students from a variety of disciplines, as well as universities. This year, the Fourth edition took place in Bidart, France, October 22 and 23 2010. The teams were challenged to come up with an innovative solution to a problem presented at the beginning of the event[1], and then were assessed by the academics and manufacturers. Approximately 250 students attended the competition divided into 27 teams made of 1 to 11 members. This year, 34 projects were proposed to the teams. Each team freely selected the topic of its work, in accordance with its members' experience, knowledge or project interest.

24H is a student competition that involves organizational team strategies and creative collaboration. The organization of teamwork during the execution of short term innovative projects arises numerous questions [10], especially:

1. What is the influence of the interdisciplinary grouping of teams? Is there some special influence of the team composition by gender, or by field of study (industrial, construction, physical, informatics, ergonomics, computer, consulting, management, and logistics)?
2. How to assess the demands posed on the teams in function of their experience?
3. How are the teams influenced by the prior knowledge of the members?
4. Is there any importance of the number of ideas produced and the time taken of the selection of ideas?
5. Does the leader have a role in the creative teamwork performance?

Our research interest of the team creative performance in the QPD is driven by the possibilities that the answers could impact the industrial projects development. As we know, the businesses impose strict time constraints to its product development teams in order to reduce costs of research and development (R&D). For this reason, the creative stage of design definition is crucial for the overall performances of the product. The initial ideas presented by the teams in charge of conceptualizing the product, generate a “path dependency” through the entire project development, and also create a “snowball” effect in the following stages of production: changes made during the first stage of the project are less

[1] For more details, please see: http://www.24h.estia.fr/index.php?lang=en

costly to bring about than the changes made during the final stages of production [5].
One aspect of the QPD is the question about if this "creative burst of energy that builds momentum for a project and sets it on a course to meet project goals" [12] should be effective in terms of creativity thinking or creativity performance. Lindsey et al, [12] also mentioned that the charrette could "transform a project from a static, complex problem to a successful, buildable plan" (Ibid). Usually, it is an intensely focused, multiday session that uses a collaborative approach to create realistic and achievable designs that work.

On the other hand, company teams are formed within an interdisciplinary context. In other words, teams are not created according to the employees creativity, but instead, according to their professional competence (domain-skills) [4]; this way, comprising different levels of experience. Also, expert members could work with the novice members. Hoegl and Parboteeah [8] claim that experience and shared abilities allow for a team to be more efficient in completing tasks, but not necessarily in the effectiveness nor quality of their creative solutions [1].
Other important aspect of the charrette activity is the benefits to facilitate the "interaction and feedback mechanism between industry respondents and academia" [7 p. 67]. Also, the charrette is used by "researchers to gather data relatively quickly, collect valuable input from experienced practitioners, make excellent industry contacts, and gain insights with several collection strategies"(Ibid, p. 75)
In the scope of work carried out by the 27 teams, we analyzed four variables linked to the activities of creative teamwork in QPD and the comparison of the Long-term Project Development (LPD): a) the interdisciplinary grouping of teams, b) the assessment of the task demand (projects proposal) posed on the teams, c) the influence of experience and prior knowledge, on the number of ideas produced and the selection of ideas into the time assigned and, d) the composition of team in relation with the leader influence.

2 METHODOLOGICAL PLAN FOR THE STUDY OF CREATIVE ACTIVITIES IN 24H

After the implementation of the experimental protocol during the Montreal Edition of the 24H, our research group decided to conduct a comparative study between the creative teams that attended the Fourth Edition of Bidart and the Canadian team T27[11]. Contrasting our initial experimental protocol elaborated for monitoring the quick project development, we elaborated a protocol for a long period. We decided to carry out an investigation in accordance with the time as a variable and to add another variable: the analysis of the influence of the leader in the performance of the group. The hypothesis was that in QPG, the creative teamwork performance is not affected by reduced time period of work.

2.1 Subjects

After an invitation was sent out by the organizing committee, almost 200 students registered and attended the local competition and 42 students worked from remote locations through videoconference from Grenoble (France), Bath, Wolverhampton (UK), and Montréal (Canada)[2]. During the 24H, the constitution of groups is free. Often, students accustomed to work together, gather in the same team.. Other participants first picked the topic or one specific project owner and then constituted the team randomly with other members according to their order of registration. In Table 1, we get a glimpse of how the teams were formed: number, field of work and institution. Following the jury's assessment, the first 10 teams were ranked according to their position at the end of the competition. The teams with an outstanding creative performance were placed from T1 to T12 and the teams without a mention from T13 to T27. And in Table 2, we show the composition of the T26 during the 24H and the longer period. The participants of T27 were undergrad students from ÉTS, three enrolled in electrical engineering and one in IT engineering. The shaded portion represents the students composing T27.

2.2 Task

a. Charrette 24H

The competition begins by a 60 minute meeting made for groups to prepare their constitution, and to choose their topic. Demands and constraints of the competition are first presented. Then, alternatives projects – and their issues - were presented to the students during a 20 minute PowerPoint presentation. Thirty four projects were proposed. The remaining 23 hours are then freely used by the groups to plan a strategic solution or outline a process for achieving it. At the end of the 24 hours, the teams have 3 minutes to present their solution.

b. Long period activity 3 months

After the competition, the enterprise requested the participation of team T27 to develop in details ideas and solutions exposed during the competition. T27 at the beginning was composed by six participants, and then by 4 participants. The activities of this team were developed at ETS during 3 months.

2.3 Procedure

We decided to study the variation in quantity of ideas produced in the 24H by the first prized team T1 and by T27 in their participation during the long period of time. We also asked them about the composition of the team: a) the team and their personal creative characteristics, in particular the leader's intervention, as well as, b) the team confidence –how was the work dynamics. These responses were compared between the average of the first prize team composed and by the performance of T27 in the long-term.
We also ranked the team performance according to the general classification – the main "output" obtained for each winning team (10 teams) in function of judges decision (Committee of decision of the contest). We have to highlight that the creativity assessment is a contextual and social assessment [2], for this reason, we used at this study the same classification assigned for the final judge results. They classified the teams at the end of the competition, according to the teams' presentation.

Table 1. Team composition by number of participants, time of knowing each others, discipline and school

Team	n	Domain	School	Time of grouping	Award
T1	10	Mechanical, Electronics, Software, CAD	ESTIA (9), ECE Paris (1) **Fr**	+2 years	1st Prize
T2	10	Mechanical, Software, Design	ESTIA (8), Ec. Boole/Cachan (1), Nursing (1) **Fr**	+2 years	2nd Prize
T3	10	Engineering, Business	Mondragon Univ. (8) **Sp**, ESTIA **Fr** (2)	+2 years	3rd Prize
T4	10	Enterprises-Leadership	Jyväskylä Univ **Fi**. (8) Mondragon Univ **Sp**, (2)**,**	-1 year	Best Breakthrough Award
T5	10	Enterprises-Leadership-*Innovation*	Mondragon Univ. **Sp** (10)	-1 year	Best Marketing Award
T6	10	Engineering 1st year & 2nd year Mechanical, Electronics, Software, CAD	ESTIA **Fr** (10)	+2 years	Best Virtual Animation Award

[2] For more information about 24H Bidart you could see: Jimenez et al (2011)

T7	10	Communication, Materials, Engineering	ESTIA (5), Biology (1), Ec. Mines (4) **Fr**	+2 years	Best Prototype Award
T8	6	Engineering 1st year	ESTIA **Fr** (6)	-1 year	Best Environment Award
T9	10	Engineering, Sport	ESTIA (5), IFMA (4), Sport (1) **Fr**	-1 year	Best Invention Award
T10	10	Engineering	Unemployed Engineer **Fr**	Alone	Award of the perseverance
T11	5 (5)	no data available (videoconference)	Wolverhampton Univ. **UK**		Best Design Award
T12	10	Engineering, Anatomy	ESTIA (2), Ec. Mines (6), Sport (2), **Fr**	-1 year	Best Video Award
T13	10	Mechanical, Biology	UTC (5), ESTIA (4), UTBM (1)	-1 year	
T14	10	Economics, Finance, Engineering	ESTIA (2), Mondragon Univ. (8)	-1 year	
T15	8	Electronics, Mechanical, Ergonomics	ESTIA (3), ENIT (2) UDS (3) **Fr**	-1 year	
T16	7	Engineering 1st year	ESTIA (7) **Fr**	-1 year	
T17	10 (5)	Mechanical, Design (videoconference)	EILCO (5) **Fr**, Bath Univ. (5) **UK**	(5) +2 years	
T18	6	Aeronautics, Ind, Commerce	ESTIA (3). Ec. Mines (1) Consulting (1) **Fr** Ec. Commerce (1) **Sp**	0 years	
T19	7	Industrial maintenance	Univ. Paris 8 (7)	+2 years	
T20	3	Inform, Mec-electr	ESTIA (3)	+2 years	
T21	10	Engineering 1st year	ESTIA (9), INSA Toulouse (1)	-1 year	
T22	10	Industrial Design	Mondragon Univ. (10) , **Sp**	+2 years	
T23	8	Ind. Design, Architecture, Engineering	Mondragon Univ. (8), **Sp**	-1 year	
T24	11 (10)	Mec, Indus, eco-design (videoconference)	INPG (11)	-1 year	
T25	10 (9)	Eco-design, Software, Maths (videoconference)	Master GMP (3), INPG (7)	-1 year	
T26	10 (8)	Mec and IT Eng., Law, Political Science, Environment (videoconference)	ÉTS (6), Université de Sherbrooke (2), UQAM (1), UQO (1)	-1 to 2 year	Local Award
T27	5 (4)	Elec, It Engineering	ÉTS (4), Université de Sherbrooke (1)	1-2 years	

Table 2. Composition of T26 and T27

#	Domains	Schools
1	Electrical Engineering	ETS
2	Electrical Engineering	Université de Sherbrooke
3	Electrical Engineering	ETS
4	IT Engineering	ETS
5	Electrical Engineering	ETS
6	Law	Université de Sherbrooke
7	Political Sciences	UQAM
8	Mechanical Engineering	ETS
9	Environment	UQO
10	Innovation Management	ETS

Data was collected using interviews done at three moments of the competition and data on the creative performance of the groups were collected by adapting the experimental plan by Vangundi [14].

Interviews were prepared according to a questionnaire covering the following subjects:

1. Group composition and grouping characteristics
2. Ideas evolution and team previous experience of work
3. Perceived complexity of the problem
4. Performance of the leader

The main questions were:

1. What was the number of ideas before making the selection of the idea?
2. When was the idea selected?
3. When was the idea fully defined and what were the following activities?
4. What was the amount of time the group members had known each other?

What were the needs, resources and difficulties to develop the idea?

3 DATA ANALYSIS

3.1 Time Required for Team Building and Interdisciplinary Fields.

We adapted the VanGundy (VanGundy, 1984) evaluation of creative performance of team. The assessment consists of a questionnaire on how teams were created based on 16 personal characteristics: tolerance to ambiguity, ability to work with complex problems, flexibility of thought, capacity to come up with multiple ideas, research of original ideas, level of control over the project, perseverance, self confidence, risk taking, ability to see a problem from different points of view, extraversion, convergent and divergent thought, intuitive and analytic thought, ability to add details or improve on a proposed idea and interest in aestheticism and the ability for independent thought. VanGundy [14] also suggests teams internal characteristics: 1) same sex, 2) diversity of personality, 3) homogeneousness in creative skills 4) compatibility: when mutual needs are fulfilled 5) ability to work together 6) Vangundy proposed that the required time for team building is two years: less than two years of work experience have a lower score, and 7) group size: made of 3 to 4 members.

We adapted the assessment from VanGundy [14] to an evaluation according to five group characteristics, see Table 3. Each of these characteristic is evaluated by a scoring system from 1 to 5 (1 represents the absence of the characteristic, and 5 its higher presence). A higher score represents strong compatibility in a creative work team and clarity in reporting the complexity of the initial task assigned to them. In Table 3, we can observe the final results achieved by the teams.

The score inter-domain is high when the team was composed by different disciplines or professions. The item grouping time shows that inside the team there are members who know each other for more than 2 years (VanGundy [14] confers more score if the team have certain maturity). The homogenous item refers to the equal manner of discussing in the process of sharing the ideas given by the teammates. A high score means a good homogeneity in the manner of taking a decision by the team.

Table 3. Team characteristics adapted of Vangundy's group creative assessment [14]

Scores	T1- Charrette QPD	T27 - LPD
Inter-domain	3	3
Grouping time	4	2
Homogenous	2	3
Personal compatibility	5	2
Total	**14**	**10**

Personal compatibility is a score proposed for the leader to assess his/her perception of the compatibility between the members of his/her team.

3.2 The complexity of the problem perceived by the participants

The perception of the problem's complexity is evaluated through the form "assessing task clarity" [14, p. 138]. This evaluation allows the team members to estimate, amongst other things: the complexity of the problem by reporting their given efforts, their previous experience in the subject matter, the time needed to develop a solution and the number of procedures or operations required to complete the project. Table 4 presents general scores obtained by each team. Moreover, analyzing the VanGundy [14] results in Table 1 indicates the need to emphasize the efforts on the lowest scores in the assessment of complexity of the creative question.

Table 4. Task complexity adapted of Vangundy's assessment [14]

Scores	T1	T27
Domaine K	4	4
Complexity perception	3	3
Subjet-K project	4	3
Flexibility	4	4
Risks	4	2
Total	19	16

To analyze the results, VanGundy [14] proposed that the score of the group's composition form and the assessment of the problem complexity should be summarized. We choose an adapted scoring system from 0 to 20, and the assessment of the project's complexity score from 0 to 30. We observed in Table 3 and Table 4, certain homogeneousness in the results of the assessment of the Team's Composition (Table 3), and in the Complexity assessment (Table 4). We are inclined to think that these results are coherent with the mandatory numbers of teams within the competition and their freedom to select their subject of work.

It is to notice that VanGundy [14] mentioned that should pay attention to the lowest score. So, we decided to study the variable of the knowledge of the domain and the subject matter of the project, inside the item of Problem Complexity Assessment, as seen in Table 4.

3.3 Production of ideas (time variable)

3.3.1 Charrette activity 24H Bidart

In Figure 1, we find the results of the number of ideas produced and the time when the idea selected appeared. Figure 2 shows the amount of time spent in group work according to the teams themselves to the idea development process: 1i is the time that the first idea appeared and iD when the team finished the process of idea selection and then begins to work on the presentation.

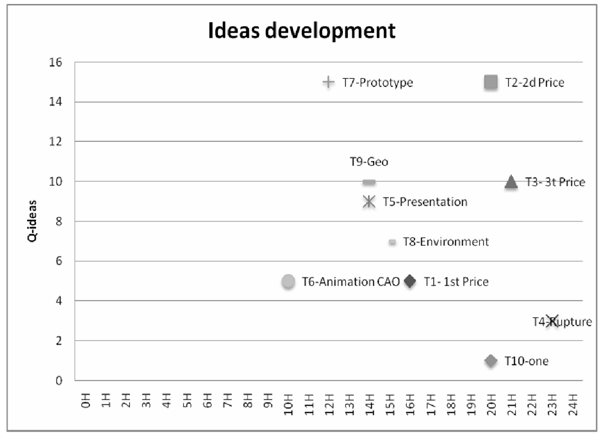

Figure 1. of ideas produced and time of idea selection throughout the competition.

In Figure 2, we placed the total production of ideas (Q-ideas) throughout the 24 hours until the time of the selection of the idea. The teams that came up with a large number of ideas, such as T7, T2, T9 as well as, the teams producing a limited number of ideas, such as T10, T4, T6 or T1 proceeded at a slower rate in reaching their selected idea.

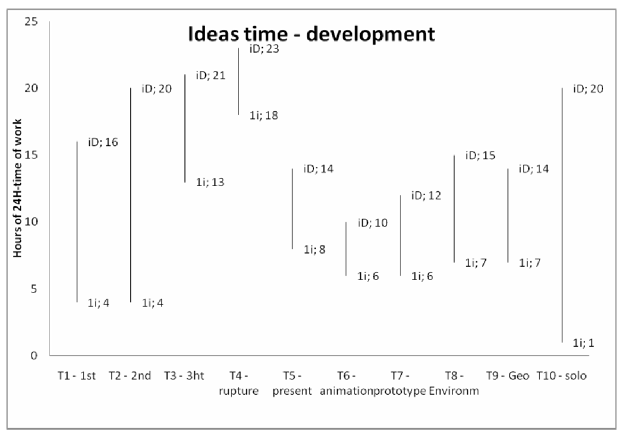

Figure 2. Time of development of the ideas by team.

Nijstad et al. [13] explain that teams can limit their creative flow by becoming attached to an idea too early in the process or by lacking of an idea selection. Another aspect that stands out is the importance given to details or deadlines. Also, the early work impacts the ideas production as seen in Figure 2. The teams that resort to different tools for modelling their ideas, progress much faster in the selection of their idea. We would like to highlight that team T6 and T7 were the most prepared in regards to informational tools. They also developed the most sketches and designs, and asked for help from the organizers to ensure that their selected idea was properly targeted within the criteria of competition.
In the teamwork dynamics, as shown the Figure 2, we could see a different pathway of development between the teams that were awarded by the project T1 to T4, and the teams T5 to T10 which developed some project characteristics: the presentation, the animation or the prototype realisation.

Also seen in Figure 2, the winning teams began creative teamwork quickly. Four hours after the beginning of the contest, T1and T2 were able to begin their creative work, while the other teams began their work only after at least six hours. In contrast, T1 and T2 had more time for the development of the idea from 16H to 20H. Teams T5, T6, T7, T8, and T9 had an early process of idea development from 10H to 15H; they spent more time in the detailed work of the idea selection. In that way, T5, T6, T7, T8, and T9 spend more time in some aspect of the idea presentation. Team T4, awarded the price "Rupture" had an atypical performance. It had a very low number of ideas (5) and a later process of development and selection. T1 and T2 had a better understanding of the subject matter of their project and applied a strategy of more elaborated ideas and product definition. The strategy of T5, T6 and T7 was centered on the presentation of one idea less matured. In the next section, we will propose an analysis of that kind of teamwork.
The teams with experience on the subject matter of the project such as T1 or T8, produced the lowest number of ideas, as well as T4 or T6 with the least experience. T2 and T7 produced the greater number of ideas. T4 and T7 required the most amount of time to select their final idea as seen in Figure 5.

3.3.2 Long-term Project Development
Following the 24H, the Canadian team, T27, was requested by the company they selected the project from, to continue developing its idea. The team had a period of 3 months to develop a working prototype. Because of several constraints on top of the team and task characteristics, the team shows a different behaviour when generating new ideas. Amongst those constraints, we count 1) the stress factor not being as present as during the 24H, 2) the availability of the members considering that the project was directed alongside of their school academic activities and the fact that the project began a few weeks before the exam period and the Holiday break, as well as 3) the availability of outside resources and equipment.

It is to be mentioned that the team was working on a solution that had been presented during the 24H, and this affected the scope of the project now being to take a concept and build a working prototype. To be able to do so, they required specific knowledge about the existing technologies and the equipment that supports it. Their academic background gave them basic knowledge for the work they had to accomplish, but the members still had to gain more experience to facilitate the work. The team also had to acquire the technologies either through ETS or the company to be able to carry out the development. Figure 4 shows the number of ideas produced throughout the three months. The development is now at week 8.

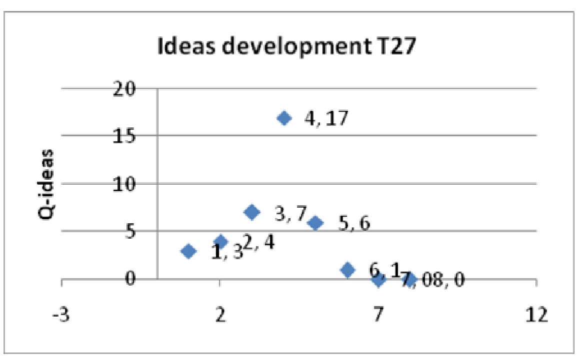

Figure 3. Number of ideas produced throughout the four months

Based on figure 4, we notice that the number of ideas is low during weeks 1 through 3, which represents the exam and the Holiday periods. This decrease is caused by the limited availability of the members and the personnel from the school and company during that period. The team generate a maximum of ideas at the return to school, week 4. Also, a decrease in idea generation appears as the project deadline approaches resulting from the stabilisation of the project and the arrival of the purchased equipment.

Although T27 members knew each other for 1 or 2 years prior to the 24H, they have never had the opportunity to work on the same project because of their field of study or the year they belong to. During the 24H, they got to know each other better and then choose to continue working together on the "real" project. This situation is another source of change in the idea generation behaviour.

3.4 Leader role in QPD or in LPD

In QPD or charrette, Lindsey et al (2003) [12] explain the role of facilators. The facilitators are able to "motivate the participants and keep the charrette on track, demonstrate skills in encouraging constructive contribution from all participants and adhering to the agenda to ensure participants and organizers are satisfied with the results" (p.10). Lindsey et al [12] suggest that all the participants commit to "add to the charrette experience through needed expertise, credibility, funding or support" (Idem). In fact, the advantage of the charrette is the identification of potential partners.
We assume that in the creative teamwork, in particular in the larger teams (T1 was composed by 10 participants according with Bidart protocol), the leader had a special role in the team performance. In order to improve the creative potential of the groups [14] "group leaders can exert considerable control in helping groups to attain this potential […] among the important group condition that a leader could control to some extent are openness to the ideas of others, willingness to take risks, perception of the internal environment as nonthreatening, feeling of freedom and spontaneity, and in general atmosphere of trust" (p. 7).
The leader influences the team dynamics and in our case, he could determine the team idea selection and the team idea development. Also, the leader could influence the team, when he/she manages the knowledge of the team and in the group idea selection or development, the leader could act like: "a proposer, a prescriber, an evaluator or a legislator" (Choulier, 2011, p.83). The data obtained does not let us analyze more deeply these roles, but we can observe that the leader of T1 had a relative high score as seen in Table 5.

Table 5. Leader intervention assessment

Scores	T1	T27
Leader K-sharing	5	3
Leader ideas acceptation	4	4
Leader process control	4	5
Self-esteem	5	3
Total	18	15

4 CONCLUDING REMARKS

The teams' work dynamic is the main subject to QPD and is favourable when the teammates possess the appropriate characteristics, both personal and as a group. Essentially, they must possess creative traits such as: tolerance to ambiguity, perseverance, flexibility of thought, the use of different media or research tools and the creative nourishment of the chosen idea. Moreover, the results are favourable when there is balance between previous experience and a large number of ideas produced in at earlier moment, and awareness and extended process of the selection of the ideas. This time, we didn't find enough information or data to conclude on the importance of the group maturity (time of the group work together for more than two years), as shown the Table 1, 58% of the awarded teams had more than two years of working together or the inter-domain or inter-disciplinary and it has effected on the team performance.

The range of professions amongst the participants creates an interdisciplinary effect, and we assume that this could have a positive effect on the team's composition and on the assessment of the perceived complexity of the issue. Nevertheless, the multidisciplinary group or the skills diversity did not have a direct influence on the results (of belonging)? Nevertheless, it makes the teams choose their subject matter with a certain level of comfort within the work team. Informally, they demonstrated the existence of an adequate work environment. It is interesting that in the almost 58% of the winning teams had members from different disciplines and, the teams who share the same discipline, were composed of students of different universities or were first year students.

We have observed the existence of two obstacles or situations that slow the dynamics of QPD: a) previous experience with issues in the field of work to be developed and only a small quantity of ideas produced, and b) minimal experience in the subject matter and a large quantity of ideas produced. In other words, if previous experience (previous knowledge of subject matter) produced a reduced number of ideas, what other skills or strategies allow the creative development of the team to improve? The work of T1 and T2 was focused on the strategy of idea definition and development, they took more than 16 hours of idea analysis and selection, while the other winning teams spend less time in the idea definition or selection and took more time to prepare the presentation (see Figure 3 and section 3.2), we observed a strategy of the presentation rather than of creative work. Moreover other questions such as, the influence of the small and bigger team on the creativity, the influence of the previous knowledge, etc. will be the object of future research.

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Modeling methodologies and simulations to investigate impact-induced traumatic injuries sustained by obese children

Jong-Eun Kim, Min-Heng Hsieh, Phillip C. Shum, Young-Ho Kim, Alan M. Shih
Department of Mechanical Engineering, University of Alabama at Birmingham,
Birmingham, AL 35294, USA

R. Shane Tubbs
Pediatric Neurosurgery, Children's Hospital,
Birmingham, AL 35233, USA

David B. Allison
Department of Biostatistics, and Nutrition Obesity Research Center,
University of Alabama at Birmingham,
Birmingham, AL 35294, USA

ABSTRACT

The prevalence of childhood obesity has substantially increased and is an important public health issue in most industrialized countries. Motor vehicle crashes (MVCs) continue to be the leading cause of injury and death for children worldwide. Sports activities and falls are other risks for unintentional traumatic injuries. Many studies have been conducted on injury prevention of children on the basis of average sized children and their surrogates. It is questionable as to whether or not current child protective and restraint systems that are optimized for the average sized children are safe enough for obese children. Moreover, risk and injury mechanisms of obese children in MVCs and other accidents are still unknown.

The objective of this study is to investigate quantitatively the impact-induced risk and injury severity sustained by obese children as compared to their nonobese counterparts. In general, computational impact analyses to simulate MVCs and other accidents are carried out using multibody or finite element models. The multibody method has been an attractive technique because of its capability of analyzing complex kinematics of the human body with easy modeling and rapid analysis. Meanwhile, finite element models provide a far more accurate representation of the biomechanical system than multibody models. However, finite element modeling and computer simulation are labor and time intensive processes.

Two different approaches are employed in this study. The first approach is to develop biofidelic finite element models of the child musculoskeletal system and flesh layer regarding various levels of obesity. Computational impact simulations are performed under a variety of scenarios including falls from various heights and frontal/side MVCs. The biomechanical responses (stress, strain, and deformation) of bone and soft tissues from model simulations are used for quantitative risk assessments that can estimate bony fracture and soft tissue lesion. One of the critical barriers to this approach is the scarcity of biofidelic finite element models of children. In this study, a validated in-house finite element model of a 10-year-old pelvis-femur complex is used to examine pelvis and hip injuries of obese children against dynamic loading conditions.

The second approach is to develop whole body models through a hybrid modeling technique integrating multibody and finite element methods. The existing multibody Hybrid III 3-year-old and 6-year-old dummy models, hereafter referred to as the standard models, are modified to develop obese child dummy models. To represent geometry and properties of subcutaneous adipose tissue in the torso, finite element models are created based on geometry data, which are reconstructed from magnetic resonance imaging (MRI) datasets of obese subjects. The torso adipose tissue models with a hyperelastic property of human fat are then integrated into the standard multibody models to represent obese occupants. This approach enables us to investigate the mechanistic roles of the adipose tissue (both momentum and cushion effects) on the injury severity. The inertial parameters and sizes of the limbs are also increased proportionally as obesity increases. Frontal MVC simulations are performed considering a variety of occupant restraint systems, and regional body (head, neck and thorax) injuries are measured. The injury outcomes from standard and a series of non-standard (at-risk, overweight, obese) dummy models are compared using statistical data analysis techniques to examine the effect of childhood obesity on regional body injuries in MVCs.

The outcomes of this study will advance our understanding of the injury mechanisms and provide strategies for improving safety for the rapidly increasing obese child population. This study is supported by the National Institutes of Health and the Nutrition Obesity Research Center at the University of Alabama at Birmingham.

Keywords: Obese children, Injury, Modeling, Finite element, Multibody.

Modeling of wind turbine performance in complex terrain using dynamic simulation

Aapo KOIVUNIEMI, Daniil PERFILIEV, Janne HEIKKINEN, Olli PYRHONEN, Jari BACKMAN
Lappeenranta University of Technology
Lappeenranta, 53851, Finland

ABSTRACT

Sharp wind speed changes with height is significant in areas with complex terrain, such as in Finland with its complex terrain and large areas of forested land. This study evaluates turbine power production simulation with accurately measured wind shear profiles for dynamic simulation using Unsteady Blade Element Momentum Method (BEMM). The time-dependent BEMM calculation is done for each blade, where also the flapping and lead-lagging phenomena are included. The developed Simulink model uses a variable speed pitch controlled system, where the related electrical and mechanical losses are included. This model is a new contribution to previous Simulink models of wind turbines. The wind shear profile calculation was compared with the conventional power curve calculation method that is based on velocity profiles at nacelle height. The results showed an increase of 3.5% in energy production, which would affect the expected yield during the turbine life-time performance. The difference is caused by the wind shear consideration and by the introduced dynamic model that takes into account the mechanical and electrical transient processes.

Keywords: wind turbine, dynamic simulation, unsteady BEMM, Simulink

1. INTRODUCTION

Wind resource estimation of a planned wind farm site is one of the most important activities when a wind farm investment is prepared [1]. The wind resource estimates are based on wind measurements, long-term wind data, and topographical site modeling. The analysis is executed using software tools commonly named as wind farm design tools (WFD tools). Annual energy production (AEP) evaluation requires detailed knowledge of wind turbine performance in addition to wind data. WFD tools apply power curves of the turbines to estimate the turbine output power within given wind conditions. The power curve is typically based on a single verification site as described in [2], and is thus valid only within wind conditions reasonably close to the verification site. For this reason, the WFD tools should make corrections to AEP estimates based on the measured wind shear and turbulence. In complex inland terrain having forests, hills, and gorges, the wind shear values may deviate from those used in turbine design. In such cases, assumptions related to the turbine power curve may not be valid. WFD tools may also give wrong results not only due to power curve inaccuracies, but also because of difficulties to model a higher wind shear compared with traditional wind farm sites. In Finland, the planned wind power tariff system has raised interest in wind farm investments also in wide inland areas with complex terrain.

Wind speed measurements in the south-eastern part of Finland have been the starting point of this study. The measurements were carried out using LIDAR equipment. The needed aerodynamical and mechanical information for calculation was based on the 1.5 MW WindPACT prototype wind turbine by National Renewable Energy Laboratory (NREL). The only modification is that the turbine is assumed to have a direct drive generator. The choice of turbine was motivated by the fact that aerodynamic and performance data for this turbine are easily available unlike in the case of many commercially used turbines.

Unsteady Blade Element Momentum Method (BEMM) can be used for aerodynamic analysis of wind turbine when a time-dependent wind flow is modeled [3]. This paper presents a method for turbine simulation and energy production estimation, where the dynamic model consists of unsteady BEMM describing rotor performance, basic mechanical structure calculations, generator and turbine control loops. A comparison of the proposed simulation method with an energy production approximation is made based on standard power curve calculation using wind velocity measurements at the hub height. The main study goal is to create universal Simulink model of wind turbine aerodynamics, drive train and control system, which does not exist so far.

2. SIMULINK MODEL

When considering the opportunities of wind farm erection or manufacturing a new turbine one has to model its behavior under appropriate conditions to avoid expensive experiments. Usually, industrial commercial software is used for these purposes. National Renewable Energy Laboratory developed software package that includes ADAMS, FAST, WT_Perf and others, which can process aerodynamical and mechanical calculations. Use of multiple software packages makes interactive operation of different model parts challenging and requires a lot of interfacing. GHBladed is a commercial software package, which combines necessary dynamic modules for wind turbine performance simulation. Although it provides a more user-friendly interface, the price for the whole package can turn many researchers and businessmen away from it. The main problem of all mentioned software for researchers is that one can't go deep inside to the "initial code" and make additions by himself. In other words, this software is limited to the used turbine models and operated methods they came with. This limitation might not seem important for project managers and engineers, but is crucial for wind energy researchers. To create such universal wind turbine model that can be filled in by new different blocks in future Simulink/Matlab environment was chosen as widespread modeling tool among researchers all over the world.

General view of the model is presented on Figure 1. It consists of Input information block, Rotor model with its aerodynamical and mechanical calculations, Loss model calculation block, Generator model, as well as rotational speed and pitch angle control blocks.

3. UNSTEADY BEMM

To determine the energy production of wind turbines in stationary wind conditions, it is sufficient to apply the classical Blade Element Momentum Method [3]. However, due to

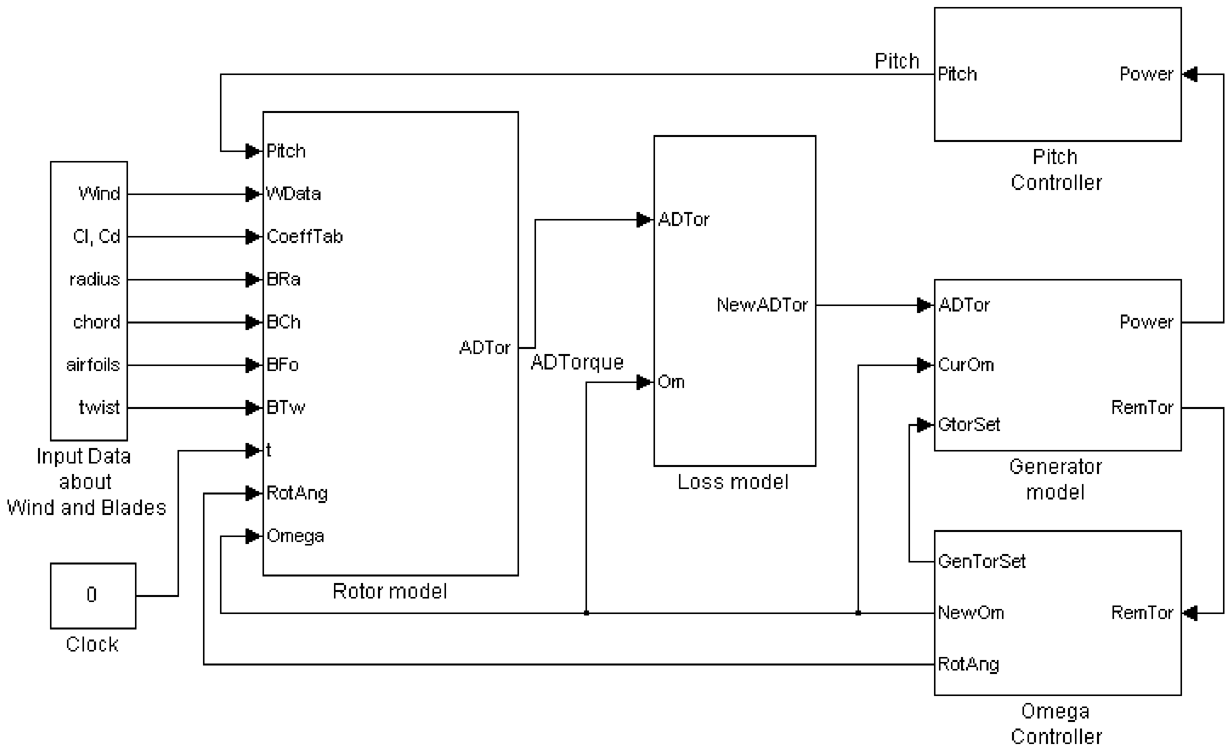

Figure 1. Simulink dynamic model of wind turbine

atmospheric turbulence, the wind flow is unstable, and therefore one must use the time-dependent or unsteady BEMM, which allows to take into account the previous state of the rotor and its impact on the next time step. Main goal of the method is to determine the torque on the shaft of the turbine-generator and forces acting on each blade element (total number of elements are usually about 30-60) on every time step. Mentioned parameters are depended on *relative wind velocity* $\mathbf{V}_{\mathbf{rel}}$ seen by each blade element (see Figure 2). Relative wind velocity vector consist of undisturbed wind velocity $\mathbf{V}_\mathbf{0}$, rotational velocity $\mathbf{V}_{\mathbf{rot}}$ (ω and θ_{cone} are not visible in Figure 2), and induced velocity $\mathbf{W}$:

$$\mathbf{V}_{\mathbf{rel}} = \mathbf{V}_\mathbf{0} + \mathbf{V}_{\mathbf{rot}} + \mathbf{W} \Rightarrow$$
$$\begin{pmatrix} V_{rel,y} \\ V_{rel,z} \end{pmatrix} = \begin{pmatrix} V_y \\ V_z \end{pmatrix} + \begin{pmatrix} -\omega x \cos\theta_{cone} \\ 0 \end{pmatrix} + \begin{pmatrix} W_y \\ W_z \end{pmatrix} \quad (1)$$

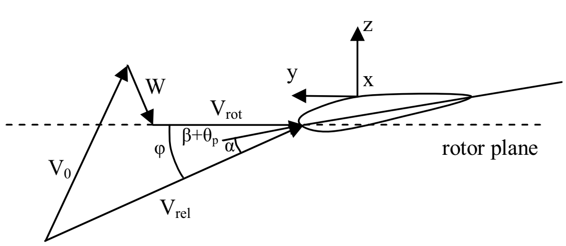

Figure 2. Velocity triangle seen by the blade element [3].

The angle of wind flow attack, α, defines values of lift and drag coefficients:

$$\alpha = \phi - (\beta - \theta_p) \quad (2)$$

where $\tan\phi = \dfrac{V_{rel,z}}{-V_{rel,y}}$, ϕ is relative angle of attack, β is blade element twist angle, θ_p is blade pitch angle.

The essence of the BEMM is to determine induced velocity $\mathbf{W}$ and than the local angles of attack for each element.

To get undisturbed wind velocity $\mathbf{V}_\mathbf{0}$ seen by the blade element we need to transform the stream velocity $\mathbf{V}_\mathbf{1}$ from inertial coordinate system placed at the bottom of the tower to coordinate system connected with blade element (see Figure 3) by mean of transformational matrixes:

$$\mathbf{V}_\mathbf{0} = \begin{pmatrix} V_x \\ V_y \\ V_z \end{pmatrix} = \mathbf{a}_{45} \cdot \mathbf{a}_{34} \cdot \mathbf{a}_{23} \cdot \mathbf{a}_{12} \mathbf{V}_\mathbf{1} \quad (3)$$

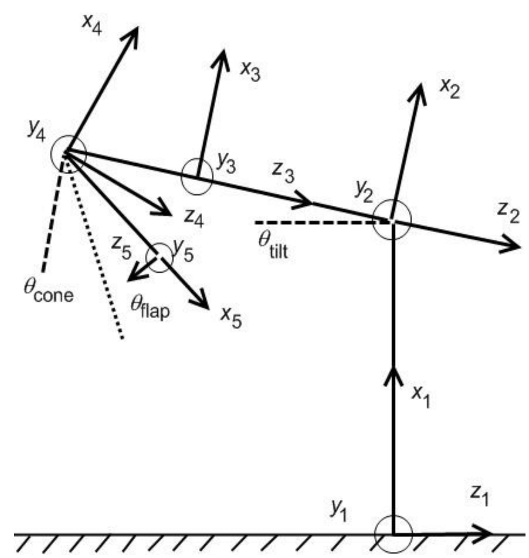

Figure 3. Wind turbine coordinate systems [3] with proposed additional coordinate system 5.

Coordinate system 1 is connected with bottom of the tower (ground), system 2 with turbine nacelle, system 3 with generator-turbine shaft which is considered being stiff; system 4 with coned blades [3]. Coordinate system 5 with flapped and lead-lagged blade elements has been added to describe mechanical deformation of blades. Transformational matrixes are defined by following equations:

$$\mathbf{a_{12}} = \begin{pmatrix} 1 & 0 & 0 \\ 0 & \cos\theta_{yaw} & \sin\theta_{yaw} \\ 0 & -\sin\theta_{yaw} & \cos\theta_{yaw} \end{pmatrix} \times \begin{pmatrix} \cos\theta_{tilt} & 0 & -\sin\theta_{tilt} \\ 0 & 1 & 0 \\ \sin\theta_{tilt} & 0 & \cos\theta_{tilt} \end{pmatrix} \times \begin{pmatrix} 1 & 0 & 0 \\ 0 & 1 & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{4}$$

$$\mathbf{a_{23}} = \begin{pmatrix} \cos\theta_{wing} & \sin\theta_{wing} & 0 \\ -\sin\theta_{wing} & \cos\theta_{wing} & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{5}$$

$$\mathbf{a_{34}} = \begin{pmatrix} \cos\theta_{cone} & 0 & -\sin\theta_{cone} \\ 0 & 1 & 0 \\ \sin\theta_{cone} & 0 & \cos\theta_{cone} \end{pmatrix} \tag{6}$$

$$\mathbf{a_{45}} = \begin{pmatrix} \cos\theta_{flap} & 0 & -\sin\theta_{flap} \\ 0 & 1 & 0 \\ \sin\theta_{flap} & 0 & \cos\theta_{flap} \end{pmatrix} \times \begin{pmatrix} \cos\theta_{l-lag} & \sin\theta_{l-lag} & 0 \\ -\sin\theta_{l-lag} & \cos\theta_{l-lag} & 0 \\ 0 & 0 & 1 \end{pmatrix} \tag{7}$$

Position of the blade element in system 5 is defined by vector $\mathbf{r_5}$=(x,0,0)+(x_1,y_1,z_1), where x is the blade element length and (x_1,y_1,z_1) is the location of end point of previous blade element relative to the turbine hub. These coordinates are transformed to coordinate system 1, because the incoming wind velocity is given in the fixed system:

$$\mathbf{r_1} = \mathbf{a_{12}^T} \cdot \mathbf{a_{23}^T} \cdot \mathbf{a_{34}^T} \cdot \mathbf{a_{45}^T} \cdot \mathbf{r_5} \tag{8}$$

The coordinate transforms are used to find out the correct position of a blade element in coordinate system 1, and to project the wind speed vector from coordinate system 1 to coordinate system orthogonal to the blade element.

To calculate induced velocity **W** a dynamic inflow model is applied. It stated that induced velocity can be described by two first order differential equations:

$$W_{\text{int}} + \tau_1 \frac{dW_{\text{int}}}{dt} = W_{qs} + k\tau_1 \frac{dW_{qs}}{dt} \tag{9.a}$$

$$W + \tau_2 \frac{dW}{dt} = W_{\text{int}} \tag{9.b}$$

where W_{int} is intermediate, W_{qs} is quasi-static and W is final filtered values. Two time constants are defined as:

$$\tau_1 = \frac{1.1}{(1-1.3a)} \cdot \frac{R}{V_0}$$
$$\tau_2 = (0.39 - 0.26\left(\frac{r}{R}\right)^2) \cdot \tau_1 \tag{10}$$

where R is the rotor radius, k equal to 0.6 and a is the axial induction factor that is not allowed to exceed 0.5. It is defined as:

$$a = \frac{|\mathbf{V_0}| - |\mathbf{V_0} + f_g \mathbf{n}(\mathbf{n}\cdot\mathbf{W})|}{|\mathbf{V_0}|} \tag{11}$$

n is the unit vector equal to (0,0,-1). f_g is known as Glauert correction factor for turbulent wake state. The following experimental relations are used to calculate it:

$$f_g = \begin{cases} 1 & for\ a \le 0.2 \\ \frac{0.2}{a}(2 - \frac{0.2}{a}) & for\ a > 0.2 \end{cases} \tag{12}$$

To solve equation system (9) several steps shall be done. First calculate $W_{qs}^{\ i}$ using equation:

$$\begin{pmatrix} W_{qs,y}^i \\ W_{qs,z}^i \end{pmatrix} = \begin{pmatrix} \dfrac{-BL\sin\phi}{4\pi\rho xF|\mathbf{V_0} + f_g\mathbf{n}(\mathbf{n}\cdot\mathbf{W})|} \\ \dfrac{-BL\cos\phi}{4\pi\rho xF|\mathbf{V_0} + f_g\mathbf{n}(\mathbf{n}\cdot\mathbf{W})|} \end{pmatrix} \tag{13}$$

where B – number of blades, L – lift force, ρ =1.225kg/m^3 – air density, F- tip and hub loss factor. The latest is defined as:

$$F = \frac{4}{\pi^2}\cos^{-1}\left[\exp^{-\frac{B}{2}\frac{R-r}{r\sin\phi}}\right]\cos\left[\exp^{-\frac{B}{2}\frac{r-R_{hub}}{R_{hub}\sin\phi}}\right] \tag{14}$$

Second, calculate right hand side of equation (9.a) using backward difference:

$$H = W_{qs}^i + k\tau_1 \frac{W_{qs}^i - W_{qs}^{i-1}}{\Delta t} \tag{15}$$

Than solve equation (9.a) analytically:

$$W_{\text{int}} = H + (W_{\text{int}}^{i-1} - H)\exp(\frac{-\Delta t}{\tau_1}) \tag{16}$$

And finally define analytically the induced wind velocity vector:

$$W^i = W_{\text{int}}^i + (W^{i-1} - W_{\text{int}}^{i-1})\exp(\frac{-\Delta t}{\tau_2}) \tag{17}$$

Lift and drag forces are computed as:

$$L = \frac{1}{2}\rho|\mathbf{V_{rel}}|^2 cC_l$$
$$D = \frac{1}{2}\rho|\mathbf{V_{rel}}|^2 cC_d \tag{18}$$

where c is chord of blade element, C_l, C_d are lift and drag coefficients correspondingly.

As probably already noticed calculation of the relative wind velocity is not linear process, instead it should be found iteratively. To summarize the unsteady BEMM let's give step by step instruction for calculations of each blade element:

1) define position and preliminary velocities for each blade element by Eq. (4)-(7),(8),(1) using old values for induced velocity;
2) define the flow angle and angle of attack by Eq.(2), look in the table for appropriate C_l and C_d coefficients.
3) define lift and drag forces by Eq. (18)
4) define new values for induced velocity by Eq. (9) and (10)
5) recalculate relative angle of attack, Eq. (1) and (2), with new values of induced velocity

6) continue the procedure from step 3) until the relative wind velocity will converge.

The normal and tangential forces can be calculated with obtained values of lift, drag and relative wind flow angle:

$$\begin{aligned} p_z &= L\cos\phi + D\sin\phi \\ p_y &= L\sin\phi - D\cos\phi \end{aligned} \tag{19}$$

3.1 STRUCTURAL MECHANICS OF BLADES

Mechanics of turbine blades are roughly taken into simulation procedure. Deformations of each blade are simulated by employing the linear equations of structural mechanics, which are valid for small deflections (although in reality deflections can be large and nonlinear analysis that takes relatively long computational time should be applied). Following equations are used for defining deflections if the calculated point x is located further than the single force point from the fixed end of the beam [4]:

$$v(x) = \frac{Fa^2 l}{6EI}\left(3 - \frac{a}{l} - \frac{3x}{l}\right) \tag{20}$$

where F denotes force component, a is location of the force point from the fixed end, l is length of the beam, E is Young's modulus (equal to 73 GPa for E-class glass fiber) and I is second moment of inertia, which can be calculated by using equation:

$$I_y = \int y^2 dA \tag{21}$$

for the second moment of inertia about y-axis y is the distance from the y-axis to the elemental area dA. If the point x is located closer to the fixed end than the force, the following equation is used:

$$v(x) = \frac{Fa^3}{6EI}\left(2 - 3\frac{x-b}{a} + \frac{(x-b)^3}{a^3}\right) \tag{22}$$

where b is force location from the free end. Slope of the deformation curve is derivatives of equations shown above.

A single blade is divided into number of elements. The cross section of the blade is modeled with average chord and height of the blade along the whole length and twist angle is assumed to be zero. The constant cross-section is used in all elements. On each time step, there are force components in all three global directions in all elements. Only tangential and axial projections of the force are taken into account in deformation analysis. Superposition principle is used to get the deflections in both studied directions. Deflections due to forces are calculated and flapping angle and lead lag angle of each element is taken into next time step to calculate continuous deflections. Force components are changing if the blade angles are changing. By using simplified linear equations the real deflections are not gotten, but the objective is to give a hint how these deflections are affecting the force components and further overall torque and power of the generator. For more sophisticated analysis, a nonlinear static analysis and more accurate geometric model should be used, by utilizing, for example, Finite Element Method.

4. ROTOR DYNAMICS, GENERATOR AND PITCH CONTROL LOOP

The wind turbine examined in this study has a variable speed pitch controlled system. Rotational speed adjustment is used for maintaining the optimal tip speed ratio to generate maximum power, while the pitch control system limits the aerodynamic power of the wind turbine at high wind speeds in order to prevent overloading of electrical components and to limit mechanical loads. Rotational speed and pitch angle should be changed dynamically with the change in the incoming stream velocity. For this purpose, proportional and integral controllers are used. The dynamics of the rotor speed is given by equation:

$$\frac{d\omega_{rot}}{dt} = \frac{T_{rot} - T_{gen}}{J} \tag{23}$$

where J is the moment of inertia of the turbine-generator system. In this study, the moment of inertia was calculated assuming that the hub is a solid cylinder and the blades are rods attached to the hub, with sizes and masses found in [5], and the moment of inertia of the direct drive generator was assumed to be approximately 0.5×10^6 kgm^2. This gives an approximation of J equal to 5.5×10^6 kgm^2.

The generator torque proportional to square of rotational speed and its characteristic is described by equation:

$$T_{gen} = \frac{1}{2}\rho\pi\frac{\omega_{rot}^2 R^5}{\lambda_{opt}^3}C_{p,\max} = K\omega_{rot}^2 \tag{24}$$

The coefficient of proportionality is calculated to be K = 91521 Nms^2/rad^2 (R=35m, λ_{opt}=8, $C_{p,max}$=0.46, ρ=1.225kg/m^3).
Output electrical power of wind turbine is defined through generator torque, rotational speed and losses:

$$P_{out} = T_{gen}\cdot\omega_{rot}\cdot\eta \tag{25}$$

Pitching of blades starts when the aerodynamic power of turbine exceeds the nominal generator power. By decreasing the wind flow angle of attack, the generated aerodynamic power can be reduced. The pitch change law is given as:

$$\frac{d\theta_{rot}}{dt} = \frac{K_I(P - P_{ref})}{1 + \frac{\theta_{rot}(t)}{K_K}} \tag{26}$$

In the equation, P_{ref} is the nominal power of the generator, which should not exceed 1.5 MW. The integral controller coefficient K_I and the gain reduction constant K_K are determined experimentally in order to meet the stated requirements and to keep the rate of pitch chance within a reasonable range. In this study, the following values are set: K_K=10^{-3}deg, K_I=10^{-6} deg/(Ws).

5. ELECTRICAL AND MECHANICAL LOSSES

Turbine drive train losses include all the electrical and mechanical losses when converting rotor mechanical power to electrical power measured at the turbine transformer output. Sometimes the transformer losses are included into transmission and distribution losses instead of drive train losses. In the case of accurate loss analysis, the losses should be modeled as a function of load, as described for instance in [6]. As a part of that study, electrical losses in full and partial loads of multiple drive train variants have been analyzed and reported. The loss distribution of direct drive system with different loads is shown in Table 1. In the simulation model a lookup table with linear interpolation and constant end values were used.

Table1. Drive train loss distribution [kW] and total efficiency [%] of 1.5MW direct drive wind turbine according to [7].

Power	Gen	Cabel	Act Rec.	DC Link	Util. Inv.	Filt.	Trans.	ALL	η [%]
90	8	0.8	3.3	1.1	4.2	0.8	3.4	21.6	80.65
375	15	2.5	3.9	1.4	4.8	1.4	4.5	33.5	91.8
750	29	5.7	6.3	1.8	9.9	3.2	6	61.9	92.38
1125	52	11.7	10.2	2.1	15.9	5.2	7.5	104.6	91.49
1500	85	20.1	15	2.5	22.8	10.4	9	164.8	90.1

The same values of partial load electrical losses were used in both methods under comparison.

An attempt was also done to model mechanical losses of main shaft bearings, which were considered to be double row radial spherical roller bearings [5]. The friction in a bearing consists of two parts – applied load M_l and lubricant viscous friction M_v [8]. The applied load friction depends only on the weight of the supported load (shaft and rotor) and is static during normal operation, while the viscous friction is also dependent on the rotational speed of the rotor. The basic formulas are:

$$M_f = M_l + M_v \tag{27}$$

$$M_l = \frac{F^{1.5} d^{-0.5}}{1000} \tag{28}$$

$$M_v = \begin{cases} 10^{-7} f_o d_m^3 \left(v_o N\right)^{\frac{2}{3}}, N \geq 12rpm \\ 160 \cdot 10^{-7} f_o d_m^3, N < 12rpm \end{cases} \tag{29}$$

where F is the weight of the load, d is the bore diameter of the bearing, d_m is the pitch diameter of the bearing, v_0 is the kinematic viscosity of the lubricant, N is the rotational speed of the rotor and f_0 is a constant depending on the lubrication method. The values for constants f_0, d_m, d and v_0 in the formulas were discovered in a suitable bearing catalog based on the bearing dimensions and type described in [5]. However it should be noted that the effect of the bearing friction is very small.

6. ENERGY PRODUCTION ESTIMATION USING POWER CURVE OF WIND TURBINE

Energy production E of a wind turbine is commonly calculated using following equation [1]:

$$E = T \int_0^\infty pr(u) Pw(u) du \tag{30}$$

In the formula, T is the calculation time, u is the hub height wind speed, the distribution $pr(u)$ is the probability of wind speed u, and the power curve $Pw(u)$ is the power produced when the wind speed is u. This power-curve-based method is widely used in most WFD tools [1, 10,11].

The power curve $Pw(u)$ is obtained using the previously described dynamic simulator with artificially generated wind data as input. The synthetic data contained a slowly and linearly rising wind speed from 0 m/s to 25 m/s. The generated output power value divided into 50 speed bins and averaged within these bins to estimate the mean power for every speed bin. This method is used in the IEC standard for wind turbine power curve measurement [2]. The produced power curve is presented on Figure 4.

The measured wind speeds divided into similar speed bins as seen in Figure 5. The integral eq.(30) calculated using the standard approximate rectangle method

$$E \approx T \sum_{n=0}^{50} pr(n) Pw(n) \tag{31}$$

where n is the number of the speed bin.

7. WIND DATA DESCRIPTION

The wind data used in this article is measured using LIDAR equipment in Lappeenranta, southeastern Finland. The device measured wind speeds at 20 meter height intervals each second. The maximum height used is 200 meters. The LIDAR data contains several blanks and other clear errors, which is filled with measured wind data from a nearby TV tower. A data period of 168 hours from 17 to 23 Oct 2010 is selected since it contained days with low, medium and high winds, as can be seen in Figure 6.

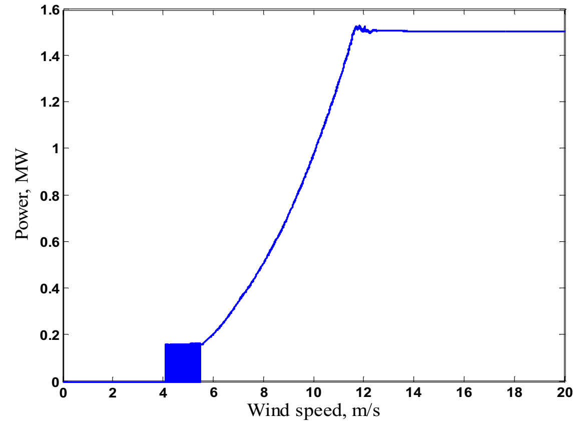

Figure 4. Artificial power curve of wind turbine.

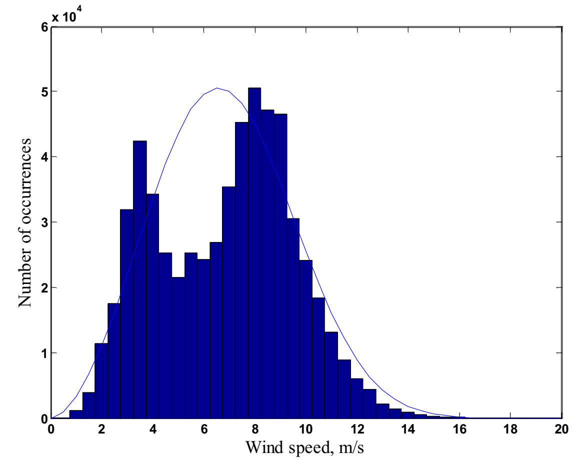

Figure 5. Wind speed bins and the Weibull fit.

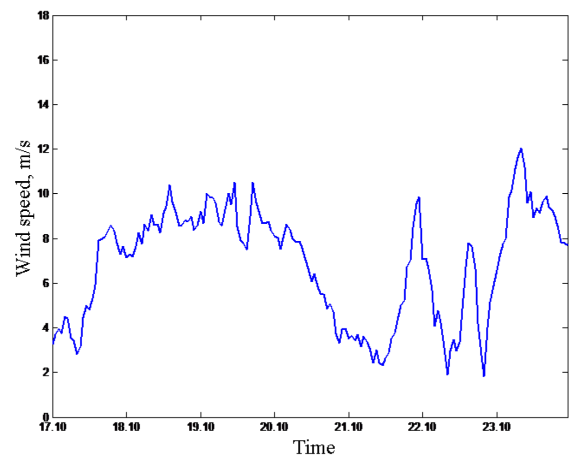

Figure 6. Tower height wind speed data.

The dynamic simulation uses the data directly as a time series. With a one-second sampling time, the time series has 604 800 samples. For the power curve calculation, the wind velocity distribution has to be extracted from the data. While the most commonly used distribution for wind data is the Weibull distribution, it does not fit the emergent omni-directional wind distribution well, as seen in Figure 5. This is likely due to the short measurement period. For this reason, it is decided to use the emergent distribution for the power-curve-based calculations.

8. COMPARISON OF POWER CURVE WITH DYNAMIC SIMULATION MODEL

One of the objectives of the study was to compare two methods of calculating wind turbine energy production. The power curve calculation method is used by most WSD tools, and can therefore be taken as the base method. However, the results obtained with the studied dynamic model of the turbine are more realistic, since the change of the wind speed with height, ignored by the first model, is essential to the final result.

The basic method, which uses the power curve, showed that the wind turbine energy production for given wind conditions over the investigated time interval of one week is 72.43 MWh. The analysis of the same input conditions by the dynamic model identifies produced energy at the rate of 75.03 MWh representing the difference of 3.5%. The difference of 3.5% in terms of economics, using the proposed 83.5€/MWh [12] feed-in tariff for wind turbines and estimating the real annual capacity-hours to be about the typical 2400h [7], the production difference obtained is about 3000€/turbine/year, or about 600000€ for the 20 year usable life of a small 15 MW wind farm. Thus, the use of the basic method may produce a large error when designing the installation of a windmill.

There are several reasons for this. Firstly, the dynamic model takes into account the change in wind speed with height and the associated asymmetrical distribution of energy produced by individual blades of the turbine rotor depending on their position in the vertical plane of rotation. This phenomenon of sharp wind speed change with height is significant in areas with complex terrain, such as in Finland with its complex terrain and large areas of forested land. Secondly, the dynamic model with its unsteady BEMM takes into account the transient processes occurring with spontaneous changes in wind speed. But when using the power curve it is assumed that the turbine power changes instantly according to the wind.

9. CONCLUSIONS

This paper presents a wind turbine model created in the Simulink environment. The unsteady BEMM constitutes the core of the dynamic model. It takes into account the transient processes occurring with inconstant changes of the wind speed. The global clusters include wind turbine aerodynamic calculations, basic structural mechanics, generator model, and controllers. The developed model allows to take into account instability in the wind speed distribution with height. To determine the adequacy of the dynamic model, it is compared with the classical technique based on power curve calculations generated artificially. The analysis is based on the data of actual one-week wind speed observations near the town of Lappeenranta, Finland in October 2010.The aerodynamical and mechanical information required for calculation was determined based on the WindPACT 1.5 MW wind turbine.

A comparative analysis shows that the estimated energy output determined by the dynamic model is 3.5% more than the one determined by the power curve method. Hence, it can be argued that when considering wind turbine projects, one should use a dynamic model in order to obtain adequate results without neglecting the wind speed distribution with height as well as dynamic behavior of wind speeds. Ultimately, this has a significant influence on the decision of wind turbine installation.

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Design, Model Calculation and Preparation of Molecular Dye Sensor Compounds

Young-A SON, Hyungjoo KIM
Department of Advanced Organic Materials Engineering, Chungnam National University
Daejeon, 305-764, S. Korea

and

Do-Hyun LEE
Korea Dyeing Research & Technology Center, S. Korea

The popularity of organic dye chemosensors in material science and chemical engineering has been rapidly growing, being enjoyed in the science and engineering field for various applications [1-5]. The opto-based absorption and emission properties of organic chemosensor dyes were prepared and discussed in terms of their model calculation approaches and empirical results in electron transfer systems. Studies on attractive absorption changing property of dye sensor chromophore and fluorophore have been greatly enjoyed in the related industrial and research fields such as optoelectronics, chemosensor, biosensor and so on. The optical property based on intramolecular charge transfer system of dye sensor molecules can be utilized as suitable sensing probes for checking media polarity and determining colorimetric chemosensing effect, especially hazardous parts detection.

In this work, electron pushing-pulling system dye sensors were designed and synthesized with the corresponding donor and acceptor groups. The selected donor moieties might be provided prominent amorphous properties which are very useful in designing and synthesizing functional polymeric molecules and in fabricating devices. Other reasons to choose are commercial availabilities in high purity and low price. Donor-bridge-acceptor (D-A) type dye sensors can produce impressive optical-physical properties, yielding them potentially suitable for applications in the synthesis of small functional organic molecules. Small organic functional molecules have unique advantages, such as better solubility, amorphous character, and represent an area of research which needs to be explored and developed. Currently, their applications in metalorganic compounds is rapidly expanding and becoming widespread in self-assembly processes, photoluminescence applications, chiral organocatalysts, and ingrafts with nanomaterials.

In addition, the molecular structures and the status of energy levels were designed and modeled to obtain the desired characteristic in chemosensor functions. In this context, the results of molecular orbital computer simulations, based on DMol3 simulation of Material Studio, were found to provide a reasonable explanation for the observed spectral properties. The molecular orbital (HOMO and LUMO energy level) of dye-sensors were computationally optimized using the density function theory (DFT) with exchange correction functional of local density approximation (LDA) based on the Perdew-Wang (PWC) set and the levels were compared with the experimentally determined data, being calculated by cyclic voltammetry. The obtained findings were related to the push-pull features causing dramatic electron flows in absorption as well as in photoluminescence.

Thus, the prepared dye sensors were investigated with absorption and emission properties, solvatochromic behaviors, pH induced color switching effects, chemosensing effects and HOMO/LUMO energy potentials with computer simulation. And the related details were then discussed.

ACKNOWLEDGEMENTS

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Analog Modeling Complex Dynamical Systems Using Simple Electrical Circuits

Elena TAMAŠEVIČIŪTĖ
Department of Mechanical and Process Engineering, Swiss Federal Institute of Technology Zürich
Zürich CH-8092, Switzerland

Gytis MYKOLAITIS
Department of Physics, Vilnius Gediminas Technical University, 11 Saulėtekio
Vilnius LT-10223, Lithuania

and

Arūnas TAMAŠEVIČIUS
Nonlinear Electronics Laboratory, Center for Physical Sciences and Technology, 11 A. Goštauto
Vilnius LT-01108, Lithuania

ABSTRACT

Simple analog electrical circuit representing complex dynamical system is described. As case study an array of thirty FitzHugh–Nagumo coupled electronic oscillators, imitating dynamics of neurons, is considered. Due to the parallel processing analog simulation exhibits very fast performance compared with the numerical integration.

Keywords: Analog Computing, Analog Models, Analog Electrical Circuits, Oscillators and Networks.

1. INTRODUCTION

There are many examples in science and engineering where analog electrical circuits have been used to model temporal evolution of dynamical systems. This modeling method has been applied to diverse disciplines and areas. The Mackey−Glass delay differential equation, well known to describe hematological disorders, has a simple electronic analog [1]. A simple electrical circuit has been suggested [2] to imitate the chaotic behavior of a periodically forced mechanical system, described by the Duffing−Holmes equations. Several electrical circuits have been proposed to model the dynamics of neurons [3, 4]. A very interesting solution has been suggested to model mammalian cochlea using high order electrical circuit [5]. One more example is the electrical circuit modeling movement of a spacecraft at the Lagrange point of the astrodynamical Sun−Earth system [6]. It should be emphasized that design of such electrical circuits is not for its own purpose. The analog circuits mentioned above have been employed for testing various methods developed to control dynamics of the systems, specifically to stabilize either steady states [6-9] or periodic orbits [10]. In addition, experiments with electronic analogs can help to better understand the mechanisms behind the behaviors of complex systems, e.g. pitch in human perception of sound [11]. Moreover, the electronic cochlea provides an efficient design of an artificial hearing sensor [12].

One can argue that there is no difference between an analog electrical circuit, imitating a dynamical system, and an analog computer, solving corresponding differential equations. We note that any analog computer is a standard collection of the following main blocks: inverting RC integrators, inverting adders, invertors, inverting and noninverting amplifiers, multipliers, and piecewise linear nonlinear units. Programming of the differential equations on an analog computer is simply wiring these units according to strictly predetermined rules. Differences between the "intrinsically" analog electrical circuits, simulating behavior of dynamical systems, and the conventional analog computers were discussed by Matsumoto, Chua and Komuro 25 years ago in [13]. In this regard it makes sense to present here an excerpt of their paper: "… *the circuit … is not an analog computer in the sense that its building blocks are not integrators. They are ordinary circuit elements; namely, resistors, inductors and capacitors. Both current and voltage of each circuit element play a crucial role in the dynamics of the circuit. On the contrary, the variables in a typical analog computer are merely node voltages of the capacitor− integrator building−block modules, where the circuit current is completely irrelevant in the circuit's dynamic operation. Hence it would be misleading to confuse our circuit as an analog computer…*" [13].

In the present paper, we describe an analog model presented as case study, namely a network of simple electrical circuits, which imitates dynamics of interacting neurons.

2. MATHEMATICAL MODEL

The mathematical model is given by a set of coupled ordinary differential equations [13]:

$$\dot{x}_i = ax_i - F(x_i) - y_i - b_i + c(<x> - x_i),$$
$$\dot{y}_i = x_i - dy_i, \quad i = 1,2,\dots N, \quad <x> = \sum x_i / N,$$
$$F(|x_i| \le 1) = 0, \quad F(x_i < -1) = d_1 x_i, \quad F(x_i > 1) = d_2 x_i.$$

Here c is the coupling factor; N is the number of cells.

3. NUMERICAL SIMULATION RESULTS

Numerical simulations for $N = 30$, $a = 3.4$, $b_i = 3 - 0.05(i - 1)$, $d = 0.15$, $d_1 = 60$, $d_2 = 3.4$ were performed using the FREEPASCAL software with the integration step $h = 10^{-4}$. Typical results are presented in Figs. 1–4.

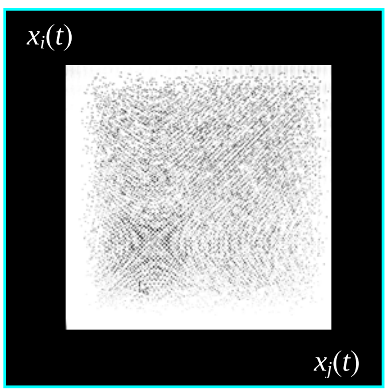

Fig. 1. Lissajous figure (phase portrait) [$x_i(t)$ *vs.* $x_j(t)$, $i \neq j$], non-synchronized case, $c = 0$; 1500 periods of the variable $x_i(t)$.

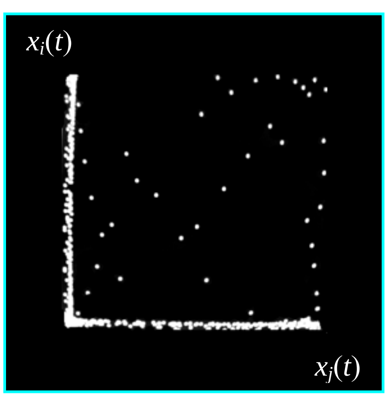

Fig. 2. Poincaré section [$x_i(t)$ *vs.* $x_j(t)$ at $x_k(t) = 1\pm0.01$, $dx_k(t)/dt < 0$, $i \neq j$, $i \neq k$, $j \neq k$], non-synchronized case, $c = 0$; 1500 dots.

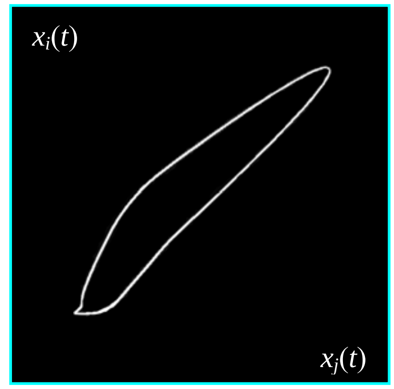

Fig. 3. Lissajous figure (phase portrait) [$x_i(t)$ *vs.* $x_j(t)$, $i \neq j$], synchronized case, $c = 0.7$; 1500 periods of the variable $x_i(t)$.

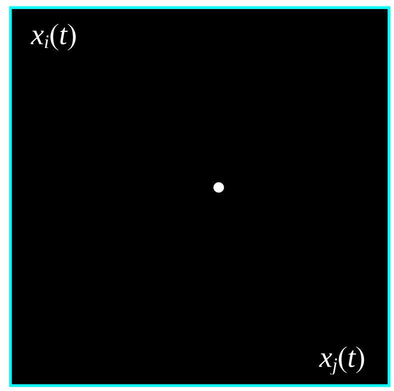

Fig. 4. Poincaré section [$x_i(t)$ *vs.* $x_j(t)$ at $x_k(t) = 1\pm0.01$, $dx_k(t)/dt < 0$, $i \neq j$, $i \neq k$, $j \neq k$], synchronized case, $c = 0.7$; 1500 dots.

4. ELECTRICAL CIRCUITS

A network of 30 mean-field coupled (star configuration) electronic neurons is sketched in Fig. 5.

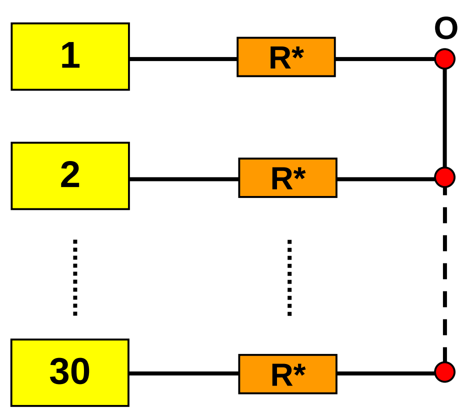

Fig. 5. Block diagram of the mean–field coupled neurons. Coupling resistors R* are tuneable units. Node **O** is the common coupling node.

Fig. 6 depicts the FitzHugh–Nagumo type electronic circuit representing the individual neurons. The neuron cells in the array are slightly mismatched, either by setting different parameters of the LC tanks or by different external dc biasing of the circuit (corresponds constant term b_i in the differential equations), meeting the fact that in real world there are no strictly identical units.

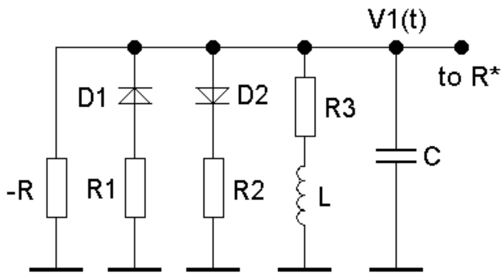

Fig. 6. Circuit diagram of an electronic analog of a neuron. Element labeled with –R is a negative resistance, implemented by means of a negative impedance converter.

General view of the hardware circuit is shown in Fig. 7. The construction contains four floors. The electronic neurons are on the ground, the 1st, and the 3rd floor (10 neurons on each floor), while the all coupling resistors R* are placed on the 2nd floor. Output waveform from a single neuron is presented in Fig. 8.

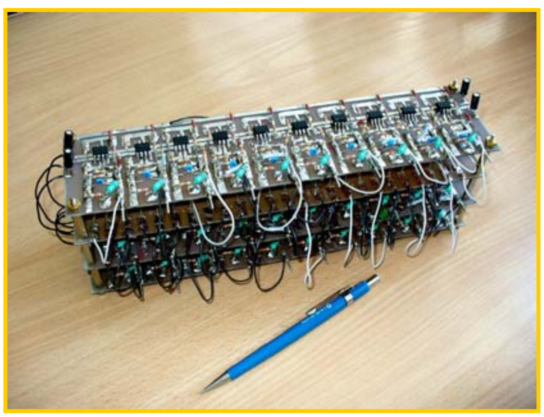

Fig. 7. Hardware prototype of the array of 30 "neurons". Dimensions W×H×D=27 cm × 8 cm × 6.5 cm (10.6"× 3.1"× 2.6")

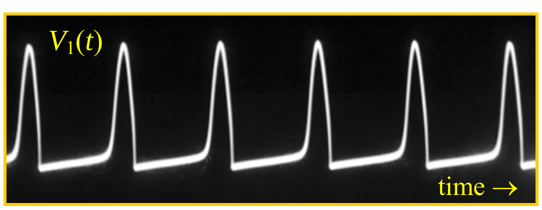

Fig. 8. Typical output waveform from a single electronic neuron $V_1(t)$. Spike amplitude ≈ 10 V, period $T \approx 80$ μs, frequency $f = 1/T \approx 12.5$ kHz.

Table 1. Frequencies of individual electronic neurons.

No.	*f*, kHz	No.	*f*, kHz	No.	*f*, kHz
1	12.280	**11**	12.830	**21**	13.472
2	12.299	**12**	12.856	**22**	13.487
3	12.340	**13**	12.872	**23**	13.570
4	12.412	**14**	12.982	**24**	13.626
5	12.482	**15**	13.077	**25**	13.668
6	12.543	**16**	13.128	**26**	13.702
7	12.659	**17**	13.237	**27**	13.727
8	12.717	**18**	13.283	**28**	13.773
9	12.769	**19**	13.393	**29**	13.801
10	12.776	**20**	13.394	**30**	13.802

5. ANALOG SIMULATION RESULTS

In the case of weak coupling (large R*) the neurons are spiking independently at their individual frequencies (see Table 1). The intricate Lissajous figure (Fig. 9), multi-dot Poincaré section (Fig. 10), and multiple discrete lines in the spectrum (Fig. 11) confirm this statement.

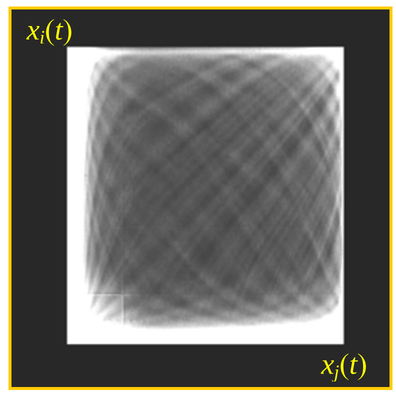

Fig. 9. Lissajous figure (phase portrait) [$x_i(t)$ *vs.* $x_j(t)$, $i \neq j$], non-synchronized case. Exposure time 1/8 s = 0.125 s. 1500 of snapped periods.

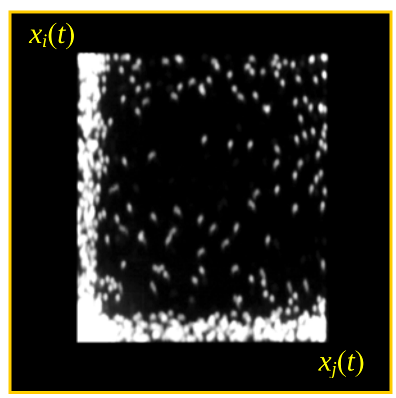

Fig. 10. Poincaré section [$x_i(t)$ *vs.* $x_j(t)$ at $x_k(t) = 1$, $dx_k(t)/dt < 0$, $i \neq j$, $i \neq k$, $j \neq k$], non-synchronized case. Exposure time 1/8 s = 0.125 s. 1500 snapped dots (1 dot per period of variable $x_k(t)$).

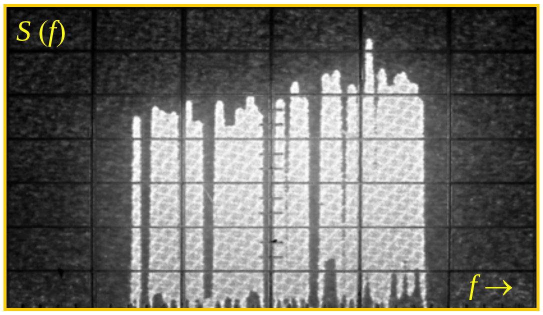

Fig. 11. Frequency spectrum $S(f)$ of the mean field $< x >$ in the full range from 11.5 kHz to 14.5 kHz, non-synchronized case. 30 lines from the electronic neurons i = 1,2, … 30. Spectral lines fill the band from ≈ 12.3 kHz to ≈ 13.8 kHz. Horizontal scale: linear 500 Hz/div. Spectral resolution $\Delta f = 3$ Hz. Vertical scale: linear.

For stronger coupling (smaller R*) all neurons become fully synchronized, i.e. phase–locked, as is evident from the Lissajous figure displaying a simple ellipse (Fig. 12), a single dot in the Poincaré section (Fig. 13), and the spectrum containing a single line (Fig. 14).

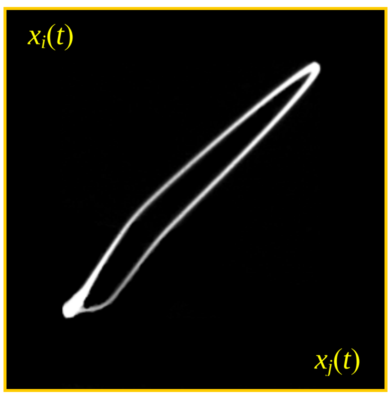

Fig. 12. Lissajous figure [$x_i(t)$ *vs.* $x_j(t)$, $i \neq j$]. Synchronized case. Exposure time 1/8 s = 0.125 s. 1500 snapped periods.

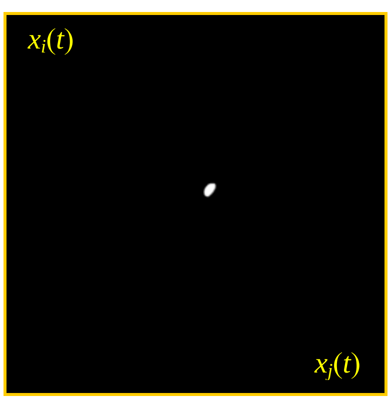

Fig. 13. Poincaré section [$x_i(t)$ *vs.* $x_j(t)$ at $x_k(t) = 1$, $dx_k(t)/dt < 0$, $i \neq j$, $i \neq k$, $j \neq k$], synchronized case. Exposure time 1/8 s = 0.125 s. 1500 snapped dots (1 dot per period of variable $x_k(t)$).

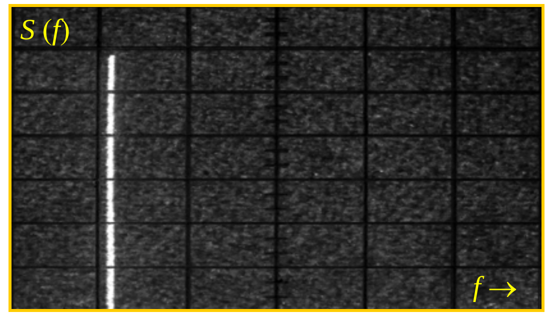

Fig. 14. Frequency spectrum $S(f)$ of the mean field $< x >$ in the full range from 11.5 kHz to 14.5 kHz, synchronized case for i = 1,2,…30. Single spectral line from the all thirty oscillators at f_0 ≈12 kHz (higher harmonics at ≈ 24 kHz, ≈ 36 kHz, … are out of the shown range). Horizontal scale: linear 500 Hz/div. Spectral resolution $\Delta f = 3$ Hz. Vertical scale: linear.

In addition to the main simulation results presented in Figs. 9–14, we have taken frequency spectrum in a zoomed frequency scale (Fig. 15) to be sure that the spectrum is not continuous one (as observed in noisy and chaotic systems), but has well defined discrete structure.

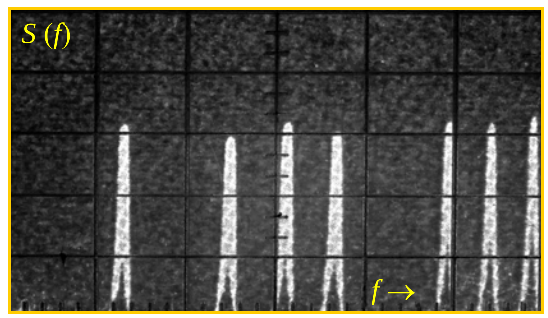

Fig. 15. Frequency spectrum $S(f)$ of the mean field $< x >$, detailed view in the frequency range from 12.60 to 12.90 kHz, non-synchronized case. Seven spectral lines from the oscillators i = 7, 8, …13. Horizontal scale: linear 50 Hz/div. Spectral resolution $\Delta f = 3$ Hz. Vertical scale: linear.

We note that in order to display analog simulation results presented in Figs. 9-15 from the hardware circuit in Fig. 7 one needs some special electronic equipment. Namely, an oscilloscope with an "**X**" input (horizontal deflection channel) and a "**Y**" input (vertical deflection channel) is required to take the Lissajous figures. An "**X–Y**" channeled oscilloscope with an additional feature of external beam modulation ("**Z**" input) is necessary (along with an external pulse generator) to plot the Poincaré sections. Finally, either a digital oscilloscope with an integrated Fast Fourier Transform function or an analog spectrum analyzer is needed to get the frequency spectra. However this equipment may not be available in a standard scientific or engineering laboratory.

To get around the problem a standard multi–channel (at least 2–channel) oscilloscope can be used for displaying the waveforms $x_i(t)$ and $x_j(t)$ from the pairs of neurons, $i \neq j$, as shown in Fig. 16 and Fig. 17. The internal horizontal sweep saw–tooth generator of the oscilloscope should be synchronized with one of the input waveform, either to $x_i(t)$ or to $x_j(t)$. The waveforms can be inspected visually on the screen of the oscilloscope and photos can be taken, if necessary.

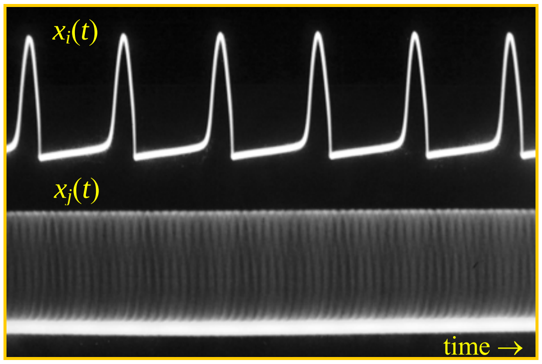

Fig. 16. Waveforms $x_i(t)$ (top) and $x_j(t)$ (bottom), $i \neq j$, non-synchronized case. Exposure time 1/8 s = 0.125 s. 250 snapped sweeps. Each waveform is 125 sweeps (750 periods of $x_i(t)$). Oscilloscope is synchronized internally to $x_i(t)$.

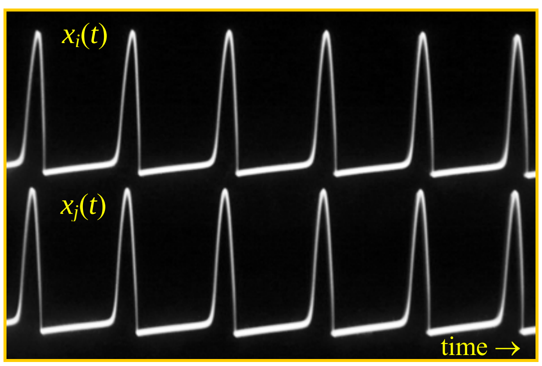

Fig. 17. Waveforms $x_i(t)$ (top) and $x_j(t)$ (bottom), $i \neq j$, synchronized case. Exposure time 1/8 s = 0.125 s. 250 snapped sweeps. Each waveform is 125 sweeps (750 periods of $x_i(t)$). Oscilloscope is synchronized internally to $x_i(t)$.

However, this method (also the previously described Lissajous plots and Poincaré sections techniques) requires checking the state of all different pairs of the oscillators ($i \neq j$). It maybe time consuming procedure, since there are $P = N \times (N-1)/2$ pairs in the network of N neurons. In the case of $N = 30$ there are $P = 435$ pairs.

Therefore we propose one more extremely simple alternative technique for checking the network, whether it is in either non-synchronized or synchronized state. One needs a simple single–channel oscilloscope only. Instead of checking the all $P = 435$ pairs, the method makes use of a single measurement only. Examples are shown in Fig. 18 and Fig. 19. In the non-synchronized case the mean–field voltage $< x >$ taken from the node O has relatively low amplitude (< 1 V) and can not synchronized by the oscilloscope (Fig. 18). In contrast, the synchronized mean–field voltage $< x >$ has relatively high amplitude (> 10 V); it is easily synchronized on the screen of the oscilloscope (Fig. 19); exhibits spiking waveform similar to that of a single neuron (see Fig. 8.)

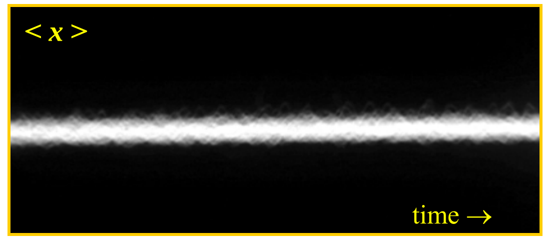

Fig. 18. Waveform of the mean field $< x >$, non-synchronized case. Exposure time 1/8 s = 0.125 s. 250 snapped sweeps. Oscilloscope is not able to synchronize to this intricate non-periodic waveform.

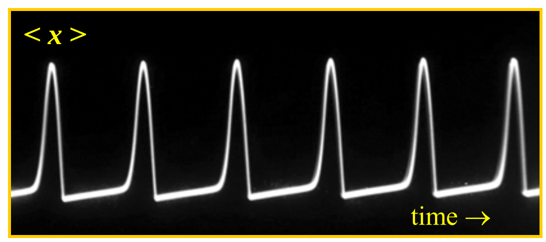

Fig. 19. Waveform of the mean field $< x >$, synchronized case. Exposure time 1/8 s = 0.125 s. 250 snapped sweeps (1500 periods). Oscilloscope easily synchronizes to this simple periodic waveform.

6. COMPARISON BETWEEN NUMERICAL AND ANALOG SIMULATIONS

One of the most important characteristics of any modeling technique is the simulation time required to obtain the result. This parameter is given in Table 2 to compare the two considered methods, numerical *versus* analog.

Table 2. Time elapsed building a plot.

Plot type	Numerical method*	Analog method
Lissajous figure (1500 periods)	8 min. 20 s	0.125 s
Poincaré section (1500 dots)	33 min. 40 s	0.125 s
Waveform $x(t)$ (1500 periods)	8 min. 20 s	0.125 s

* A standard PC with Intel 1.7 GHz central processor was used.

7. CONCLUDING REMARKS

We have designed, built and investigated an electrical network consisting of N FitzHugh–Nagumo oscillators coupled in a star configuration, and have demonstrated the synchronization effect. The following was taken into account when choosing the number of oscillators $N = 30$. The minimal number of units in a star configuration is $N_{min} = 3$ [14]. On one hand, number 30 is by an order larger than N_{min}. Thus, 30 oscillators are sufficient to be treated as large array. On the other hand, 30 oscillators is rather small amount of electrical units that can be easily and inexpensively built for a scientific laboratory.

It is evident from Table2 that the analog simulation technique has great advantage against the numerical simulation from the point of view of time consumption. This is due to fact that analog simulation uses parallel processing; it is independent on N, the number of the units. Meanwhile, numerical simulation employs series processing; the processing time is proportional to N. Moreover, analog simulations operate with continuous flows on a continuous time scale, in contrast to numerical methods, which require discretization of time and other variables by using small integration step.

In contrast to analog computers, the analog modeling described in the paper is based on some specific analog electrical circuit for a given dynamical system or given differential equation. Despite its limitation to specific systems or equations, electrical circuits have an attractive advantage of simplicity and cheapness. Such circuits comprise rather small number of simple electrical components: resistors, capacitors, inductors, semiconductor diodes, may include operational amplifiers.

The analog modeling method using simple electrical circuits can be applied to many other dynamical systems, especially to complex networks.

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Modified Gas Condensate Down-hole PVT Property Correlations

Johnson UGWU, Edward MASON and Edward GOBINA
Robert Gordon University, Aberdeen
AB10 1FR, UK.

ABSTRACT

In this investigation some widely used correlations for gas-condensate PVT properties were subjected to validation test, and were found to be inadequate for prediction of condensate down-hole PVT properties below the saturation pressure. The error margins associated with the use of some of these correlations for predicting condensate compressibility factor, density and viscosity were at levels unacceptable for engineering calculations. The new correlations include Eqs. (1), (4) and (22) for condensate compressibility factor, density and viscosity respectively. The modified correlations were tested and validated against large experimental measured database. The results showed a superior performance of the modified to the existing correlations in comparison with measured database. The novelty of this investigation is the demystification of the perplexing fluid PVT properties phase behaviour which is a barrier to accurate well deliverability modelling in gas condensate reservoirs.

1. INTRODUCTION

Accurate well deliverability prediction depends largely on accurate estimation of fluid PVT properties used as they govern reservoir productivity especially in gas condensate reservoir where compositional variations and phase changes arising from retrograde behaviour complicates fluid property modelling. The scarcity of measured PVT properties for reservoir simulation, production system design, analysis and optimisation accounts for recent popularity of use of correlations. More so, laboratory method and Equation of state (EOS) are tedious, expensive, time consuming and sometimes it is impossible to recreate exact reservoir conditions in the laboratory, making the use of correlations more attractive. The new correlations developed will serve as an alternative tool for designers, operators and service providers as a fit for purpose correlations for accurate well deliverability forecast below the saturation pressure in gas-condensate reservoirs. PVT correlations in-spite of its generic limitation as empirical model adds value to experimental data. This is because the experimental data required are only the test, development and the validation data. Accurate correlations developed and validated are capable of predicting the required down-hole properties at other desired reservoir conditions where experimental measurements may be difficult or impossible, thereby reducing the number of experiments and the associated costs.

The difference between compositional and black oil modelling in reservoir simulation is the PVT properties. The black oil model assumption is not usually valid for production of gas-condensate reservoir below the dew point pressure. The preference for use of black oil model approach in modelling well deliverability in gas-condensate reservoir instead of use of cumbersome and time consuming fine grid numerical simulation was the motivation for this investigation. The methods used for development of the modified correlations were specifically chosen to correct for compositional variation in black oil model approach to make it valid for condensate well deliverability prediction, which conceptually requires compositional approach. Several scholars [1][2][3][4] involved in the use of black oil approach in modelling well performance in gas–condensate reservoir is an indication of the popularity this approach.

When representative condensate sample properties are not available, the use of correlations is imperative, [5]. The ranges of PVT data currently encountered in the industry at higher depths were not used in development of existing correlations for the three key gas-condensate properties considered in this work. This may be part of the reasons for poor performance of the available correlations and the current effort has attempted to bridge the gap by proposing modified correlations that have been validated.

The new correlations were based on a wide data-base of measured experimental results whose maximum compositions are given in appendix B for compressibility factor, density and viscosity sourced from Sutton, [6, 7], Elsharkawy, [8, 9, 10, 11], and other published data bases. These sources are fully credited in this report. The new correlations were derived from existing models and it is important to briefly review these previous work to date.

2. MILESTONES IN PREDICTION OF HYDROCARBON PVT PROPERTIES

The main approaches in predicting fluid properties include;

(i) Compositional or Gas Gravity based

(ii) Corresponding States

(iii) Equations of State Method:

These methods have been employed as a single approach or combination for prediction of PVT properties. The present study combined the compositional, gas gravity with corresponding state approach. These approaches are highlighted by the contributions of many Scholars as briefly discussed below.

Numerous studies on prediction of natural gas condensate PVT properties exist in the literature. A major milestone in prediction of natural gas PVT properties includes the Katz and Standing, [12] Charts for determination of compressibility factors of reservoir fluid. The chart is still the basis for the prediction of compressibility factor by many correlations presently in the Oil and Gas industry though in digital forms. The digital forms of the Katz Chart were facilitated by several scholars, (Hall and Yarborough [13]; Dranchuk Abou Kisser, (DAK) [14][15]. These were followed by evaluation work to determine the accuracy of the developed digital correlation for Katz Chart. The magnitude of errors associated with the use of correlations for prediction compressibility factor were highlighted in Abd-el Fattah's work in which he provide guidelines for range of applicability of correlations for prediction of compressibility factor. Most of the correlations involved the use of some form of equation of state (EOS) involving trial and error method of solution and the accuracy of these methods is within 0.5%, but for region where reduced temperature, Tr=1 and reduced

pressure, Pr>1 very large errors have been reported (Kumar, 1987Further developments on improving the performance of compressibility factor correlations followed. Witchet and Aziz, [16] proposed a correlation factor to extend the applicability of the Standing and Katz compressibility factor chart to sour gases. The inaccurate prediction of PVT properties of reservoir fluids arising from non-hydrocarbon components stimulated further investigation into ways of improving the performance prediction of down-hole PVT properties, Sutton, [6, 7] Elsharkawy, [8, 9, 10, 11].
The problems with most of the available correlations applied for natural gas- condensate PVT properties prediction were developed for sweet and dry gases. The applications of these correlations to natural gas-condensate reservoir fluid property predictions are not only limited by geographical locations of the reservoir as a general problem with empirical correlations, but also to a range of reservoir temperatures and pressures. Though some of the available correlations for natural gases have been modified, further modifications are still needed to cater for liquid condensate flow below the saturation pressure. Available correlations are mostly for flow of condensate above the dew/saturation pressure. Accurate PVT properties for flow of condensate below the saturation pressure which is the main subject of this work may provide insight to the much needed technology towards remediation of condensate banking and production of the lost condensate to the formation. The compressibility factor correlation developed by Standing and Katz up to the digitized versions by Dranchuk and Abou Kassem and others have all been specific to sweet and dry gases. This led Londono [17] to suggest that the attempts for prediction of compressibility factors should be extended to gas-condensate systems.
The major focus of numerous works has been on the improvement of the prediction of the pseudo critical properties of gas mixtures including heptanes plus fractions using different mixing rules and accounting for the non-hydrocarbon contents as critical input parameters in forecasting the compressibility factors. For a soft-ware driven industry such as Oil and Gas, there is no better time for reviewing and updating outdated correlations in most of our widely used simulators than now.

3. COMPRESSIBILITY FACTOR PROPOSED

Compressibility factor is one of the critical parameters in inflow performance relationship in both vertical and horizontal well, therefore a compulsory variable in prediction of well deliverability. On testing the performance of available compressibility factor correlations, Elsharkawy's had a lower error margin though followed closely by Sutton. The lowest absolute average error margin and the compact method of calculation of compressibility factor were the main criteria used for selection of Elsharkawy's correlation for modification. The various mixing rule correlations available in literature represents the various efforts by different scholars to extend the validity of Standing-Katz chart, developed for sweet dry gas to heavier natural gas-mixture including gas-condensate. The modification was to specifically account for condensate PVT properties below the dew-point pressure. To get a better fit of digitised standing-Katz chart to measured condensate compressibility factor using modified Elsharkwy mixing rule, a multiple non-linear regression of Elsharkawy parameter was done using statistical software, MINITAB on large database of published gas-condensate measured compressibility factor. This resulted in the following new modified expressions for condensate compressibility factor given by Eq. 1;

$$Z_m = \frac{Z_{DAK}}{2} + 0.36015 \qquad (1)$$

Where;

$$Z_{DAK} = \left[A_1 + \frac{A_2}{T_{pr}} + \frac{A_3}{T_{pr}^3} + \frac{A_4}{T_{pr}^4} + \frac{A_5}{T_{pr}^5}\right]\rho r + \left[A_6 + \frac{A_7}{T_{pr}} + \frac{A_8}{T_{pr}^2}\right]\rho_r^2 - A_9\left[\frac{A_7}{T_{pr}} + \frac{A_8}{T_{pr}^2}\right]\rho_{pr}^5 + A_{10}\left(1 + A_{11}\rho_r^2\right)\frac{\rho_r^2}{T_{pr}^3} 3\exp\left[-A_{11}\rho_r^2\right] + 1 \qquad (2)$$

$$\rho_r = \frac{0.27P_{pr}}{ZT_{pr}} \qquad (3)$$

Where $\boldsymbol{A}_1 = 0.3265,\ \boldsymbol{A}_2 = -1.0700,$
$\boldsymbol{A}_3 = -0.5339,\ \boldsymbol{A}_4 = 0.01569,\ \boldsymbol{A}_5 = -0.05165,$
$\boldsymbol{A}_6 = 0.5475,\ \boldsymbol{A}_7 = -0.7361,$
$\boldsymbol{A}_8 = 0.1844,\ \boldsymbol{A}_9 = 0.1056,\ \boldsymbol{A}_{10} = 0.6134,$
$\boldsymbol{A}_{11} = 0.7210.$

Calculation steps for Eq. (1) to(4) are defined in appendix A.

The modified Z- factor, Zm was used to predict condensate density from the equation (4);

$$\rho_c = \frac{PM_a}{Z_m RT} \qquad (4)$$

The model was validated with published measured database. It gave superior performance on comparison with some widely used correlation in the industry as shown in figures 1 and 2, tables 1 and 2

4. EVALUATION OF VISCOSITY CORRELATIONS;

The most widely used correlations for viscosity prediction in gas and gas-condensate reservoirs were reviewed with view to evaluate performance as first step to developing more accurate methods for condensate viscosity prediction for application to modelling well deliverability below dew point pressure in gas-condensate reservoirs. The correlations evaluated in the study include;

(i) Lee-Gonzalez-Eakin (LGE) [19]
(ii) Sutton, [20]
(iii) Elsharkawy, [11]
(iv) Carr-Kobayashi-Burrows (1959) as modified by Dempsey (CKB-D) (1965)

4.1 Lee-Gonzalez-Eakin [19] (LGE)

The theoretical concept of this model can be mathematically expressed as follows;

$$\mu_g = 10^{-4} K \times \exp\left[X\left(\frac{\rho_g}{62.4}\right)^Y\right] \qquad (5)$$

Where,

$$K = \frac{(9.379 + 0.016 M_a) T^{1.5}}{209.2 + 19.26 M_a + T} \quad (6)$$

$$X = 3.448 + \frac{986.4}{T} + 0.01009 M_a \quad (7)$$

$$Y = 2.4 - 0.2X \quad (8)$$

Many viscosity correlations in petroleum reservoir engineering are derived from Lee-Gonzalez's model and have always been acknowledged for this significant contribution.

4.2 Sutton, (2007) viscosity correlation
A modified LGE correlation expressed as follows;

$$\mu_{gsc}\xi = 10^{-4}\begin{bmatrix} 0.807 T_{pr}^{0.618} \\ -0.357\exp(-0.449 T_{pr}) \\ +0.34\exp(-4.058 T_{pr}) + 0.018 \end{bmatrix} \quad (9)$$

Where, viscosity parameter

$$\xi = 0.9490\left(\frac{T_{pc}}{M^3 P_{pc}^{\ 4}}\right)^{1/6} \quad (10)$$

$$\mu_g = \mu_{gsc} \times \exp\left[X\left(\frac{\rho_g}{62.4}\right)^Y\right] \quad (11)$$

Where,

$$X = 3.47 + \frac{1588}{T} + 0.0009 M_a \quad (12)$$

$$Y = 1.66378 - 0.04679 X \quad (13)$$

4.3. Elsharkawy, (2006) viscosity correlation
This is an extension of the LGE viscosity correlation to correct for the presence of non-hydrocarbons and the C_{7+} content present in heavy reservoir gases and condensates.
The original form of Elsharkawy model is

$$\mu_g = 10^{-4} K \times \exp\left[X\left(\frac{\rho_g}{62.4}\right)^Y\right] \quad (14)$$

Where,

$$K = \frac{(9.379 + 0.016 M_a) T^{1.5}}{209.2 + 19.26 M_a + T} \quad (15)$$

$$X = 3.448 + \frac{986.4}{T} + 0.01009 M_a \quad (16)$$

$$Y = 2.4 - 0.2X \quad (17)$$

And corrected for non-hydrocarbon and the heptanes plus fraction as follows;

$$\Delta\mu_{H2S} = y_{H2S}\left(-3.2268\times10^{-3}\log\gamma_g + 2.1479\times10^{-3}\right) \quad (18)$$

$$\Delta\mu_{CO2} = y_{CO2}\left(6.4366\times10^{-3}\log\gamma_g + 6.7255\times10^{-3}\right) \quad (19)$$

$$\Delta\mu_{C7+} = y_{C7+}\left(-3.2875\times10^{-1}\log\gamma_g + 1.2885\times10^{-1}\right) \quad (20)$$

Giving the corrected viscosity correlation as;

$$(\mu_c)_{corrected} = \mu_c + \Delta\mu_{H2S} + \Delta\mu_{CO2} + \Delta\mu_{C7+} \quad (21)$$

Where $\mu_g = \mu_c$

4.4 New viscosity correlation (study)
The margin of errors associated with the use of existing gas-condensate viscosity correlations were found to be high on performance evaluation and needed upgrading for meaningful engineering calculations.
Elsharkawy [11] Viscosity correlation gave the least average absolute error compared to other widely used viscosity correlations and had a better versatility of application to non hydrocarbon impurities and heptanes plus fraction. Based on the above criteria was selected for further modification to improve on the accuracy of prediction of gas-condensate viscosity which was the main objective of this part of the study. Viscosity is very significant parameter in predicting the productivity of any class of petroleum reservoir. The sensitivity of this parameter to temperature, composition and pressure is high, and any error in prediction could lead to misleading production forecast.
The method applied for developing the new prediction procedure for gas condensate viscosity below the saturation pressure included the following steps;

(i) Created a compositional database for published measured gas condensate viscosity at different reservoir pressure and temperature condition of world-wide sample representation.
(ii) Compiled and evaluated performance of different available viscosity correlations against the created database.
(iii) Used average absolute error criteria for model selection for further development for lack of good match of any of the tested to measured values in the database.
(iv) Modification of the Elsharkawy [11] Viscosity model that gave the least absolute average error margin on evaluation using part of the database as development and validation data, ensuring that development data was different from validation data to eliminate the likely error.
(v) Validated the modified model and compared the performance with the best available correlation based on the evaluated performance of the existing models as shown in figure 3 below.

Measured condensate viscosity database from CVD test was used to derive new coefficient for the original Elsharkawy viscosity model using non-linear regression statistical techniques. The above technique resulted in the following new modified Elsharkawy, (Study) viscosity correlation;

$$\mu_c = K^{-2.5}\exp(176 + 0.062\rho Y - 15.5X) \quad (22)$$

Where K, Y and X are same as in equations (15 – 17) and the corrections for the non hydrocarbon contents and heptanes plus fraction remains same as defined in equations (18 – 21).

5. RESULTS AND DISCUSSIONS

The correlations in each case in figures 1 and 2 were validated with measured experimental database to test for accuracy, physical trend consistency. Figures 1 and 2 suggest a good performance of the new correlations as the trend follows a good physical behaviour expected theoretically for compressibility factor and density as a function of pressure under isothermal reservoir conditions. The absolute average errors for the new correlations of this study as shown in tables 1 and 2 were less than that for the existing correlations, suggesting a better performance. The modified (study) correlations showed a better agreement with the measured experimental database in figures 1 and 2. The improvement in the correlation could translate to accurate well deliverability prediction in gas condensate reservoirs as the properties correlated are critical variables in both vertical and horizontal well models that predict well deliverability. The existing viscosity correlations in figure 3 show absolute average errors far in excess of the range acceptable for technical calculations. This may be as result of the data which the correlations were derived. Present reservoir production scenarios are experiencing a harsher offshore environment (deeper water, high temperature and pressure) and these are reflected on the new database for the modified correlation. Figures 4 went further to define error as under prediction of the viscosity values using the existing correlations, Elsharkawy, [11] and Sutton, [7]. These average errors in figure 4 could translate to unreliable production forecast figures that could have serious investment implications. The accuracy of fluid characterisation achieved by the modified correlation is important in production optimization, facility and field development plans.

6. CONCLUSIONS

Compressibility factor, density and viscosity correlations for prediction of Condensate PVT properties below the dew point pressure have been developed. They were developed from Elsharkawy correlations which are more applicable for condensate flow above the dew point. The new models are Eqs. (1), (4) and (22) for condensate compressibility factor, density and viscosity respectively.

On validation, the new correlations have demonstrated superior performance over the existing models. These correlations are indispensable in modelling well deliverability below the dew point pressure in gas-condensate reservoirs. Condensate below the saturation pressure has been reported to have perplexing flow behaviour resulting from great variability in composition from reservoir thermodynamics. The prediction of the key PVT properties becomes difficult and complex as result. This makes accurate prediction of well deliverability at those reservoir conditions unreliable, and optimization of such reservoir becomes impossible except with the use of fine grid numerical simulation which is expensive. Some insights have been given on how to solve the above problems in another investigation not reported here, by application of developed correlations on semi analytical horizontal well models for prediction of well deliverability. The contribution of this work is much with respect to making the use of semi analytical models for accurate well deliverability prediction, production optimisation of gas condensate reservoirs and reduced cost of experimentation as the correlations can be alternatively used.

The novelty of this investigation is the demystification of the perplexing fluid PVT properties phase behaviour which is a barrier to accurate well deliverability modelling in gas condensate reservoirs.

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8. NOMENCLATURE

E_j , E_k, F_j	SSBV Mixing Rule parameters
$\alpha_0 - \alpha_{15}$	Correlation Constants
$\beta_0 - \beta_7$	Correlation Constants
$A_1 - A_{11}$	DAK and DPR correlations constants
X ,Y	Viscosity Correlation parameter
y_{C7+}	Mole fraction of the C_{7+} plus fraction
y_i	Mole fraction of the 'i' component
Z	Gas Compressibility factor
β	Turbulence Factor
h	Reservoir Thickness (ft)
h_p	Perforated Interval (ft)
J	Mixing Rule parameters
J'	Corrected J parameter for Mixing Rules
k	Permeability (md)
K	Viscosity Correlation parameters
K'	Corrected K parameter for Mixing Rules
P_{sc}	Pressure at standard conditions (psi)
P_R	Reservoir Pressure (psi)
P_{wf}	Bottom hole flowing pressure (psi)
Q	Gas flow rate (scf/day)
r_e	Drainage Radius (ft)
r_w	Wellbore Radius (ft)
R	Universal gas constant = 10.73 psia ft^3/lb-mole °R
S	Skin Factor
V	Volume (ft^3)
ε	Wichert – Aziz Correction factor

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Table 1 Percentage average absolute error margins for different Z-factor correlations

Reservoir pressure(psia)	Sutton, 2006 % Error	Elsharkawy % Error	Study % error
4190	-11.30	-19.33	-2.64
3600	-19.80	5.29	7.96
3000	-22.44	-7.47	1.19
2400	-22.83	-16.37	-2.70
1800	-20.43	-18.28	-1.91
1200	-17.20	-18.44	0.22
700	-14.36	-19.11	1.93
AAE	**18.34**	**14.90**	**2.65**

AAE - Average Absolute Error

Table 2 Predicted gas-condensate density using modified Elsharkawy's compressibility factor correlation approach and AAE

Reservoir Pressures (psi)	Experiment Density(lb/f	Elsharkawy Density(lb/f	Modified Mc Density(lb/f	Elsharkawy % Error	Study) % Error
4190	27.34	21.06	25.46	22.99	6.88
3600	19.52	21.03	19.04	-7.76	2.47
3000	15.06	14.33	14.5	4.86	3.74
2400	11.3	9.94	10.91	12.05	3.43
1800	7.95	6.86	7.88	13.72	0.88
1200	5.06	4.35	5.2	13.97	-2.85
700	2.91	2.49	3.1	14.3	-6.67
		Average Absolute Error		12.81	3.85

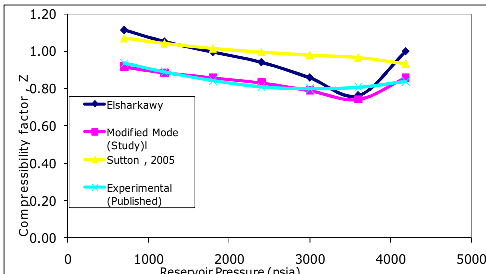


Figure 1 Validation of modified compressibility factor

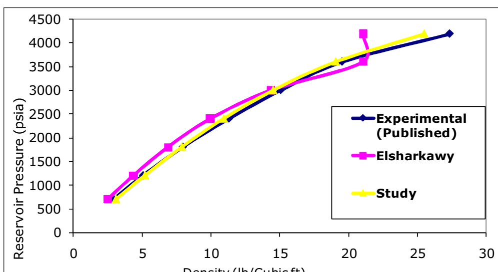


Figure 2 Validation of modified density correlation with experimental data

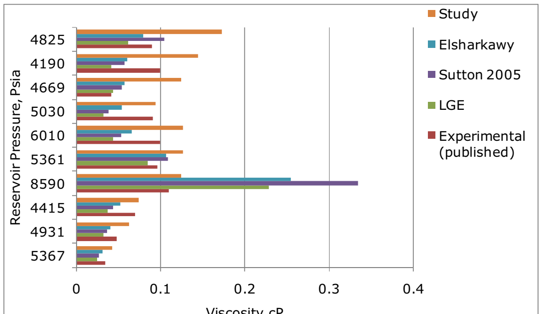


Figure 3 Validation of Existing and Study Condensate Viscosity Correlations with Published Experimental Data

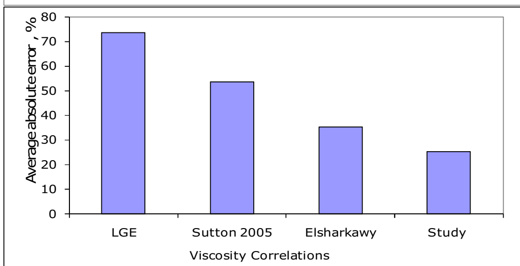


Figure 4 Absolute average error comparison for gas-condensate viscosity correlations

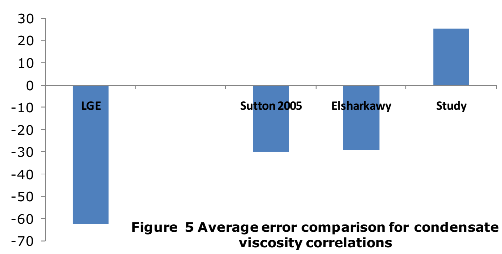


Figure 5 Average error comparison for condensate viscosity correlations

10. APPENDIX A

Summary of Calculation steps;

Compressibility factor;

The calculation steps are same with Elsharkawy, 2006 except the difference in the new coefficients got from regression analysis.

The governing equations for the mixing rule include;

$$J_{\inf} = \alpha_0 + \left[\alpha_1\left(y_i\frac{T_{ci}}{P_{ci}}\right)_{H2S}\right] + \left[\alpha_2\left(y_i\frac{T_{ci}}{P_{ci}}\right)_{CO2}\right] + \left[\alpha_3\left(y_i\frac{T_{ci}}{P_{ci}}\right)_{N2}\right] + \left[\alpha_4\sum\left(y_i\frac{T_{ci}}{P_{ci}}\right)_{C1-C6}\right] + \alpha_5\left(y_i M\right)_{C7+} \quad (23)$$

$$K_{\inf} = \beta_0 + \left[\beta_1\left(y_i\frac{T_{ci}}{\sqrt{P_{ci}}}\right)_{H2S}\right] + \left[\beta_2\left(y_i\frac{T_{ci}}{\sqrt{P_{ci}}}\right)_{CO2}\right] + \left[\beta_3\left(y_i\frac{T_{ci}}{\sqrt{P_{ci}}}\right)_{N2}\right] + \left[\beta_4\sum\left(y_i\frac{T_{ci}}{\sqrt{P_{ci}}}\right)_{C1-C6}\right] + \beta_5\left(y_i M\right)_{C7+} \quad (24)$$

Where;

$\alpha_0 = 0.036983$, $\alpha_1 = 1.043902$, $\alpha_2 = 0.894942$

$\alpha_3 = 0.792231$, $\alpha_4 = 0.882295$, $\alpha_5 = 0.018637$

$\beta_0 = -0.7765003$, $\beta_1 = 1.0695317$, $\beta_2 = 0.985$

$\beta_3 = 0.8617653$, $\beta_4 = 1.0127054$, $\beta_5 = 0.4014$

To properly define all the parameters required in calculating the pseudo-critical properties, the mixing rule of Stewart-Burkhardt-Voo was adopted, defining Parameter J as follows;

$$J = \left(\frac{1}{3}\right)\left[\sum yi\left(\frac{T_c}{P_c}\right)_i\right] + \left(\frac{2}{3}\right)\left[\sum yi\left(\frac{T_c}{P_c}\right)_i^{0.5}\right]^2 \quad (25)$$

$$K = \sum\left[yi\left(\frac{T_c}{P_c^{0.5}}\right)_i\right] \quad (26)$$

From a given composition, the parameters $J_{\inf}, K_{\inf}$ could be calculated from equations 23 and 24 and the pseudo-critical properties were calculated using the correlations below;

$$T_{pc} = \frac{K_{\inf}^2}{J} \quad (27)$$

$$P_{pc} = \frac{T_{pc}}{J_{\inf}} \quad (28)$$

The pseudo reduced properties were calculated from the two correlations below and applied to calculation of compressibility factor from DAK correlations, equation 2 for fitting Standing and Katz compressibility chart.

$$P_{pr} = \frac{P}{P_{pc}} \quad (29)$$

$$T_{pr} = \frac{T}{T_{pc}} \quad (30)$$

Appendix B

Table B1 Maximum value of Condensate PVT data used in study

Pressure (psia)	10000
Temperature (^{0}F)	500
Gas gravity	30
Gravity (^{o}API)	70
H2S	0.745 (mole fractions)
CO2	0.9
N2	0.25
C_1	0.98
C_2	0.30
C_3	0.13
i-C_4	0.026
n-C_4	0.052
i-C_5	0.03
n-C_5	0.02
C_6	0.05
C_{7+}	0.17

College Enrollment Forecasts Using Artificial Intelligence and Time Series Models

Chau-Kuang Chen, Ed.D
Office of Institutional Research, Meharry Medical College
Nashville, Tennessee, 37208, U.S.A

and

Aiping Yang, Ph.D
Department of Industrial Engineering, Beijing Union University
Beijing, China 100020

ABSTRACT

Decision-makers in colleges and universities need high quality enrollment forecasts to appropriately establish proper resources for academic programs and support services. However, accurate forecasts are difficult to make due to some fluctuation in the enrollment from year to year. Also, certain important factors affecting student enrollment are difficult to quantify. In addition, various forecasting techniques and related software packages may add to the technical complexity. In this study, ANN, SVM, and GEP modeling approaches were used to perform enrollment forecasts for Oklahoma State University from 1962 to 2010. The ARIMA model was also built as a benchmarking tool to verify model accuracy. Nine independent variables were entered into the model equations in an attempt to increase explanatory power. These variables include Oklahoma high school graduates, competitor college enrollment from the University of Oklahoma, state funding, and economic indicators such as state unemployment rate, gross national product, and consumer price index. The empirical results indicate that ANN and SVM models yielded remarkable model fitting statistic and exceptionally small forecasting error. ANN and SVM models have demonstrated their model validity and accuracy. Hence, they could be replicated for comparable universities elsewhere.

Keywords: Enrollment Forecast, ANN, SVM, GEP, and ARIMA

INTRODUCTION

Forecasts are the basic ingredients for intelligent planning and successful operation of any profit or nonprofit organization (Mabert, 1975). For many years, student enrollment forecasts have been one of the most important planning activities for institutions of higher education. Enrollment forecasts determine admissions decisions, financial revenue and expenditure, and requirements for staffing and facilities. Accurate forecasts are crucial challenges for colleges and universities because they are difficult to make in periods of unstable growth when turning points are unexpected. Decision-makers need the quality of enrollment forecasts to appropriately establish proper resources for academic programs and support services.

A wide variety of factors such as quality and diversity of programs, location, prestige, price relative to competitors, and recruitment policies can affect student enrollment among various campuses (Breneman, 1984). Student financial aid is intended to reduce the monetary costs of attending colleges for target populations, thereby increasing student access (Folger, 1974). Decreases in student financial aid lead to a decline in student enrollment. Changes in disposable income per capita are indicators of changing ability to pay for college (Stewart & Kate, 1978). Relative decreases in personal income per capita are expected to be associated with decreases in student enrollment. A comprehensive list of factors has been used to build enrollment forecast models in higher education. These factors include admission policies, instructional programs, high school graduates, post-baccalaureate students, related economic structure, mortality rates, migration, education benefits and costs, and scholarship programs (Lins, 1960). The feasibility of performing enrollment forecasts depends on the ability to identify the potential factors that influence student enrollment.

Forecasting techniques for college enrollment can be generally categorized as follows: subjective judgment, ratio method, cohort survival study, Markov transition model, neural network model, simulation model, and time series analysis (Chen, 2008). The choice of forecasting technique depends on the availability of data, appropriate methodology, and cost and usability of the software packages. In this study, artificial intelligence modeling techniques such as Artificial Neural Network (ANN), Support Vector Machine (SVM), and Gene Expression Programming (GEP) along with the Autoregressive Integrated Moving Average (ARIMA) methodology were constructed to perform enrollment forecasts for Oklahoma State University (OSU). These approaches deal with nonlinear functions and multidimensional data sets, which are capable of ranking the relative importance of explanatory variables affecting enrollment series and performing reliable and accurate forecasts. The purpose of constructing OSU enrollment forecast models are to determine what variables contribute the most to student enrollment, and forecaste OSU enrollment with highly accurate results. These study results can be used to facilitate the effectiveness of program planning and the efficiency of resource allocation.

OVERVIEWS OF ANN, SVM, GEP, AND ARIMA

ANN is a mathematical model simulated by the functional aspect of biological neural networks. The network is made up of interconnected groups of artificial neurons (nodes or processing units) which are embedded in input, hidden, or output layers. It processes information using a parallel approach along with the feed forward technique so that information can efficiently flow through the system in one direction from input to hidden and then to the output layer neurons. ANN involves an adaptive learning process that changes its model structure during the training phase. It is an accommodative learning model that allows for the assessment of relationship between input (independent) and output (dependent) variables based on the iterative process. The back-propagation of error is a technique used to minimize the prediction error by adjusting the connection weights from output to hidden layer and from, hidden to input layer. The ANN model is a data driven rather than a statistically driven model requiring a trial and error process in order to find the optimal network.

SVM algorithm has demonstrated its ability to solve complex prediction problems (Rice, Nenadic, & Stapley, 2005; Ng & Mishra 2007). It is a supervised machine learning technique that performs prediction by constructing a multidimensional hyperplane optimally discriminating (maximizing the margin separation) between two different classes (Vapnik, 1999). Unlike many other statistical tools, the SVM is a data driven, model free that possesses discriminative power. The algorithm achieves its high discriminative power by using special non-linear functions called kernel functions to transform the original data into a high dimensional space (Cover, 1965). Justified by Cover's theorem, any dataset can be separable if the data dimension grows. The SVM model is operated on the principle of structural risk minimization (Vapnik, 1995). It was designed to minimize true risk of misclassifying examples during the model training. It has its advantage in the practical application for small sample and generalization because of structural risk minimization (Vapnik, 1995; Wan & Campbell, 2008; Zeng, Xu, Gu, Liu, & Xu, 2008). It can be applied to the prediction of continuous outcome variables (Cristianini & Shawe-Taylor, 2000).

GEP is an evolutionary algorithm used for selecting the best function (solution) that represents the most population fit for surviving in the environment. In GEP, the chromosome is a linear, symbolic string of fixed length composed of one or more genes. The expression trees (phenotypes) are encoded in chromosomes (genotypes) and they are a visual representation used by researchers to represent equations, functions, or solutions. By knowing how to go from genotype to phenotype and vice versa, GEP can produce different equations through genetic operations (e.g., mutation, crossover, and transposition) and arithmetic operations (e.g., addition, subtraction, multiplication, and division) and then keep the best one from the population of solutions.. The evolution and optimization processes work consecutively to yield the best analytical form of the functions that can be used to solve specific complex prediction problem (Ferreira, 2001). In the first step of GEP, the chromosomes of the population are generated randomly. Then, the chromosomes are expressed and the fitness of each individual is determined based on the minimum error function. Next, the individuals are selected based on their fitness in the population to reproduce leaving the offspring with new traits. Finally, the offspring undergoes the previous steps.

The ARIMA methodology is a branch of time series analysis. In time series analysis, data points close together in time are usually expected to correlate with one another. The correlation from one period to another is employed to make reliable forecasts (Diggle, 2004; Mabert, 1975; Vandaele, 1983). Thus, time series prediction assumes that the future depends upon the present while the present depends on the past (Brinkman & McIntyre, 1997; Jennings & Young, 1988; Vandaele, 1983). ARIMA involves three basic parameters such as *p* for the amount of autocorrelation, *d* for the level of differencing, and *q* for the component for moving average. These parameters are estimated in an iterative manner using three stages of the modeling process (model identification, parameter estimation, and diagnostic checking) until the most suitable model is found (Diggle, 2004; Jennings & Young, 1988; Mabert, 1975; Vandaele, 1983).

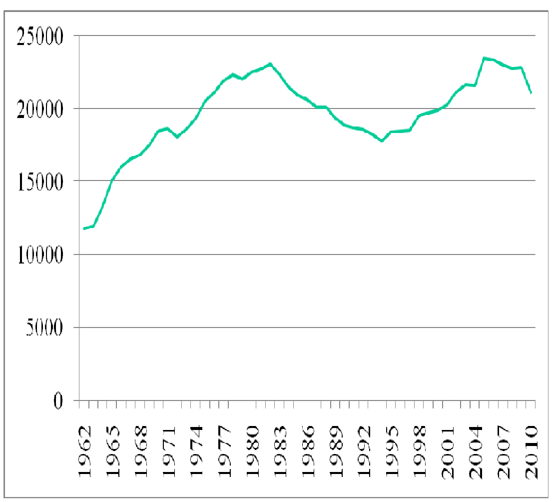
MODEL STRATEGIES

The modeling strategies were used to construct OSU enrollment forecast model to address two research questions: "Is the OSU enrollment series attributable to the impact of demographics and economic indicators?" and "Are the ANN, SVM, and GEP artificial intelligence models more accurate than the ARIMA time series model?" There were three phases of model strategies in developing enrollment forecast models. In the first phase, ANN, SVM, and GEP modeling approaches were used to construct OSU student enrollment models. In the second phase, the three steps of the ARIMA methodology (model identification, parameter estimation, and diagnostic checking) were iteratively applied (Chen, 2008). This phase allowed the researcher to generate the most suitable ARIMA model as a benchmarking tool to assess model reliability and accuracy. In the third phase, three model selection criteria (forecasting accuracy and model fitting) were used to make judgments about the most suitable OSU enrollment model by making a head-to-head comparison among ANN, SVM, GEP, and ARIMA models.

There were six steps for constructing the ANN, SVM, and GEP models. Step 1 involved data collection covering one dependent variable (OSU enrollment series from Fall 1962 to Fall 2010 as displayed in Figure 1) and nine independent variables such as demographics (OK_HG - Oklahoma high school graduates, OSULG1 - one-year lagged OSU enrollment, and OU - OU enrollment, and OULG1 - one-year lagged OU enrollment), TAXFUND - state tax fund appropriations for Oklahoma higher education, and economic climate indicators (UNEMP - Oklahoma unemployment rate, OKPCap - Oklahoma per capita income, USGNP - the United States GNP, and USPrice - the United States Consumer Price Index).

In Step 2, the underlying models were developed by the selection of activation functions for ANN and kernel functions for the SVM. It was difficult to know in advance which activation or kernel function would be the most suitable. Thus, the only strategy was a trial and error process. For the SVM classifier, there were four kernel functions readily available for model construction: linear, radial basis function (RBF), polynomial, and sigmoid.

Figure 1.
OSU Student Enrollment, 1962-2010



In Steps 3 and 4, all possible ANN, SVM, and GEP candidate models were trained and tested to achieve minimal prediction error by means of estimating parameters and performing cross-validation. For ANN, SVM, and GEP, a three-fold cross-validation was implemented to minimize the bias generated by random sampling of the training and testing data sets. The input data set was divided into three mutually exclusive subsets, where two subsets were available for training and one subset was used for testing purpose. The process was repeated three times to ensure that the model was tested in each subset. The average results from three repeated processes were used to represent the prediction results for training and test examples. In addition, the model performance was gradually improved by generating and selecting the best parameters.

In Step 5, the results of ANN, SVM, and GEP model were evaluated and compared with ARIMA model to see if they were suitable in forecasting OSU enrollment. As described earlier, for the comparison purpose, all independent variables were forced to enter the equation in one step. The benchmark comparison was carried out by comparing the model fitting and prediction accuracy. A measure of the model fit, R-squared value, is known as the coefficient of determination. This is the proportion of variation in the independent variable that is explained by the model. A higher R-squared value leads to better model fitting. The mean absolute percentage error (MAPE) measures the prediction accuracy. A small MAPE is an indication of high accuracy in prediction. The MAPE formula is written as MAPE = $\{\Sigma_{t=1}^{n} \mid [F_t - A_t] / A_t \mid 100\%\} / n$, where F_t is a predictive value at time t and A_t is an actual value at time t.

In Step 6, the top important variables and related rank orders of variables for the ANN, SVM, and GEP models was generated to facilitate variable explanation. The normalized importance was calculated by dividing the value of the highest relative importance into the value of the other relative importance. The normalized importance provides a hierarchal viewpoint of the ranking of the explanatory variables. However, it does not show the direction of relationship between each individual explanatory variable and the outcome variable.

COMPARISON OF THE BEST ANN, SVM, AND GEP WITH ARIMA MODEL

As shown in Table 1, ANN, SVM, GEP, and ARIMA models fit the data exceptionally well based on their remarkably high R-squared values of 0.96, 0.96, 0.95, and 0.96, respectively. Also, they perform highly accurate enrollment forecasts with very small values of MAPE (1.84%, 1.86%, 2.44%, and 1.91%). Obviously, these four models have demonstrated the forecasting accuracy for the OSU student enrollment. Only the ANN and SVM models slightly outperform the ARIMA model. Two identical demographics such as one-year lagged college enrollment and high school graduates can be found in all four models.

CONCLUSIONS, STRENGTHS AND WEAKNESSES

Artificial intelligence models have received much attention because they have significantly contributed to pattern recognition and data prediction. In this study, the resulting models from ANN, SVM, GEP, and ARIMA indicate that OSU enrollment is primarily a function of two demographics: Oklahoma high school graduates and one-year lagged OSU enrollment. All four models methods fit the data exceptionally well with high R squared values. Also, these models forecast highly accurate OSU enrollment with very small values of MAPE. Therefore, this study has accomplished its purposes in explaining factors affecting OSU enrollment and forecasting OSU enrollment with highly accurate results.

In this study, top important variables identified by the ANN, SVM, and GEP models were comparable to those of the ARIMA model. The consistency in the results may demonstrate the model reliability, meaning that artificial intelligence models are reliable in performing enrollment forecasts. Locating the most important variables which contribute to student enrollment can make better decisions to facilitate budget, program, and personnel planning.

ANN, SVM, and GEP models are promising for numerous reasons. First, ANN, SVM, and GEP models can be developed by newcomers within a relatively short time frame, conditional on the availability of an appropriate data set and software package. Secondly, knowledge is gained through learning and testing, which make them suitable in establishing valid relationships between variables. Thirdly, ANN and SVM models have greater prediction accuracy compared to ARIMA model, which is congruent with the literature reviews that ANN and SVM models generally produces superior prediction results. Finally, the SVM has promising property, i.e., the internal consistency depends on the implementation of v-fold cross-validation.

However, there is a limitation for the ANN, SVM, GEP, and ARIMA methodologies. Researchers have to reconstruct and reevaluate the models as years progress because of the uncertainty that surrounds the enrollment forecasting. When dealing with enrollment forecasting the following variables should remain constant: national and state economy, federal and state financial aid programs, state funding for higher education, admission standards, and graduation rates (OSU Office of Institutional Research, 2004). Also, lack of the availability of a structured methodology for constructing the ANN model presents greater challenges. Moreover, the number of hidden layers along with training tolerance needs to be determined by a trial and error process in the ANN model. The lack of mathematical theory is the most critical point in GEP. Finally, the lack of explanation for the magnitude effect of input variables is one of the major concerns in the ANN, SVM, and GEP models. Unlike ARIMA model, there is no variable selection algorithm for ANN, SVM, and GEP to select a subset of significant variables that adheres to the principle of parsimony.

Table 1.
ANN, SVM, GEP, and ARIMA Models

Model Names	Top 4 Important Variables	Model Fittings	MAPEs
ANN Model [a]	OSULG1 OU OKPCap OK_HG	0.96	1.84%
SVM Model [b]	OSULG1 OU OULG1 OK_HG	0.96	1.86%
GEP Model	OSULG1 OKPCap OK_HG USGNP	0.95	2.44%
ARIMA Model [c]	OSULG1 OK_HG USGNP OU	0.96	1.91%

[a] ANN (Hyperbolic/Identity) model
[b] SVM (linear) model parameters c=6661.79 and p = 0.0001
[c] ARIMA (1, 0, 0) model appropriateness, $\chi^2 = 19.41$, *df* = 17, and p = 0.305. All four variables are statistically significant at $p < 0.01$

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Supplier Selection Using Data Envelopment Analysis in the Presence of Imprecise Data

E. Ertugrul KARSAK, Mehtap DURSUN
Industrial Engineering Department, Galatasaray University
Istanbul 34357, Turkey
E-mail addresses: ekarsak@gsu.edu.tr , mdursun@gsu.edu.tr

and

C. Okan ÖZOGUL
R&D Department, Havelsan, Ankara, Turkey

ABSTRACT

This paper aims to present a comprehensive methodology for supplier selection, incorporating both the financial and strategic aspects and the related imprecise as well as exact data into the decision making process. A data envelopment analysis (DEA) model that can take into consideration crisp, ordinal, and fuzzy data is developed for supplier selection. The DEA approach is performed by employing average cost per unit and lead time as the input variables, and number of bills received from the supplier without errors, supplier's experience and supplier reputation as the output variables. The assessment of suppliers versus experience and reputation are represented via ordinal data, while lead time and number of bills received without errors are stated using triangular fuzzy numbers. The proposed framework is illustrated through an example problem for supplier selection.

Keywords: Supplier selection, Data envelopment analysis, Imprecise data, Fuzzy data, Multi-criteria decision making.

1. INTRODUCTION

In today's increasingly competitive and changing environment, firms must focus on rapidly responding to customer demand and must be concerned with customer satisfaction. Firms also need to reorganize their supply chain management strategy, and establish a sound strategic alliance against competitors. Supply chain management attempts to reduce supply chain risk and uncertainty, thus improving customer service, and optimizing inventory levels, business processes, and cycle times, and resulting in increased competitiveness, customer satisfaction and profitability [1].

As firms become more dependent on their suppliers, poor decisions on the selection of suppliers and the determination of order quantities to be placed with the selected suppliers results in severe consequences. Firms need to pursue effective strategies to achieve higher quality, reduced costs and shorter lead times, which also enable to sharpen their competitive edges in the global market. Hence, supplier selection has become a critical issue for establishing an effective supply chain.

In the early 1980s, Evans [2] found price to be the most important attribute in the purchase of routine products. However, recent studies have discovered a shift away from price as a primary determinant of supplier selection [3]. Organizations, which practice the latest innovations in supply chain management, no longer accept commodity partnerships that are exclusively based on price. Other important factors such as quality, delivery time and flexibility are included in managing these inter-organizational relationships.

Due to high level of difficulty in controlling and predicting a wide variety of factors which affect the decision, supplier selection has become one of the most popular areas of research in purchasing with methodologies ranging from conceptual to empirical and modeling streams. Earlier studies on supplier selection focused on identifying the criteria used to select suppliers. Dickson [4] conducted one of the early works on supplier selection and identified 23 supplier criteria which managers consider when choosing a supplier. Ellram [5] noted that research on supplier selection tends to be either descriptive or prescriptive. Descriptive studies provide information on what buyers actually do in selecting suppliers. These studies have addressed a wide array of issues, and have been extended to identify supplier selection under specific buying conditions ([6], [7]). Prescriptive research in supplier selection has used a variety of methodologies including mathematical programming, weighted average methods, payoff matrices, analytic hierarchy process (AHP), analytic network process (ANP), fuzzy set theory, and metaheuristics. Linear programming, integer programming, goal programming, data envelopment analysis (DEA), and multi-objective programming can be listed among the mathematical programming techniques employed in supplier selection. An integrated use of some of these approaches is also presented in a number of supplier selection studies. The reader is referred to Ho et al. [8] for a comprehensive review of the use of these approaches in supplier selection.

DEA has been actively used in supplier evaluation and selection for more than a decade owing to its capability of handling multiple conflicting factors without the need of eliciting subjective importance weights from the decision-makers ([9], [10], [11]). One of the major limitations of the use of conventional DEA approach in supplier selection process is the sole consideration of cardinal data. Difficulty in predicting a number of factors considered in supplier selection demand ordinal and fuzzy data to be taken into account as well. Another major limitation is the poor discriminating power of DEA models resulting in a relatively high number of suppliers rated as efficient.

In this study, an imprecise DEA model is proposed to evaluate suppliers. The proposed approach enables both exact and imprecise data to be taken into consideration. Ordinal data and fuzzy data are used to express qualitative factors. The increased discriminating power of the proposed model attained while solving substantially reduced number of linear programs avoids the burden of selecting the best supplier among a relatively high number of suppliers that are rated as efficient by the conventional DEA model.

The rest of the paper is organized as follows. Section 2 provides a brief presentation of the conventional DEA model. Section 3 introduces a DEA model that can assess crisp, ordinal and fuzzy data. A hypothetical though typical supplier selection example is presented in the subsequent section to illustrate the results of the analysis. The concluding remarks and directions for future research are provided in the final section.

2. DATA ENVELOPMENT ANALYSIS

Data envelopment analysis (DEA) is a linear programming based decision technique designed specifically to measure relative efficiency using multiple inputs and outputs without *a priori* information regarding which inputs and outputs are the most important in determining an efficiency score. DEA considers n decision making units (DMUs) to be evaluated, where each DMU consumes varying amounts of m different inputs to produce s different outputs.

The relative efficiency of a DMU is defined as the ratio of its total weighted output to its total weighted input. In mathematical programming terms, this ratio, which is to be maximized, forms the objective function for the particular DMU being evaluated. A set of normalizing constraints is required to reflect the condition that the output to input ratio of every DMU be less than or equal to unity. The mathematical programming problem is then represented as

$$\max E_{j_0} = \frac{\sum_r u_r y_{rj_0}}{\sum_i v_i x_{ij_0}}$$

subject to (1)

$$\frac{\sum_r u_r y_{rj}}{\sum_i v_i x_{ij}} \le 1, \quad j = 1, ..., n$$

$$u_r, v_i \ge \varepsilon > 0, \quad r = 1,\dots, s;\ i = 1, \dots, m$$

where E_{j_0} is the efficiency score of the evaluated DMU (j_0), u_r is the weight assigned to output r, v_i is the weight assigned to input i, y_{rj} denotes amount of output r produced by the jth DMU, x_{ij} denotes amount of input i used by the jth DMU, and ε is an infinitesimal positive number. The weights in the objective function are chosen to maximize the value of the DMU's efficiency ratio subject to the "less-than-unity" constraints. These constraints ensure that the optimal weights for the DMU in the objective function do not denote an efficiency score greater than unity either for itself or for the other DMUs. A DMU attains a relative efficiency rating of 1 only when comparisons with other DMUs do not provide evidence of inefficiency in the use of any input or output.

The fractional program is not used for actual computation of the efficiency scores due to its intractable nonlinear and nonconvex properties [12]. Rather, the fractional program is transformed to an ordinary linear program given below that is computed separately for each DMU, generating n sets of optimal weights.

$$\max E_{j_0} = \sum_r u_r y_{rj_0}$$

subject to (2)

$$\sum_i v_i x_{ij_0} = 1$$

$$\sum_r u_r y_{rj} - \sum_i v_i x_{ij} \le 0, \ j = 1, ..., n$$

$$u_r, v_i \ge \varepsilon > 0, \quad r = 1,\dots, s;\ i = 1, \dots, m.$$

The original DEA models assume that inputs and outputs are indicated as crisp numbers. Cook et al. [13] developed a model capable of handling ordinal inputs and outputs as well as factors represented using crisp data. Their approach assigns an auxiliary binary variable for every combination of ordinal variables and their distinct ranks on a predetermined scale.

3. DEA MODELS INCORPORATING EXACT, ORDINAL AND FUZZY DATA

Over the past decade, a number of researchers have published on DEA models incorporating imprecise data. Kao and Liu [14] developed an α–cut based approach to transform a fuzzy DEA model to a number of crisp DEA models. Since the efficiency values of DMUs are expressed by membership functions, a rank order of DMUs is obtained by employing fuzzy number ranking methods that may be shown to produce inconsistent outcomes. Despotis and Smirlis [15] proposed a DEA model dealing with exact and interval data. Although they claimed to decrease data manipulation efforts for the DEA model, their approach requires input and output weights to vary with respect to DMUs which would increase the number of variables by $(m + s)$ $(n – 1)$, for $i = 1, \ldots, m$ and $r = 1, \ldots, s$, for each linear program. Further, generalizing their approach to fuzzy data would be problematic since it is more reasonable to evaluate DMUs using the same level of α–cut for each linear program. Lertworasirikul et al. [16] have proposed a possibility approach for solving fuzzy DEA models where they determine the possibilistically efficient DMUs for predetermined possibility levels. Due to its extremely permissive nature, the possibility approach has a low discriminating power which often results in several efficient DMUs at all possibility levels.

This section presents DEA formulations initially developed by Karsak [17] to address decision problems involving the evaluation of relative efficiency of DMUs with respect to inputs and outputs that incorporate both exact and imprecise data. Imprecision in inputs and outputs are considered using ordinal data and fuzzy data. The concise development of the models is presented below.

Define $\tilde{x}_{ij} = \left(x_{ija}, x_{ijb}, x_{ijc}\right)$, for $0 \le x_{ija} \le x_{ijb} \le x_{ijc}$ as the fuzzy input i used by the jth DMU, and $\tilde{y}_{rj} = \left(y_{rja}, y_{rjb}, y_{rjc}\right)$ as the fuzzy output r produced by the jth DMU, where $0 \le y_{rja} \le y_{rjb} \le y_{rjc}$. Define

$$\left(x_{ij}\right)_\alpha^L = x_{ija} + \alpha_i\left(x_{ijb} - x_{ija}\right), \ \alpha_i \in [0,1],$$

$$\left(x_{ij}\right)_\alpha^U = x_{ijc} - \alpha_i\left(x_{ijc} - x_{ijb}\right), \ \alpha_i \in [0,1],$$

$$\left(y_{rj}\right)_\alpha^L = y_{rja} + \alpha_r\left(y_{rjb} - y_{rja}\right), \ \alpha_r \in [0,1],$$

$$\left(y_{rj}\right)_\alpha^U = y_{rjc} - \alpha_r\left(y_{rjc} - y_{rjb}\right), \ \alpha_r \in [0,1],$$

where $\left(x_{ij}\right)_\alpha^L$ and $\left(x_{ij}\right)_\alpha^U$ denote the lower and upper bounds of the α-cut of the membership function of $\tilde{x}_{ij}$, and similarly, $\left(y_{rj}\right)_\alpha^L$ and $\left(y_{rj}\right)_\alpha^U$ denote the lower and upper bounds of the α-cut of the membership function of $\tilde{y}_{rj}$, respectively. Let $\omega_i = v_i\alpha_i$, where $0 \le \omega_i \le v_i$. Then, $\sum_i v_i\left(x_{ij}\right)_\alpha^L$ and $\sum_i v_i\left(x_{ij}\right)_\alpha^U$ can be represented as

$$\sum_i v_i\left(x_{ij}\right)_\alpha^L = \sum_i v_i x_{ija} + \omega_i\left(x_{ijb} - x_{ija}\right),$$

$$\sum_i v_i\left(x_{ij}\right)_\alpha^U = \sum_i v_i x_{ijc} - \omega_i\left(x_{ijc} - x_{ijb}\right).$$

Similarly, define $\mu_r = u_r\ \alpha_r$, where $0 \le \mu_r \le u_r$. Then, $\sum_r u_r\left(y_{rj}\right)_\alpha^L$ and $\sum_r u_r\left(y_{rj}\right)_\alpha^U$ can be represented respectively as

$$\sum_r u_r\left(y_{rj}\right)_\alpha^L = \sum_r u_r y_{rja} + \mu_r\left(y_{rjb} - y_{rja}\right),$$

$$\sum_r u_r\left(y_{rj}\right)_\alpha^U = \sum_r u_r y_{rjc} - \mu_r\left(y_{rjc} - y_{rjb}\right).$$

Also, define $\boldsymbol{\gamma}_{\mathbf{rj}} = \left[\gamma_{r1j}, \ldots, \gamma_{rlj}, \ldots, \gamma_{rLj}\right]$ and $\boldsymbol{\delta}_{\mathbf{ij}} = \left[\delta_{i1j}, \ldots, \delta_{ilj}, \ldots, \delta_{iLj}\right]$ as the L-dimensional unit vectors, where

$$\gamma_{rlj} = \begin{cases} 1, \text{if } j \text{ is rated in the } l\text{th place w.r.t. the } r\text{th ordinal output} \\ 0, \text{otherwise} \end{cases}$$

$$\delta_{ilj} = \begin{cases} 1, \text{if } j \text{ is rated in the } l\text{th place w.r.t. the } i\text{th ordinal input} \\ 0, \text{otherwise} \end{cases}$$

Let $\left(E_{j_0}\right)^U$ and $\left(E_{j_0}\right)^L$ denote the upper and lower bounds of the α-cut of the membership function of the efficiency value for the evaluated DMU (j_0). Employing the substitutions given above, the general optimistic scenario DEA model incorporating crisp, fuzzy and ordinal data can be written as follows [17]:

$$\max\left(E_{j_0}\right)^U = \sum_{r\in C_R} u_r\, y_{rj_0} + \sum_{r\in F_R} u_r\, y_{rj_0c} - \mu_r\left(y_{rj_0c} - y_{rj_0b}\right) + \sum_{r\in O_R} \mathbf{w_r}\,\boldsymbol{\gamma}_{\mathbf{rj_0}}$$

subject to (3)

$$\sum_{i\in C_I} v_i x_{ij_0} + \sum_{i\in F_I} v_i x_{ij_0a} + \omega_i\left(x_{ij_0b} - x_{ij_0a}\right) + \sum_{i\in O_I} \mathbf{w_i}\,\boldsymbol{\delta}_{\mathbf{ij_0}} = 1$$

$$\sum_{r\in C_R} u_r y_{rj_0} + \sum_{r\in F_R} u_r y_{rj_0c} - \mu_r\left(y_{rj_0c} - y_{rj_0b}\right) + \sum_{r\in O_R} \mathbf{w_r}\boldsymbol{\gamma}_{\mathbf{rj_0}}$$
$$-\sum_{i\in C_I} v_i x_{ij_0} - \sum_{i\in F_I} v_i x_{ij_0a} + \omega_i\left(x_{ij_0b} - x_{ij_0a}\right) - \sum_{i\in O_I} \mathbf{w_i}\,\boldsymbol{\delta}_{\mathbf{ij_0}} \le 0$$

$$\sum_{r\in C_R} u_r y_{rj} + \sum_{r\in F_R} u_r y_{rja} + \mu_r\left(y_{rjb} - y_{rja}\right) + \sum_{r\in O_R} \mathbf{w_r}\boldsymbol{\gamma}_{\mathbf{rj}}$$
$$-\sum_{i\in C_I} v_i x_{ij} - \sum_{i\in F_I} v_i x_{ijc} - \omega_i\left(x_{ijc} - x_{ijb}\right) - \sum_{i\in O_I} \mathbf{w_i}\,\boldsymbol{\delta}_{\mathbf{ij}} \le 0,\ j = 1,2,...,n;\ j \ne j_0$$

$$\mu_r - u_r \le 0, \quad r \in F_R$$

$$\omega_i - v_i \le 0, \quad i \in F_I$$

$$\mu_r \ge 0, \quad r \in F_R$$

$$\omega_i \ge 0, \quad i \in F_I$$

$$u_r \ge \varepsilon > 0, \quad r \in C_R, r \in F_R$$

$$v_i \ge \varepsilon > 0, \quad i \in C_I, i \in F_I$$

$$\Psi = \left\{ \left(\mathbf{w_r}, \mathbf{w_i}\right) \middle| \begin{array}{l} w_{rl+1} - w_{rl} \ge \varepsilon, w_{r1} \ge \varepsilon,\ \ l = 1,2,\cdots,L-1; r \in O_R \\ w_{il+1} - w_{il} \ge \varepsilon, w_{i1} \ge \varepsilon,\ \ l = 1,2,\cdots,L-1; i \in O_I \end{array} \right\}$$

In the above formulation, $\mathbf{w_r} = \left[w_{r1},\ldots,w_{rl},\ldots,w_{rL}\right]$ is an L-dimensional worth vector with w_{rl} denoting the worth of being rated in the lth place with respect to the rth output, and $\mathbf{w_i} = \left[w_{i1},\ldots,w_{il},\ldots,w_{iL}\right]$ is an L-dimensional worth vector with w_{il} denoting the worth of being rated in the lth place with respect to the ith input, for $\forall l$, and Ψ is the set of admissible worth vectors. In addition, C_R, O_R and F_R respectively represent the subsets of crisp, ordinal and fuzzy outputs, while C_I, O_I and F_I are the subsets of crisp, ordinal and fuzzy inputs, respectively.

The above formulation indicates an optimistic scenario since the inputs and the outputs of the evaluated DMU are adjusted at the lower bounds and the upper bounds of the membership functions, respectively, whereas the inputs and outputs are adjusted unfavorably for the other DMUs. Alternatively, when the inputs and the outputs of the evaluated DMU are adjusted respectively at the upper bounds and the lower bounds of the membership functions, and the inputs and outputs are adjusted favorably for the other DMUs in a way that the inputs are adjusted at the lower bounds and the outputs at the upper bounds, a pessimistic scenario DEA formulation is developed.

4. ILLUSTRATIVE EXAMPLE

In this section, the proposed DEA-based methodology is illustrated through a hypothetical but typical supplier selection problem. The attributes to be minimized are viewed as inputs, whereas the ones to be maximized are considered as outputs for the supplier selection study. The decision framework involves the evaluation of the relative efficiency of 14 suppliers with respect to two inputs, namely "average cost per unit" and "lead time", and three outputs, namely "number of bills received from the supplier without errors", "supplier's experience" and "supplier reputation". "Lead time" and "number of bills received from the supplier without errors" that cannot be assessed by exact data are represented as triangular fuzzy numbers, whereas "supplier's experience" and "supplier reputation" are given as ordinal data using a 5-point Likert scale. In the 5-point scale, 5 represents the best score and 1 represents the worst score, respectively. Input and output data concerning the suppliers are given in Table 1.

In order to rectify the problems due to the significant differences in the magnitude of inputs and outputs, max-value normalization is applied to the "average cost per unit", "lead time" and "number of bills received from the supplier without errors" data. The maximization of the discrimination among consecutive rank positions and the minimum importance attached to performance attributes can be assured by using the maximum feasible value for ε, which can be determined by maximizing ε subject to the constraint set of the respective DEA formulation for $j = 1, \ldots, n$, and then by defining $\varepsilon_{\max} = \min_j \left(\varepsilon_j\right)$.

The optimistic scenario efficiency scores for the suppliers are calculated using formulation (3), while the pessimistic scenario efficiency scores are computed employing a pessimistic scenario DEA formulation. The optimistic and pessimistic scenario efficiency scores for the suppliers, which are obtained using $\varepsilon = 0.076$ computed as described above, are given in Table 2. Six suppliers, namely Sup_1, Sup_6, Sup_7, Sup_9, Sup_{11} and Sup_{13}, are determined as efficient regarding the optimistic approach due to its permissive nature, while Sup_{13} is the only efficient supplier according to the pessimistic approach. The pessimistic approach which results in a single efficient supplier has a high discriminating power. It is also worth noting that the proposed methodology determines the best supplier with a significant saving in computations compared to earlier fuzzy DEA models presented in [14], i.e. by solving only 28 linear programs and without using a fuzzy number ranking method.

Table 1. Data used to assess the relative efficiency of suppliers

Supplier (Sup_i)	Cost per unit ($)	Lead time (days)	Nr. of bills without errors	Experience	Reputation
Sup_1	7.5	(12,14,15)	(90,100,115)	2	3
Sup_2	11.4	(11,12,13)	(110,125,135)	1	4
Sup_3	10.2	(19,20,21)	(175,200,225)	4	2
Sup_4	12	(13,14,15)	(55,65,75)	2	2
Sup_5	13.4	(19,20,22)	(65,75,100)	2	2
Sup_6	8.4	(12,13,15)	(175,205,225)	3	3
Sup_7	7.6	(11,13,17)	(85,120,135)	1	4
Sup_8	12.6	(20,22,23)	(175,190,200)	3	3
Sup_9	8.2	(11,12,14)	(50,90,100)	4	2
Sup_{10}	11	(17,19,20)	(260,275,300)	5	3
Sup_{11}	7.8	(11,14,15)	(175,200,250)	2	3
Sup_{12}	11.6	(21,22,23)	(75,90,100)	4	1
Sup_{13}	10.2	(13,14,15)	(300,325,340)	5	4
Sup_{14}	12.6	(17,19,21)	(150,175,190)	4	3

5. CONCLUSIONS

The proposed approach is a sound and effective tool that enables qualitative as well as quantitative aspects to be taken into account, and thus improves the quality of complex supplier selection decisions. However, one shall note the limitations of the analysis which may also indicate directions for future research.

First, although the proposed approach enables to systematically incorporate the qualitative factors into the decision process, subjective judgment may still be required in selecting the inputs and outputs as well as interpreting the results of the analysis. Furthermore, in this study, triangular fuzzy numbers are used to represent fuzzy values due to their intuitive appeal and mathematical ease in computations. The use of nonlinear membership functions for fuzzy data would necessitate approaches for solving nonlinear programming models to be developed.

Future research will also focus on the implementation of the proposed approach in supplier selection problems using real-world data.

Table 2. DEA efficiency values of suppliers

Supplier (Sup_i)	Optimistic scenario efficiency score	Pessimistic scenario efficiency score
Sup_1	1.000	0.988
Sup_2	0.993	0.800
Sup_3	0.742	0.724
Sup_4	0.703	0.552
Sup_5	0.363	0.321
Sup_6	1.000	0.953
Sup_7	1.000	0.981
Sup_8	0.555	0.539
Sup_9	1.000	0.960
Sup_{10}	0.848	0.828
Sup_{11}	1.000	0.961
Sup_{12}	0.519	0.505
Sup_{13}	1.000	1.000
Sup_{14}	0.701	0.620

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EVALUATING THE EFFECT OF INFORMATION TECHNOLOGY IN SMALL BUSINESSES

Dr. Peter Newman
Capella University
Minneapolis, MN 55402, USA

and

Dr. Edward Goldberg
School f Business and Technology, Capella Tower,
Minneapolis, MN 55402, USA

and

Dr. Suheil Nassar
IBM Corp
Durham, NC 27709, USA

ABSTRACT

Information technology (IT) has become a strategic vehicle for small businesses to achieve and sustain their competitive advantage. Prior research has suggested that information technology plays an important role in the decision-making process. The purpose of this study is to examine the relationship between organizational IT performance and decision-making effectiveness in small businesses. In this study, a survey of 300 managers working in small businesses is proposed to gather data and measure the relationship between organizational IT performance and decision-making effectiveness. Descriptive statistics and Crohnbach's Alpha are used to analyze the data. Information technology has provided managers with many benefits such as access to an abundance of informational sources, quicker responses due to the speed of gathering information, and overall improvement in the decision-making process. With the opportunities available through the use of information technology, discovering measures in which to use these resources are crucial to the success of the business. This study is focused on the effect information technology has on decision-making in small businesses.

INTRODUCTION

The problem to be studied is the lack of knowledge on the importance of IT and how organizational IT performance affects decision-making effectiveness in small businesses. Huber (1990) [6] suggests that additional research needs to be directed towards studying how IT can affect organizational design, intelligence, and the decision-making process.

Current technology has presented opportunities for managers to create, maneuver, and evaluate (Schmidt, 1994) [9] information for making the most critical decisions at any level within a business. Decisions originate from information, and IT provides a process of simultaneously gathering and distributing information swiftly and inexpensively throughout a business. IT has become a powerful tool that managers have come to rely on to improve the quality of decision-making.

Managers perceive the organizational computing environment as a dynamic feature in the decision-making process. Research has suggested that there is a correlation between decision-making and the organizational computing environment (OC) along with the use of computing and communication technologies (Teng &

Calhoun, 1996) [11]. Decisions involve different degrees of structure and stretch across many levels of management, and IT encompasses both computing and communication tools. Teng & Calhoun [10] suggest that the continued use of IT over a period of time may advance the way in which a manager performs his responsibilities and provide for improved decision- making. It is implied that there is a connection to improvements in decision-making when a greater usage of IT is applied. If a better understanding of how to utilize IT to improve the decision-making process can be achieved, then a new level of effectiveness will certainly follow (Teng & Calhoun) [11].

Decision-making is the focal point of strategy in any business, and advances in technology have provided opportunities to improve both its quality and effectiveness. IT has provided businesses with competitive advantages aiding in the decision-making process. Technology opens new areas of resources creating pathways that allow businesses to optimize their decision-making. The success or failure of a business relies heavily on technology, which has become an essential part of the decision-making process. Having the knowledge to make the right decision is critical from the beginning of the process. Bloodgood and Salisbury (2001) [1] state:

Historically, information technology has had the net effect of making knowledge more explicit. This is done in order to facilitate more rapid transmission (e.g. by the use of email), standardized decision-making procedures (e.g. through the use of decision support systems), or codify knowledge. (p. 62)

PURPOSE

The purpose of the proposed research was to study the lack of knowledge on the importance of IT and how organizational IT performance affects decision-making effectiveness in small businesses. The significance of this research revealed the value of technological factors and the role they played in integrating technology components in the decision-making process. The results can be used in small businesses as a significant source of guidance to make well-informed technological decisions. The need for a distinct understanding of the technology available is necessary in order for businesses to succeed (Haines, 2004) [5]. IT generates new opportunities that may provide businesses with an understanding to make appropriate decisions that aid with sustaining a competitive advantage (Haines) [5].

METHOD

The purpose of this proposed research was to determine the significance that the implementation of IT had on the decision-making process in small businesses. The objective of the study was to understand the influence of IT usage on effective decision-making in small businesses. The research method employed for this study consisted of a quantitative correlational method. This type of method is appropriate for the study because it is used to explain relationships among different variables and then specify the degree of association (Creswell, 2002) [4]. In non-experimental research the researcher has no "direct control of independent variables because their manifestations have already occurred or because they are inherently not manipulable" (Kelinger, 1986, p.348) [7]. The objective of this study was to gain an understanding of the relationship between organizational IT performance and decision-making effectiveness in a small business setting and the survey method " is the most appropriate for this study" (Li, 2002,p.69) [8]. A non-experimental correlational research method consisting of a survey instrument was used for the study. This research method is appropriate because it allows statistical inferences to be constructed since it is performed in a natural setting, which help to strengthen the external validity of the study (Wood, 2000) [12].

LITERATURE REVIEW

Boudreaux (2006) [2] conveys the adoption of technology contributes to timelier, more precise and relevant information that is beneficial to the business. Information, whether it is historical or predictive, along with real time indicators, has an impact in the everyday process of strategic decision-making. Prior research examines Enhanced Business Reporting (EBR), which helps a business to gather better information in respect to business performance so that improved strategic decision-making can be put into place. The objective of the Enhanced Business Reporting Consortium (EBRC) is to improve the information required to make better strategic decisions. Its objective is to work on the quality, integrity, and transparency of the information utilized in forming a strategic decision in a most cost effective and timely approach. The EBRC has been creating a framework that will offer a structure for presenting information other than financial reporting, such as key performance indicators, strategic direction, underlying business drivers and managements assessments of risks and opportunities. All of these factors play a vital role when integrating information, which assists managers with the option to make more efficient strategic decisions. The framework provides an in-depth indication of how well the business is performing from different aspects, allowing the business to supply needed information so that more effective decisions are achieved (Boudreaux, 2006) [2]. The objective is to create a path so that information on all levels is able to be incorporated into the decision-making process, and that all businesses, regardless of the size, can benefit from its use. New qualifications and proficiency to guide managers in their decision-making strategies. Issues such as the importance of business process management, increased mobility, and new opportunities that require new skills for future Information Systems organizations are researched and analyzed. Research has confirmed that IT does make a difference and management has been escalating their strategic influence over decision-making (Scott, 2007).

RESULTS

Results of the survey showed that there was a significant positive bivariate association between organizational IT performance and decision-making effectiveness. None of the demographic variables including gender, age, length of time at current job, length of time using computer, work function, business industry, and company size, were associated with decision-making effectiveness. Results from the multiple regression analysis showed that there was a significant association between organizational IT performance and decision-making association between organizational IT performances and decision-making in multivariate context. The significant association between organizational IT performance and decision-making effectiveness remained after controlling for gender, age, work function, length of time in current job, length of time using a computer, industry, and company size. As the correlation analysis showed that there was a relationship between organizational IT performance and decision-making which r equaled -.46, p<, 001 was significant and had better organizational IT performance. When businesses choose not to take a proactive choice in incorporating IT, it leaves management at a disadvantage in decision-making, and increases the possibility for failure.

This study did not find any significant association between organizational IT performance and any of the demographic variables (gender, age, work function, and length of time in current job, length of time using computers, industry, and company size). Buhalis (1998) [3] conveyed that effective leadership could be measured by the knowledge and success from experience. The results of the study indicated that the majority of the respondents had more than 5 years experience using technology and that factor did not have a significant effect on organizational IT performance: f (3, 296) =0.31,p>.05.

Bivariate association between decision-making effectiveness and each of the demographic variables as well as IT performance and each of the demographic was assessed. Results from the series of ANOVA analysis show that reported decision-making effectiveness did not significantly differ across age groups, length of time at current job, length of time using computer, work function, business industry, or company size. These results indicated that none of the demographic variables were associated with decision-making effectiveness based on the lack of correlation between the demographic variables and the effectiveness of decision-making.

The framework was analyzed through the qualitative study and tested by managers in small businesses. The framework implies that between IT performance and decision-making effectiveness the results will improve the strategic decision resulting in growing the organization. Improved strategic decisions and the implementation of technology provide improved communication and management generating better quality decisions.

There is a positive relationship between organizational IT performance and decision-making effectiveness. This relationship can persuade small businesses to explore and utilize the opportunities provided by IT. Decisions originate from information, and IT provides a process of simultaneously gathering and distributing information swiftly and inexpensively throughout a business. IT has become a powerful tool that managers have come to rely on to improve the quality of decision-making. Teng & Calhoun [11] suggest that the continued use of IT over a period of time may advance the way in which a manager performs his responsibilities and provide for improved decision-making. If a better understanding of how to utilize IT to improve the decision-making process can be achieved, then a new level of effectiveness will certainly follow (Teng & Calhoun, 1996) [11].

Decision-making is a significant task, and it is essential for those in managerial positions to be able to understand the importance of the Internet in managerial decision-making. With the wide range of IT available today businesses have the opportunity to utilize these resources in such a way so that they can achieve the most effective results from their decision-making (Wood, 2002) [12]. Businesses today are searching for technology solutions that can provide the opportunity to expand their organization. The lack of importance of IT and how an organization IT affects the decision-making effectiveness in small businesses is determined by technical factors. IT can generate new opportunities that can potentially provide businesses with decision-making tools that will aid them in sustaining competitive advantage.

RECOMMENDATIONS

The study measured the importance of IT organizational performance and the knowledge that decision-making effectiveness has in small businesses. The research revealed the value of technical factors and the role they played in integrating technology components in the decision-making process. Decision-making can be limited and globally constrained, preventing resourcefulness and innovation within organizations. The expectation on managements' ability and action influence the environment of an organization, so the decision maker is proactive rather than reactive. Reponses regarding effectiveness of IT are user specific as opposed the company specific, but given the 300 respondents surveyed it would not be possible to identify each specific respondent in each separate company. Responses cannot always be taken as accurate descriptions of what the respondents actually do or really feel about something. It is implied that organizations grow better decision-makers by experience, education and operational processes that require critical and creative thinking, which creates success in an organization. Experience alone will not adequately prepare management to be effective decision makers in the future.

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Competition to Design the Brand Strategy Decision Making Model

Su-Man Wang
Dept. Marketing Management, Takming University of Science and Technology
56, Sec. 1, Huanshan Rd., Neihu, Taipei 11451, Taiwan

and

Ming-Hui Chen
Dept. Marketing Management, Takming University of Science and Technology
56, Sec. 1, Huanshan Rd., Neihu, Taipei 11451, Taiwan

ABSTRACT

In 1980, Porter proposed that "the general competition policy generic strategies" pointed out three different strategies which would give their business a competitive advantage. However, because nowadays the development of branding goods is so important to consumers, companies not only need to analyze the relative competitive advantage, but also need to make decisions on the design of the brand; the most important attribute of this paper is to combine the competitive strategy theory and the branding strategy design theory, which develops a competitive strategy to design a corporate branding decision analysis model. Keywords: competitive strategy, branding strategy, decision-making model.

Keywords: Branding Strategy, Competitive Strategy, Corporate Branding, Decision Making.

1. INTRODUCTION

The impact of decision-making is very significant to developments of companies. Any company facing complicated and volatile business environments of globalization tends to have successful business due to having the right brand strategy, hence being in good condition to compete. This key factor is essential, if a company is to succeed. The competitive strategy matrix of Michael E. Porter1 in the strategic management field is the most reliable theory in the academic and industry fields. His strategy matrix is mainly based on the dimensions of strategic scope and strategic strength to develop the generic strategies. However, to a company, brands represent very valuable legal assets because the sale of brands can affect consumer behavior, and also guarantee continuous income in the future. The branding strategy of a company reflects the company's sales of different products on the use of the general characteristics and the number and nature of the brand elements. Usually when a company introduces new products, it has three main options, 1. Developing new brand elements for new products, 2. Utilizing some of the already existing brand elements, and 3. Combining new and already existing brand elements. This paper uses the most commonly used cost efficiency and product differentiation of the generic strategies as the two variables in the decision-making about brands. This implies that different companies should coordinate their product cost and the advantage of product differentiation to design adequate brand strategy to maximize their profits.

This paper, which is based on the above dimensions of competitive advantage and has gone through literature review, expert interviews, application of modified Delphi method, and competitive strategy, proposes a corporate branding decision analysis model.

2. LITERATURE REVIEW

1) Competitive strategy literature

According to the competitive strategy organizations adopt, we will discover how organizations utilize their resources and select their best strategy to strive for the most favorable competitive position in order to improve operation performance. Following are different perspectives from a number of scholars to explain the competitive strategy. Willian [2]proposed strategy for stability, growth, withdrawal, and combination. Miles and Sno [3] proposed four strategic rules according to an organization's business unit strategy and their adaptation to the environment. These rules are defender, prospector, analyzer, and reactor. Herbert & Deresky [4] integrated different scholars' strategies according to the strategies they adopted and proposed for different stages of the product life cycle: Select to build solid foundation strategy during the period of germination and growth stage, and then adopt strategies to expand, and grow; maintain stability of profit base during mature stage ; and adopt harvesting, size, and cost reduction strategy during a recession stage. The competitive strategy proposed by Porter in 1980 mentioned that organizations have three competitive strategies to choose from in order to gain competitive benefits and to perform better than other competitors. The three competitive strategies namely are, low-cost leadership, differentiate products, and focus. This paper is based on the related literature about competitive strategy, the characteristics of brand strategy, the main advantage of Porter's concept about the cost competitive advantage, and differentiation advantage variables as the basis that designs the brand strategy decision-making.

2) Brand Strategy

The purpose of the branding strategy is to create a resonance between companies and consumers, and to take advantage of their strengths and their opponent's weaknesses [5]. Laforet and Saunders [6]carried out structural analysis of an enterprise brand, and put forward six types of brand strategy: corporate domination strategy, business unit disposal strategy, the double brand strategy, endorsed brand strategy, brand dominant strategy, and the brand name of hidden corporate domination strategy. However, Kotler[7] proposed brand strategy decision-making, which is when the enterprise can use the following brand strategies after the brand is decided: 1. Line extensions: it is under the same brand name, in accordance with different styles, and packaging, to introduce new products. 2. Brand extensions: it is to extend the existing brand name to other types of new products. 3. Multi-brands: it means within the same product category, according to product attributes, consumers' motivation to purchase different brands, to create different product characteristics and preferences. 4. New Brands: it refers to existing brands that were found unsuitable for new products, a new brand should be introduced for the new products. 5. Co-brands: it is also known as dual branding, which is to combine two or more named brands in order to create a synergistic effect. Furthermore, Kotler and Keller [8] promoted branded variants which provides a particular brand line's specific retailers or marketing channels. Another strategy for a licensed product is to authorize the brand name licensed to actual manufacturers of products. Synthesizing all the above scholars' competitive strategies and the definitions of a variety of brand strategies, this study analyzed the product costs of competitors and differentiation degree of production, and drafted brand strategies of competitive advantage, which need to be adjusted and modified at any time under the change of the environment, in order to maintain continuing brand competitiveness. Therefore, this paper combined and applied over a number of brand strategies, and developed a competitive brand strategy design model.

3. METHODOLOGY

This paper, which is based on the above dimensions of competitive advantage and has gone through literature review, expert interviews, application of modified Delphi method, and competitive strategy, proposes a corporate branding decision analysis model.

1) Determination of consistency

The Standard of Determination of this article follows the idea of Fahety [9] and Holden & Wedman [10], as Table 1. The result of the completion of questionnaires shows the high and moderate level consistency as over 83.3%.

Table 1. Criteria of consistency

Consistent high	Low	Moderate	High
Interquartile	Q <=	0.6 <Q <=	Q> 1

2) Discrimination of Stability

When some of the subjects being discussed do not reach the level of consensus, companies need to use questionnaire of the overall stability as a decision basis of whether or not they should end the investigation. The Discrimination of Stability of this paper adopted the criteria proposed by Murry and Hommons [11] and is based on the number of change of experts' opinion, which is less than 20 percent, as the expert group to the opinions of individual items to stabilize the distribution of minimum standards such as Equation (1). (Number of Change / all numbers)* 100%<20% . .. (1)

3) Fuzzy Delphi Method

By the application of Fuzzy theory, we can resolve the ambiguity of experts' consensus, as well as providing experts more flexibility of assessment scale, so that the results of Fuzzy Delphi method is more rigorous and reasonable. At the same time, we can reduce the back and forth number of questionnaires to improve the quality and efficiency of computing steps of Fuzzy Delphi method questionnaire. Due to the considerable length of this article, I will not discuss it here. The selection of number of experts in this study was based on the proposal of Adler and Ziglio [12], which suggested to follow the principle of 10-15 homogeneous exports when conducting a questionnaire.

4. ANALYSIS of BRAND AND DESIGH STRATEGY

Specific decision-making analysis of brand strategy design of competitive strategy uses quantitative-oriented analysis. The operation method is commonly used by social science research such as Decile 5 Likert Scale. According to the statistic outcome of returned questionnaire, this paper used the interquartile range test groups to examine the variation of brand strategy from experts' opinion to find a consensus of experts of all levels. Besides, this paper also analyzed Fuzzy Delphi Conversion of triangular Fuzzy numbers, and built a competitive brand strategy design model. This study involved a group twelve experts and utilized the decide five Likert-type scale as the attainment of individual experts to collect the extent of agreement on various items of indicators. Table 2 shows the consensus of consistent statistical analysis in Table 2.

Table 2 Discriminate of Consensus of Brand Strategy

Level of	Items of Brand	Percentage
High	5	83.33%
Moderate	1	16.67%
Low consistency	0	0
Total	6	100%

Through the above analysis of interquartile range, stability and consistency checking and testing by the above analysis, the strategies excerpted and constituted the final strategic direction. Further more, the analysis of Fuzzy Delphi conversion of triangular Fuzzy numbers, contributed to build the competitive strategy design model as in Figure 1.

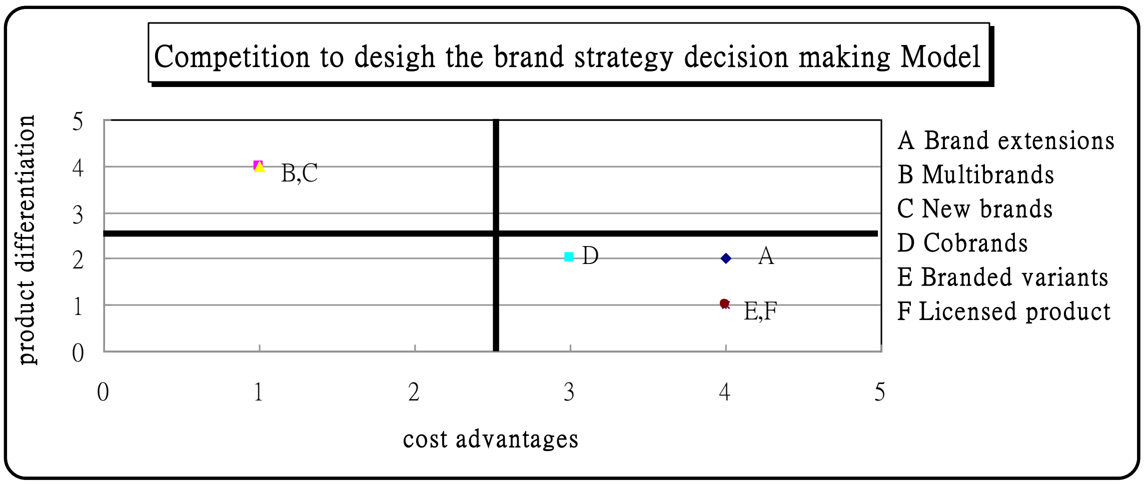

Fig. 1 Competition to design the brand strategy decision marking model

The results indicate that companies with high-product differentiation and low-cost advantages should adopt multi-brand or new brand strategy; the companies with low-product differentiation and high-cost competitive advantage should adopt brand variation promotion strategies or product authorization strategy; the companies with relatively moderate cost advantage and product differentiation will benefit more to adopt dual brand strategy.

5. CONCLUSIONS

A business brand name will possibly attract more customers who are loyal to a brand. It is also helpful to segment the market and help enterprises to establish their corporate image. However, the brand of products also increases a company's costs and expenses. Companies must review their costs and product differentiation of themselves and their competitors to make right decision of a business brand. Competitive strategy brand design model is an external advantage comparison-analyzing tool for companies with competitive product cost and differentiation advantage. This model will help companies a tool to examine the brand design strategy in corporate brand strategy at all time.

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Enterprise Information Security Policy Assessment - An Extended Framework for Metrics Development Utilising the Goal-Question-Metric Approach

Maria Soto Corpuz
Information Security Institute, Queensland University of Technology
Brisbane, Queensland/4000, Australia

ABSTRACT

Effective enterprise information security policy management requires review and assessment activities to ensure information security policies are aligned with business goals and objectives. As security policy management involves the elements of policy development process and the security policy as output, the context for security policy assessment requires goal-based metrics for these two elements. However, the current security management assessment methods only provide checklist types of assessment that are predefined by industry best practices and do not allow for developing specific goal-based metrics. Utilizing theories drawn from literature, this paper proposes the Enterprise Information Security Policy Assessment approach that expands on the Goal-Question-Metric (GQM) approach. The proposed assessment approach is then applied in a case scenario example to illustrate a practical application. It is shown that the proposed framework addresses the requirement for developing assessment metrics and allows for the concurrent undertaking of process-based and product-based assessment. Recommendations for further research activities include the conduct of empirical research to validate the propositions and the practical application of the proposed assessment approach in case studies to provide opportunities to introduce further enhancements to the approach.

Keywords: information security policy; information security management assessment; security policy assessment; security assessment

1. INTRODUCTION

Organizations develop enterprise information security policy to provide strategic direction in implementing their information security management programs [1][2][3][4][5][6]. The enterprise information security policy (herein referred to as security policy in this paper) defines information security program goals, assigns responsibilities and sets security control requirements [1][7] based on corporate business and risk management objectives [3][4][5]. It is a major element of an organization's corporate governance [8] and risk management strategy [9].

The development and management of security policies are required for the effective governance and implementation of information security [6][10][11]. Effective information security policy management requires policy review activities in addition to policy development and implementation [6][7][8][9] to address evolving risk exposures [2] and provide risk assurance to organizations. However, as will be presented in this paper, limitations in information security assessment methods include the lack of a measurement methodology that facilitates metric development [12].

In addressing these limitations, Section 2 first discusses the required considerations for security policy development and the contextual elements of security policy assessment. Section 3 then presents a review of the current security management assessment methods in the context of security policy assessment. In Section 4, the Enterprise Information Security Policy, a security policy assessment framework that expands on the Goal-Question-Metric approach (GQM) [13] is proposed. This is followed by Section 5 which presents a case scenario example to illustrate a practical application of the proposed policy assessment approach. Lastly, conclusions and recommendations for further research are provided in Section 6.

2. ENTERPRISE INFORMATION SECURITY POLICY ASSESSMENT

An assessment is a data gathering exercise conducted as an element of a learning process the results of which are used to review and revise an organization's objectives and strategies [14]. Assessments are undertaken in regular pre-defined periods to establish the stages of improvement (or degradation) in learning.

Information security assessments commonly take on the perspective defined by the information security management standards [3][4][5][15] and are conducted mainly as a requirement to evaluate organizational compliance to legislation and mandatory standards. The drivers for information security policy management include the need for IT governance [9][16][17], the requirement for regulatory compliance [18] and risk management [2].

The major considerations for developing and managing security policies that are defined and cited by the security policy management frameworks [6][11][19] and the best practice guidelines [1][2][3][4][5][6]include the following:

1) Contextual business alignment [2][7][16][19][20] – it is a requirement for policy development process to be aligned with corporate business and/or organizational requirements such as corporate governance and risk management;
2) Integrated security policy structure [5][6][21] - the outcome of the development process should result in product set of security policies, practices and procedures

that are coordinated and integrated and implemented at different levels;

3) Cost-efficient implementation [22][23] – implementation and enforcement of security policies should be balanced between cost and benefits; and
4) Continuous improvement management [2][24] – development process should facilitate policies to be continually reassessed and updated to address evolving risks.

The drivers and the policy characteristics comprise the contextual elements for security policy assessment. These assessment elements are considered in defining the domains of security policy assessment and evaluating assessment methods which are presented and discussed in the next section.

Domains of Security Policy Assessment

The elements of an assessment activity usually consist of a defined purpose and method of measurement [25] and which involves metrics development [26]. The purpose or requirement for assessment defines the method of measurement and the metrics approach. Management of security policies requires both the establishment of a policy development process and the effective implementation of the product set of security policies. For this paper, a security policy assessment method may be classified as either a process-based approach or a product-based approach. The process-based approach is utilized if the primary assessment objective is business process improvement whereas the product-based assessment approach is utilized if effectiveness of security policy implementation is the primary assessment concern [12].

Process-based Assessment: A driver for utilizing process-based assessment is the requirement for business improvement drawn from the corporate need for improving business performance and productivity [27]. Such requirements for process assessment are usually brought about by organisational changes in corporate structure, strategic business direction and overall corporate objectives [28]. These changes impact the implementation of strategic aspects of corporate governance such as information security.Research literature has indicated that information security has become a major part of corporate governance [1][3][8] that focuses more on people, processes and information in addition to IT [9]. As the security policy provides the critical direction-setting aspect of information security, it is one of the most important controls of corporate governance and requires continuous assessment [1][10].

A process-based assessment approach commonly utilized by information security management frameworks [3][4][5][15] is the maturity assessment model that is adapted from the conceptual model of the capability maturity model (CMM) developed for software process improvement [29]. There is wide acceptance [4][30][31] that to address the requirement for information security assurance through process improvement, the metrics for process-based assessment involve the quality elements defined in the maturity model [29] that consist of consistency, repeatability, predictability of outcomes and continuous optimization. Based these conceptual considerations, it is proposed that:

Proposition 1 (P1)*: The utilization of the quality elements of consistency, repeatability, predictability of outcomes and continuous optimization for process-based security policy assessment will be similar to those quality elements used in the maturity model for continuous process improvement adapted for information security management systems.*

Product-based Assessment: Another driver for security policy assessment is the requirement to ascertain the effectiveness of the security policies as internal controls for achieving and maintaining organizational information security assurance [2][24]. The security policy is based on business and organizational requirements for security risk management [6]. It requires continuous assessment and revision to address evolving risks according to organizational changes [2][11]. The continuous assessment of the security policy ensures practices and procedures within the security policy are coordinated and integrated [2].

In this perspective, the main considerations for product-based assessment are the policy quality elements that address the need for security policies to be aligned with business and/or organizational requirements such as the need for corporate governance or risk management [2][7][8][16]. Other requirements include the need for coordinated and integrated policy structure that is enforced through different levels of internal controls [6] that is implemented according to balanced cost efficiencies [8].

Policy development for information security takes on concepts of strategic planning by way of objective setting and coming up with the program of projects to be undertaken according to the set business objectives. This apparent similarity where it is defined that the security policy contains a layered structure set of sub-policies and procedural implementation that need to be reviewed and assessed may be undertaken in the same manner as that of a corporate strategy or policy and its related program plan of business initiatives.

From this discussion, it may be considered that the development and management of the security policy is a strategic planning process derived from other corporate-level business policy requirements. It is then proposed that:

Proposition 2 (P2)*: The utilization of the quality elements of contextual business alignment, integrated policy structure and cost-efficiencies for product-based security policy assessment will be similar to those quality elements used in the assessment of strategic business policy*.

In the next section, the security assessment methods are evaluated based on propositions ***P1*** and ***P2***.

3. COMPARISON OF SECURITY ASSESSMENT APPROACHES IN THE CONTEXT OF SECURITY POLICY ASSESSMENT

Information security assessments are required to maintain organizational security assurance. Although vast majority of organizations conduct security audits, the tools and methods of assessment used for security is far from universal. Depending on the business objective for security assessment, assessment methods can be categorized as either traditional checklists of security controls or capability maturity assessment methods that focus on audit of processes.

Traditional Checklist Assessment Method: The tools and methods of assessment used for security is far from universal. Depending on the business objective for security assessment which is usually for compliance and certification purposes, the traditional methods of assessment involve auditing of security technologies and controls against checklists provided by industry standards and best practices. Checklists define the criteria to be used as evaluation basis for the security properties of IT products and systems [32]. Another kind of assessment criteria checklist may also contain basic categories providing internal controls statements for compliance [3][4][5][15][33]. The checklist approach is usually employed for high-level security audit for purposes of meeting certification against the standard or meeting compliance requirements.

Maturity Assessment Models: The traditional checklist approach has progressed to include elements that define the state of maturity of processes as adopted from the assessment approach of the capability maturity model for developed by the Software Engineering Institute for evaluating software development [29]. The maturity assessment model uses a defined 5-level maturity categorization to assess capability based on process maturity. It utilizes a maturity-level checklist to measure process and productivity of the software development life cycle [34][35]. Adapted for assessing information security compliance through standard checklists of security control statements presented by the best practice standards [4][30][31], the maturity model has also been widely used to evaluate the information security management system within the organization.

Evaluation of Assessment Methods

In evaluating assessment approaches in the context of security policy assessment, the conceptual *Propositions 1* (P1) and *2* (P2) are assumed. The relevant factors used as basis for evaluation are: (1) the domain of assessment which is either process-based or product-based; and (2) the set of quality elements represented as domain metrics according to the domain of assessment.

In Table 1, the traditional checklist type and the maturity assessment methods are evaluated whether each method provides either an assessment checklist or a measurement and metrics methodology or both. A check indicates the method provides a means to assess the quality element requirement by providing either a checklist or a measurement methodology (including a metrics development process) or both. A cross means the method does not provide either the assessment checklist or the measurement methodology or both.

Based on this presentation, it is shown that the traditional checklist methods concentrate on assessment against controls defined by the prescribed checklist. It is for this reason that such checklists are used mainly in the conduct of a security audit to assess the extent of security compliance against a prescribed standard. However, the assessment based on predefined controls list does not necessarily reflect the security posture of the organization [10]. Another limitation is that the checklist type of assessment does not define levels of maturity by which an organization can assess itself thus leaving a gap by which to base improvement [36]. The lack of a progressive assessment scheme in traditional assessment methods presents a challenge to the organization in implementing an improvement approach to escalate to a higher level of maturity pertinent to their organizational policy processes, much less their policies structures.

Domain of assessment	Quality elements (domain metric)	Traditional checklist assessment methods		Capability maturity assessment methods	
		checklist	method of measurement and metrics	checklist	method of measurement and metrics
Process-based	***P1***				
	Consistency	✗	✗	✓	✗
	Repeatability	✗	✗	✓	✗
	Predictability of outcomes	✗	✗	✓	✗
	Continuous optimization	✗	✗	✓	✗
Product-based	***P2***				
	Business alignment	✓	✗	✗	✗
	Integrated policy structure	✓	✗	✗	✗
	Cost efficiency	✓	✗	✗	✗

Table 1 Evaluation of Assessment Methods Matrix

On the other hand, it is also shown that maturity assessment approaches concentrate attention on the evaluation of the process itself. This results in the oversight of assessing the resultant policy product that the process is producing. Solely utilizing the maturity assessment methods will not provide sufficient assessment results to provide an understanding of the effectiveness of the security policies based on business alignment and cost efficiency.

The utilization of any single assessment method provides assessment results relative to only those quality elements that comprise the domain used in the assessment. This linear assessment presents inherent disadvantages as assessment is not based on the whole context of policy development that should be multi-dimensional [12]. For example, using process-based assessment alone will provide assessment results relating to the policy development process and not necessarily relevant to policy effectiveness. Alternatively, even if the assessment methods are undertaken in combination, the utilization of the unsynchronized assessment methods presents problems in metric correlation that may consequently lead to conflicting and therefore unreliable results.

4. METRICS DEVELOPMENT FOR ENTERPRISE INFORMATION SECURITY POLICY ASSESSMENT

The conceptual similarities between software engineering and information security have encouraged the adoption and adaptation of software management processes and assessment models in information security.

The Goal-Question-Metric (GQM) was developed as a measurement approach for software development [37]. The method is based upon the assumption that meaningful measurement should be based on pre-defined goals for the assessment. The GQM approach was originally defined for evaluating software defects in government projects [38]. The result of the application of the GQM is a measurement system targeting a defined set of issues and rules for interpreting measurement data in three levels [13] as shown in Figure 1:

1) Conceptual level (GOAL) - a goal is defined for objects of measurement which are products, processes and resources.

2) Operational level (QUESTION) - a set of questions is developed to characterize the manner of assessment of a goal.
3) Quantitative level (METRIC) - a set of measurement data generated to answer each question in a quantitative way.

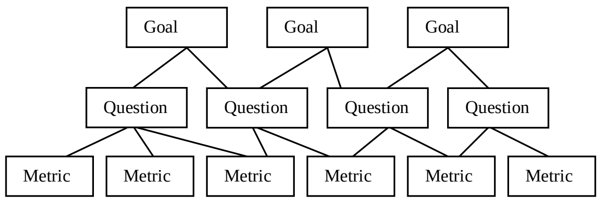

Figure 1 The Goal-Question-Metric Method
(Source: Adopted from Basili et al, 1994)

In addressing the lack of a metrics development approach in security assessment methods, the GQM is considered in this paper. There are however differences between software engineering and information security that present issues and disadvantages if these are not considered in formulating such adaptations. One such major difference is that unlike software development which is a project-based undertaking driven by a business requirement for the delivery of a software product, information security is based on an ongoing business requirement for corporate governance that is defined by the security policy. The security policy is recognized as a strategic policy that may be developed and managed according to the strategic alignment contexts of corporate risk management [19] and strategic management [20]. Thus, metric development for security policy requires an expansion to the GQM approach to allow for the consideration of the contextual alignment. This is presented in the next section.

Enterprise Information Security Policy Assessment: An Extended GQM Approach

Existing literature provides several varying security policy theories [39] [11] [6] [40][19] that present different perspectives and approaches on the development and management of security policies. Recent security policy management theories attempt to provide more focus on the requirement for alignment with corporate business objectives for risk management [19], IT planning [41] and strategic planning [20]. These approaches are based on the business planning and information systems planning integration approaches of previous research studies [42][43][44][45]. As a major consideration for security policy is its alignment with business objectives, assessment of the security policy should involve the degree of alignment between the security policy and the strategic business context for which the policy was developed. Based on this correlation between the policy alignment context and the metric development, the following hypothesis is proposed:

Hypothesis 1 (H1)*: Establishing the alignment context for security policy management positively affects the alignment of the top-down definition of goals, questions and metrics with the business requirements.*

The GQM [37] developed for software does not present an element for policy context consideration. To address this limitation and allow for the adoption of hypothesis 1 ***H1***, it is then proposed that the GQM approach is expanded as presented in Figure 2. The steps involved in the extended approach are as follows:

Step 1: Establish policy alignment context - alignment perspectives for developing and managing security policy may be based on risk management [19] [Corpuz and Barnes 2010], IT planning [41] or strategic management [20] [Corpuz 2011]. This step will align the assessment goals for the security policy, whether it is addressing corporate risks or providing corporate support as a strategic business policy.

Step 2: Define goals - goals for security policy pertain to the three objects of measurement for the security policy: (1) the security policy product; (2) the security development process; and (3) the policy resources used in implementation.

Step 3: Develop questions - questions characterize the object of measurement (product, process, resource) with respect to a quality element. Questions can be generated using the quality elements (domain metrics) for product-based and process-based assessment in Table 1 of Section 3:

Process-based: quality elements of consistency, repeatability, predictability of outcomes, continuous optimization.

Product-based: quality elements of business alignment, integrated policy structure, cost efficiencies.

Resource-based: quality element of cost efficiencies

Step 4: Define metric - generate the set of data according to the defined metric as quantitative responses to the questions.

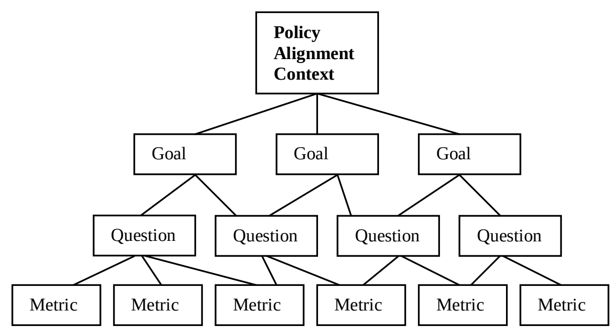

Figure 2 Enterprise Information Security Policy Assessment: An Extended GQM approach

5. A CASE EXAMPLE

An organization requiring an update to its security policy will conduct security policy assessment based on the organizational context of corporate risk management. With the assumption that enterprise information security is aligned with the corporate risk management, the following measurement approach based on the proposed extended GQM approach will yield the following as shown in Figure 3.

Step 1: Establish policy alignment context - policy alignment context is with corporate risk policy

Step 2: Define goals - goals include:

(1) security policy and policy structure should be aligned with corporate risk policy.

(2) security development process should be generate business improvement.

(3) the resources used in the security policy process should be optimally utilized within planned budget allocation.

Step 3: Develop questions - questions characterizing the policy product, process and resource with respect to the defined quality elements:

Process-based: Is policy development process repeatable and standardized to facilitate ongoing implementation and business improvement?

Product-based: Is policy aligned with risk management requirements for security controls?

Resource-based: Is policy implementation using resources in the optimum way?

Step 4: Define metric - the set of data as quantitative responses to the questions:

Process-based: Generate user compliance to procedural policies in percentage.

Product-based: Generate number of mitigated risks compared to targeted risk controls.

Resource-based: Generate cost savings in policy development through avoidance of rework in man-hours.

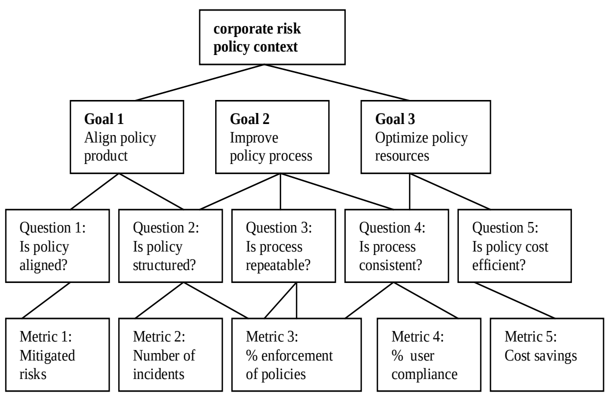

Figure 3 Case example: A GQM Metric Matrix with Policy Alignment Context Consideration

6. CONCLUSION

The management of enterprise information security policy is a strategic management activity that can be presented as an integrally aligned undertaking with corporate risk management and strategic planning. This allows for strategic management tools and methods to be adapted for security policy development and assessment. Further, security policy assessment can also adapt software development tools and process for assessment and metrics development. These conceptual adaptations for security policy management fill the gap and address limitations in existing security management approaches. Such gaps include the need for policy assessment approach and metrics development.

This paper provides a method selection for policy assessment from the current security assessment approaches through a matrix comprised of quality elements provided by the traditional assessment methods. In presenting and addressing limitations in utilizing the current approaches, the paper proposes an extended GQM approach to facilitate goal-based multi-dimensional assessment approach and a method to develop measurement metrics. By providing an example case scenario, it is briefly shown that the proposed framework addresses the requirement for developing assessment metrics and allows for concurrent process-based and product-based assessment. Metrics that can be developed include aspects such as the success rate of enforcement and the efficiency and effectiveness of the policies to address risk mitigation requirements.

Recommendations for further research activities include the conduct of empirical research to validate the propositions and the practical application of the proposed assessment approach in case studies to provide opportunities to note further enhancements to the approach.

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The Enterprise Information Security Policy as a Strategic Business Policy within the Corporate Strategic Plan

Maria Soto Corpuz
Information Security Institute, Queensland University of Technology
Brisbane, Queensland/4000, Australia

Extended Abstract

Keywords: **information security management, enterprise information security policy, strategic management**

1. INTRODUCTION

Information security has been recognized as a core requirement for corporate governance that is expected to facilitate not only the management of risks [1][2], but also as a corporate enabler that supports and contributes to the sustainability of organizational operations [3]. In implementing information security, the enterprise information security policy is the set of principles and strategies that guide the course of action for the security activities [4] and may be represented as a brief statement that defines program goals and sets information security and risk requirements [5].

The enterprise information security policy (alternatively referred to as security policy in this paper) that represents the meta-policy of information security [1] is an element of corporate ICT governance [6] and is derived from the strategic requirements for risk management and corporate governance. Consistent alignment between the security policy and the other corporate business policies and strategies has to be maintained if information security is to be implemented according to evolving business objectives. This alignment may be facilitated by managing security policy alongside other corporate business policies within the strategic management cycle.

There are however limitations in current approaches for developing and managing the security policy to facilitate consistent strategic alignment. This paper proposes a conceptual framework for security policy management by presenting propositions to positively affect security policy alignment with business policies and prescribing a security policy management approach that expounds on the propositions.

2. LIMITATIONS IN CURRENT APPROACHES

Organizational executive management often considers matters relating to information security to be mainly technical issues under the domain of information technology and commonly delegated to the IT department [5][6][7][8]. Observations by researchers [8][9] on current information security management system frameworks and standard practice guidelines [10][11][12][13] imply that these standards only provide suggestive definitions and characteristics of information security policy. There is a lack of definition of a process approach on its development and management. Information security management standards are checklists of security controls defined in generic terms [6]. Other security policy development and maintenance frameworks [14][15] that are proposed to address the limitations of the checklist approach relate to security activities that are usually conducted separately to those of corporate governance and risk management activities. Consequently, some security policy theories propose aligning the information security policy with the IT strategic planning [5][15]. In adopting these theories, full integrative relationship between security policy development and other strategic management activities such as strategic planning and corporate governance remains a challenge. The security policy is rendered as an IT-focused initiative with inadequate reference and at times misalignment with the other corporate strategic objectives that are not directly related to IT.

Further research on security policy approaches adopt the risk management framework for information security management systems as a security planning process [2][16] and as a full integrative management framework [17] between information security and corporate risk to present the actual linkages between security policy and corporate risk policy. However, these policy theories and approaches restrict the alignment positioning of information security policy with that of IT planning as it is seen as a technical concern [8][18] or at most with that of corporate risk planning as an operational risk [17].

The restrictive alignment positioning inhibits the relationship of the security policy (and consequently the management and implementation of information security) with other strategic policies and as a consequence does not encourage coordination between the different strategic policy domains. This perspective poses inherent disadvantages to the overall implementation of information security as the strategic alignment of the security policy with the other business policies is not manifested and therefore hardly understood at the board level. As shown in Figure 1, the security policy is excluded from the corporate strategic management cycle as a business policy and alignment to other corporate business policies such as the corporate governance policy is not directly accommodated.

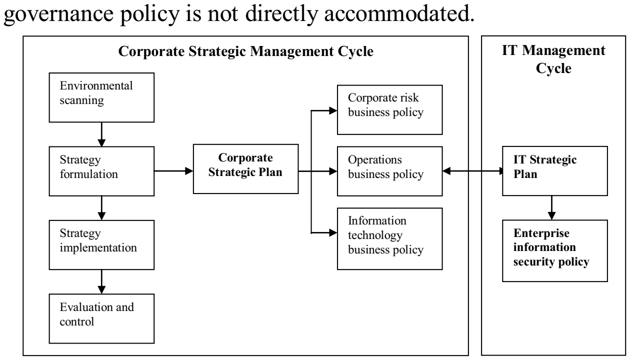

Figure 1 Traditional Alignment Approach for Enterprise Information Security Policy

The resulting security policy usually consists of an unstructured checklist set of security controls that is developed without the in-depth understanding to substantiate the requirement for functionality and value of such security policy and controls. Lacking in the corporate alignment on the strategic level, the security policy is dropped out of scope as a corporate-level agenda item. A consequence of this issue is the difficulty in obtaining the required support at the executive level [19] resulting inadequate allocation of resources and corporate support required for successful delivery of information security outcomes.

The strategic management cycle is discussed in the following section to provide a brief background upon which to base the conceptual development of the proposed security policy framework.

3. STRATEGIC MANAGEMENT AND BUSINESS POLICY

Strategic management is defined as a set of managerial decisions and actions that determines the long-run performance of a corporation [20][21][22]. The basic model of strategic management consists of four major phases namely: (1) environmental scanning; (2) strategy formulation; (3) strategy implementation; and (4) evaluation and control [22][23][24]. The environmental scanning stage involves the identification of the internal and external strategic factors that may affect the future of the organization [22].

The second stage of strategy formulation involves the development of the long-range plan through the definition of the mission, objectives, strategies and policies [24]. The mission statement defines the purpose and existence of the organization while the statement of objectives identifies what needs to be accomplished and by when to achieve the mission statement. Based on the defined mission and objectives, strategies are then developed. A strategy lays out the plan to achieve the organization's mission and objectives and requires broad directives to guide the organization's strategy formulation with its implementation [24]. These broad directives are defined in a corporate business policy [21]. As an element of strategic management, the business policy is the general management of integrated internal functions to ensure that decision's and actions are aligned with and in support of the defined mission, objectives and strategies [22].

The third stage of the strategic management model is the strategy implementation. Strategy implementation consists of developing and implementing the programs, budgets and procedures necessary to action the strategies and policies defined in the strategy formulation stage [23]. The last stage is the evaluation and control stage which involves the process of monitoring the actual performance and comparing the results with that of the defined performance objectives as a condition of business improvement [24]. The strategic management model is adopted in the development and overall management of strategic business policy strategies and may be utilized for developing security policy as a strategic business policy.

4. CONCEPTUAL FRAMEWORK FOR ENTERPRISE INFORMATION SECURITY POLICY MANAGEMENT

In this section, propositions are formulated and presented followed by the security policy management approach that expounds on the propositions.

Security Policy as Corporate Business Policy

Corporate business policies are required to provide guidelines to ensure that all decisions and activities are aligned with the defined strategies as part of good corporate governance [22] [24]. As information security has become a crucial part of corporate governance [1][7] that focuses more on people, processes and information in addition to IT [2], the security policy that provides the critical direction-setting aspect of information security is one of the most important controls of corporate governance [9].

The security policy is based on business and organizational requirements to manage risks [3] and it is balanced against cost efficiencies and business benefits [10]. It requires continuous assessment and revision to address evolving risks [25][26]. The continuous assessment of security policy ensures practices and procedures within the security policy are coordinated and integrated [11].

Policy development for information security takes on concepts of strategic planning by way of objective setting and coming up with the program of projects to be undertaken according to the set business objectives. This apparent similarity where it is defined that the security policy contains a layered structure set of sub-policies and procedural implementation that need to be reviewed and assessed may be undertaken in the same manner as that of a corporate strategy or policy and its related program plan of business initiatives.

From this discussion, it may be considered that the development and management of the security policy is a strategic planning process derived from other corporate-level business policy requirements to ensure consistent alignment. The consistent alignment may be achieved by developing and managing the security policy as a business policy alongside the other strategic policies as depicted in Figure 2. This perspective addresses the limitations in current approaches that confines the alignment positioning of information security policy only to that of IT planning. The first proposition (P1) is presented as:

Proposition 1 (P1): *Developing security policy as a corporate-level business policy positively affects its consistent alignment with other business policies as part of corporate governance.*

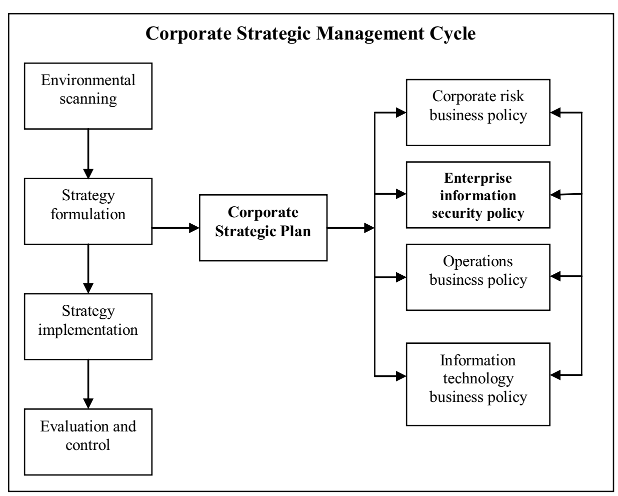

Figure 2 Proposed Alignment Approach for Security Policy as a Strategic Business Policy

Integrating Security Policy within the Strategic Planning Process for Alignment

Research studies on business planning (BP) and information systems planning (ISP) have presented various integration approaches [27][28][29][30] that may be utilized to address alignment issues across corporate functions. The need for aligning information systems planning with business planning have been demonstrated by prescriptive [27][29] and empirical studies [31][32][33] as contributing to the assurance that business objectives are met and effective information technology investments are made. Information systems planning should be integrated within business planning to achieve alignment through full integrated planning [34][35]. This involves developing both the BP and ISP strategies at the same time using the same planning process and establishing an integrative relationship between BP and ISP. The presence of the alignment mechanisms of content, timing and personnel inherent in a full integrative relationship [36] provides benefits to organizations as a result of improved coordination of information systems plans with business plans [31]. It has been asserted that information systems should not be regarded as separable from business strategy but instead fully integrated with the corporate policies [37]. As security policy development takes on the conceptual elements of information systems planning, the adoption of the full integrative planning approach between security policy and strategic business policies is applicable.

Strategizing information security as a business policy may be then be approached by integrating security policy development within the traditional strategic planning and management cycle. This approach provides for consistent coordination of changes in requirements between the security policy and the other corporate business policies as presented in Figure 3.

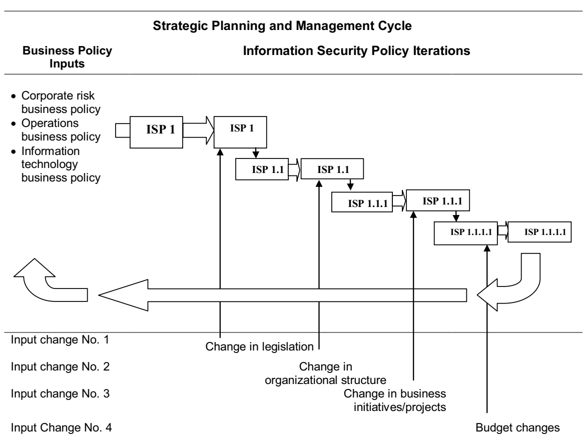

Figure 3 Timeline of Change Alignment within the Strategic Management Cycle

This manner of integrating different management domains by utilizing the same management framework process to enhance alignment has been prescribed for other corporate governance activities such as risk management [17]. From this perspective, the second proposition (P2) is formulated:

Proposition 2 (P2): *Integrating security policy development within the strategic planning and management process positively affects the consistent alignment between the business policies and the security policy.*

The Information Security Policy Management within the Strategic Management Cycle

The proposed approach for security policy management is developed by adopting the strategic management model to facilitate full integrative alignment as shown in Figure 4. This integrative approach depicts the security policy as a corporate business policy that is consistently aligned with business policies and objectives.

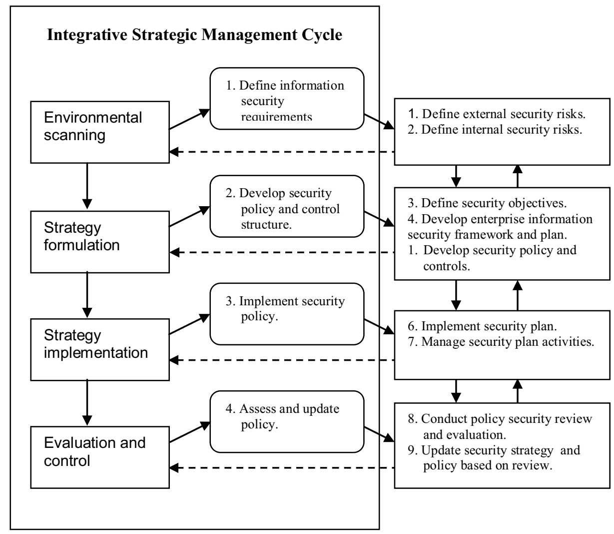

Figure 4 Integrative Approach for Developing Enterprise Information Security Policy

Briefly, the proposed framework process is described as follows:

Step 1 ***Define enterprise information security requirements*** **(environmental scanning)** – Environmental scanning for strategic planning involves defining the external factors and the internal factors affecting the business environment in all aspects [22]. This step enables the organization to establish the key business process and prioritize the focus of the strategic management efforts. The SWOT (strengths-weaknesses-opportunities-threats) analysis [38], a tool used in strategic management and business policy development, can be employed in environmental scanning. For the security policy, this step accommodates the interplay and coordination of the various factors involved in developing each corporate strategy or policy with that of the security policy requirements on the strategic level. This approach expands the security policy requirements to include the risks involved in corporate governance, risk management and business operations in addition to the usual IT-related aspects of security risks. As an example, corporate governance risks that are not usually considered in traditional non-integrative approaches but are now identifiable in this step involve risks pertaining to staff misconduct and organizational disaster management. The output of this step is the Enterprise Information Security Risk Assessment Report.

Step 2 ***Develop security policy and control structure*** **(strategy formulation)** - The costs and trade-offs of the proposed enterprise information security policy and the corresponding policy control solutions as aligned to the other business policy control structures are determined in this activity. Detailed examples of controls that are developed based on the other business policy requirements such as risk management policy and operational business policies include security planning, processing authorization, incident response, configuration management, logical access control and secure application architecture. Useful techniques for evaluating risks and developing the strategies involve group decision-making employing the Delphi technique [39] and deriving decision trees to arrive at resolutions. For this step, the integrative approach allows the matching of costs and benefits between the security policy and control structures with those of the corporate business requirements on the strategic scale. The deliverable output of this process is the Enterprise Information Security Policy.

Step 3 ***Implement security policy*** **(strategy implementation)** - Based on the enterprise information security policy derived in Step 2, the enterprise information security plan is developed. The mitigating controls for the enterprise-wide security risks identified through the security risk assessment process incorporates strategic business initiatives and are finalized and drawn into a comprehensive enterprise information security policy set of initiatives or projects. The developed information security plan may take the form of a program of projects to implement the set of security controls which may be new treatments, additional controls or modifications to current controls. An important element of the security plan is the security architecture that consists of the security technologies as part of the implemented control structure of the security policy. One such example is the security policy stating a requirement for network security. The security technology that will meet this policy requirement may involve the deployment of an antivirus and firewall system. The output of this step is the Information Security Plan that details the projects and the taxonomy of procedural policies.

Step 4 ***Assess and update policy according to evolving business requirements*** **(evaluation and control)** - In this step, the review process for each policy development cycle is conducted to provide the basis for the next round of policy development activities. This activity fulfills the requirement for business improvement as required in strategic management. Coordinating and correlating lessons learned for the policy review process with that of the corporate business policy review activities, including that of corporate risk will further enhance future policy development activities as strategic objectives are met.

3 Conclusion

The goal of enterprise information security is to enable an organization to satisfy all of its strategic business objectives by implementing systems considering information technology-related risks to the organization, its business partners and clients. Although presented in various ways, the definition and characteristics for developing the strategic policy for enterprise information security remains consistent in that the security policy should outline the organization's program set of initiatives to ensure the security controls based on risk mitigation strategies are implemented to meet business objectives.

This paper presents a conceptual framework for security policy management by introducing propositions on how treating the security policy as a business policy may positively affect consistent alignment between the different strategic level policies. The proposed full integrative planning approach for the enterprise information security policy conceptually demonstrates that the security policy can be presented as a business policy within the strategic management cycle. As such, it is argued that the security policy can take on integrated strategic planning activities alongside other strategic business policies. This integrative approach is conceptually illustrated to foster an interactive relationship between security policy and other business policies to facilitate changes according to evolving requirements. The challenge that remains is the readiness of organizations to acknowledge the strategic value of treating the security policy as a business policy by adopting the proposed framework. The recommended future research includes the adoption of the proposed security policy framework to establish applicability and the development of an assessment model for both the framework and the security policy to validate the framework propositions and identify elements of value as well as areas for improvement.

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Exposure of the environment and surface water by dangerous liquids - the slop outflow model

Ing. Michal Balatka, Ing. Pavel Fuchs, CSc., Ing. Jan Kamenicky, Ph.D. – Technical University of Liberec, Liberec; Doc. Ing. Radovan Soušek, Ph.D. – University of Pardubice, Pardubice, Czech republic; doc. Ing. Miroslav Kelemen, Ph.D. - Armed Forces Academy, Liptovský Mikuláš, Slovak republic

michal.balatka@tul.cz, pavel.fuchs@tul.cz, jan.kamenicky@tul.cz, radovan.sousek@upce.cz, miroslav.kelemen@aos.sk

Abstract

The dangerous liquid outflow means the environmental risk. The surface and the ground water is the most often in danger in case of the outflow. There is developed the numeric model of this risk type assessment. This text contains the general model principles. There is placed emphasis on the stochastic approach, because the required land cover data have only a small level of detail and many of them must be estimated. These detail data are estimated by the random approach then. The land cover data influence the liquid flow direction from a tank very often. The calculation results do not mean the deterministic values; there are used statistical data of the dangerous liquid behavior in the environment.

Key words

Ecological risk, slop outflow, dangerous goods transport, dangerous substance

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1 Introduction

Traffic or industrial accident could cause in many consequences. One of them is the outflow of dangerous liquid into the environment. Surface water and ground clay are endangered the most by this outflow. In case we want to evaluate risk associated with the outflow of dangerous liquid into e.g. the surface water, we have to know information about quantity and velocity of the dangerous liquid outflow. This information could be obtained by the numerical model of the slop spread in the real environment, described below.

The traffic accident can evoke the environmental risk along the road, so we could not presuppose only the point source of risk (in meaning of dangerous liquid outflow) but we have to calculate the distribution of risk along whole road. For example if the oil outflows from the crashed oil tank the spreading slope may cause danger to soils, streams or vegetation. This risk could be assessed. Then it is necessary to estimate the slop flowing progression as the first step of the risk assessment. This estimation means big problem for the real environment. Let`s try to solve it by our developed simulation model.

2 Required types of model results

The model of liquid outflow through the real environment is the tool for foresee how the liquid will spread from the point of accident on the earth surface. This surface could be split on smaller areas. Then we have to ask these questions for each area:

- What amount of liquid did flow in?
- What amount of liquid did infiltrate under the surface?
- What amount of liquid did evaporate?
- What amount of liquid did catch the surface of the area?

All mentioned questions could not be answered exactly for real situation. The rate of its accuracy depends on the quantity and quality of data. Because of that we initiate stochastic access. Above mentioned questions will not be answered by exact values, but they will be described by casual quantity.

3 Terrain data

The shape of terrain is the key factor for the direction of liquid outflow spread. But there are some additional factors, which are also important in presented model. These parameters belong to the characteristics of terrain and inspected liquid too.

Together they determine the speed of liquid spread, its catch on the surface, infiltration characteristics and the speed of evaporation. Description of the terrain contains from two data types:

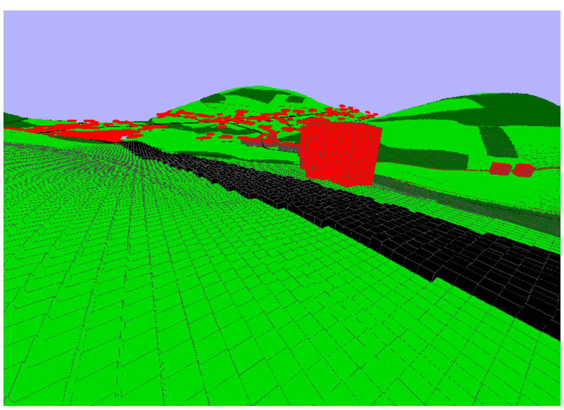
- hypsography of terrain (its elevation above sea)
- planimetry of terrain (property of terrain, objects placement, its influence to the direction of liquid spread - streets, other communications and other buildings)

Hypsography of terrain describes the shape of terrain. From the liquid spread point of view, whose height is about a few centimeters, hypsography is not exact enough - the distance of level lines, which are available, is from 10 to 30 meters.

We have to realize that some kind of detailed information about terrain roughness contain also information about terrain property, such as type of terrain, communications placing, buildings density etc. For example in case that the road leads across the gradient we can presuppose that there is a saddle in the neighbourhood. This saddle is able to change the direction of liquid spread despite of the data from the hypsography.

The geographical information system (GIS) is very often used as the basis for the work with such data. If some data are obtained in different form they will be transferred into GIS format.

Based on the data from hypsography and planimetry it is compiled digital screening model of terrain. The surface in the surrounding of liquid outflow is split into small squared elements. Each element contains data about its elevation above sea and its surface property, e.g. permeability. Digital model of terrain is the main input to the slop spread calculation.



Pic 1: Example of terrain model

4 Slop effusion evaluation

Each element of digital model of terrain is described by data about elevation above sea, surface property but mainly by state quantity of slop. Their time evolution characterizes slop behavior in time. Entities of state quantity represent the volume of liquid, outspread to the unit surface of an element. It could be understood also as the liquid level in element. State quantities have meaning as follows:

- A (m3/m2): Volume of liquid occurred on unit surface of an element
- B (m3/m2): Volume of liquid infiltrated under the unit surface of an element
- E (m3/m2): Volume of liquid evaporated from unit surface of an element

The sum of all of these quantities, multiplied by the surface of an element describes total volume of liquid in the defined time after the “zero time” of liquid outflow in the element. The sum of all volumes in the defined time after the liquid outflow is equal to the total volume of liquid outflow. Total increment of volume in unit surface in the time step Δt is given by following formula:

$$\Delta A = \Delta P - \Delta B - \Delta E - \Delta O$$

Where

ΔA(m3/m2): Increment of volume on the element surface

ΔP(m3/m2): Volume of liquid flowed in from neighbouring elements

ΔO(m3/m2): Volume of liquid flowed off to neighbouring elements

ΔB(m3/m2): Infiltrated volume of liquid

ΔE(m3/m2): Evaporated volume of liquid

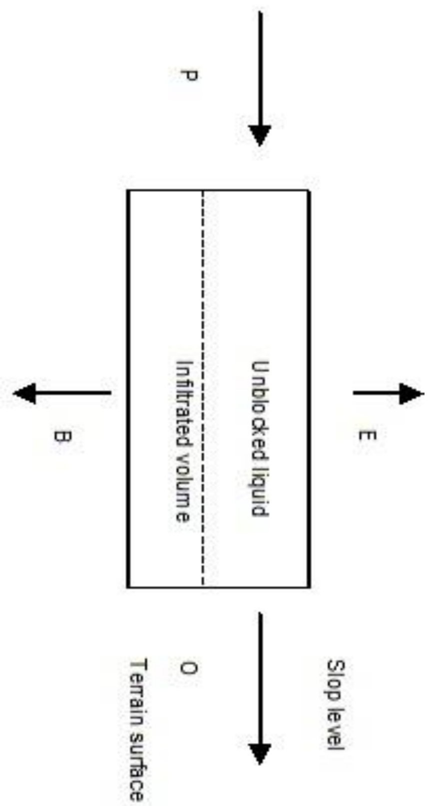
5 Surface wetting capacity

There are intermolecular forces interacting between the liquid and the surface. Because of this interaction small layer of liquid always stays on the surface. This small volume of liquid remains also on smooth surfaces and it does not spill out of this area any more. The height of this layer depends on properties of surface and of liquid too. In real terrain the most important property will be inequality of terrain and also the vegetation growing on the inspected area. These properties may increase the volume of wetted liquid several times. We are able to determine both factors based on GIS data about the type of object which lies on the element of interest.

When we know properties of liquid we are able to set minimal height of liquid layer for each type of surface. If liquid arrives to the element it must firstly reach this height till it continues spreading to next elements. The volume of the liquid, wetted on the element surface, was named as surface wetting capacity. This capacity could change during the year because of vegetation condition, coverage of surface by snow or ice etc. That's why also the problem of surface wetting capacity was solved by probabilistic approach.

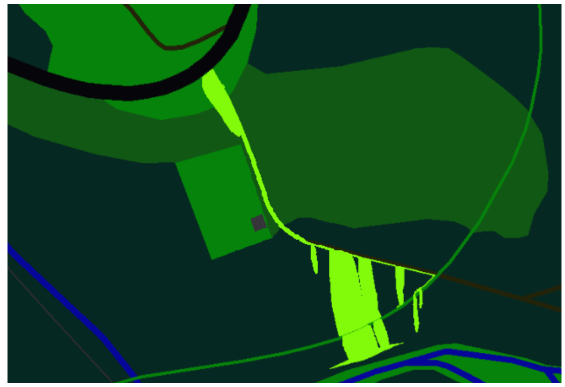
6 Liquid infiltration

During the slop spreading some volume of the liquid also infiltrates under the surface. This fact is simulated by the decrement of liquid volume per time unit. The volume of infiltrated liquid depends on properties of the soil, namely on porosity. The speed of infiltration depends on soil permeability and also on viscosity of the liquid. Important affection of infiltration process could cause the level of saturation of soil by water. Soil properties as porosity and permeability are also determined based on type of element surface.



Pic 2: Scheme of slop movement over one element in terrain model

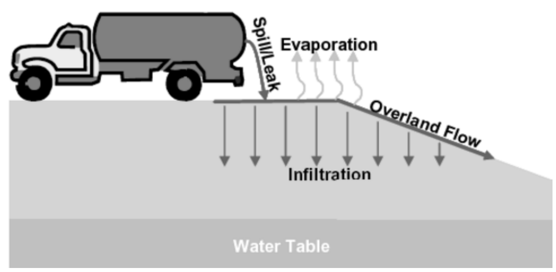
The positive increment of liquid volume to the element surface is given only by inflow of liquid from surfaces of neighbouring elements. Negative increment of liquid volume to the element surface means infiltration, evaporation and outflow if the liquid to the neighbouring elements. In case of liquid volume in the element surface is smaller than possible infiltrated volume it is evident that liquid only evaporates.



Pic 3: Example of a spilt slop

7 The behaviour of mobile slop outflow

When the liquid outflows from the tank, there is created the slop on the land surface. The slop spreads from the accident place. The land surface is wetted and some amount of liquid stays on the surface. The next part of a liquid is infiltrated into the land surface. The infiltrated amount of liquid may be very different and depends on lend surface parameters. The part of liquid amount is vaporized too. These processes are demonstrated by next picture.

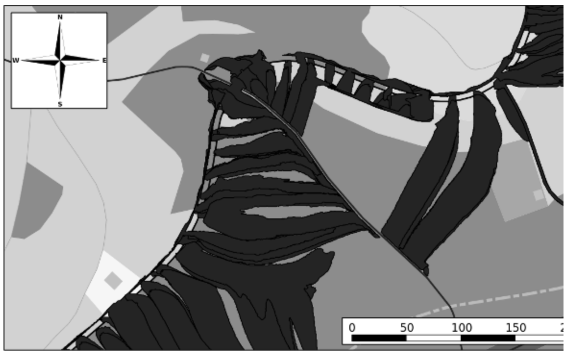


Pic 4: The scheme of mobile slop outflow

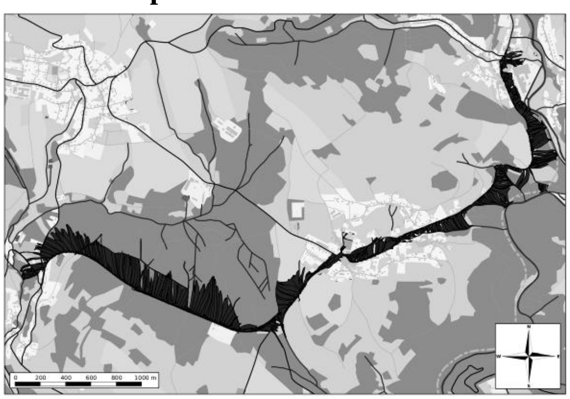
The slop is represented by thin layer of liquid. The depth of slop is usually about only a few centimetres. The slop behaviour is given mainly by the terrain slope. Every small variation of terrain may influence the slop flow direction and slop shape. These variations are for example: footpath, road, side ditch or building. The slop flowing is influenced also by the land surface type. It determines how fast the liquid flows, how fast the liquid infiltrates or what amount of liquid is retained by the surface.

When the liquid leaks from the road, surface water and soil are the most exposure parts of surroundings. The environmental damages consist of liquid properties and its spilt amount.

The simulation model presented above is built for point source of liquid outflow. It means that the accident with dangerous liquid leak must start in one defined place. But the reality is different - the road is possible line source. The accident may happen anywhere on the road. The idea of modification of our model into linear one is quite simple. We will represent the road as a group of discrete points. Let's suppose the distance of points on the road in distance of ten meters. The liquid outflow is simulated for all of them. We obtain the group of calculated slops. It is viewed on the figures below.



Pic 5: Danger zone created by calculated slops - detailed map



Pic 6: Larger danger zone viewed in lower scale

The slop spreading depends on many conditions. When the land surface conductivity is low the spill area and the spreading velocity is high. The soil with grass has large conductivity on the other hand the asphalt road has no ability to conduct. Then the liquid flows very fast and very far. The spreading velocity depends also on the liquid viscosity.

The danger zone of road must be set for different weather or different seasons. Conservative approach supposes the worst possible case. It means that the soil is saturated after the rain or is frozen. The slop area is the largest in this case and its consequences are the highest.

8 Simulation software

The slop outflow simulations are calculated by the software developed by our department. The software is divided into two parts. First part calculates the slop flow and the second part shows the results by the way of presentation in 2D or 3D view.

The calculations are time consuming when group of spills on the road is calculated. Fortunately modern information technologies provide multiprocessor systems. Their usage is optimal for this case, because the calculations can be split into parallel separate processes when each one is calculated in the same time.

9 Stochastic approach

As was written above the accuracy of results depends mainly on the quality and quantity of data describing character of surface, which liquid spread on. If there is only a small amount of data about the surface in the neighbourhood of potentially liquid outflow it is not possible to describe the accident by only one model. In praxis these data respond to more variants of terrain model. By evaluating all these models we obtain more or less different results. For each state quantity we obtain a set of results (values), which could be further statistically evaluated. One can find out e.g. mean values, dispersion, reliability intervals etc.

10 Conclusion

The text above describes main principles of numeric model, which is developed for evaluation of time development of slop spread from the point of potentially liquid outflow, caused by traffic or industrial accident. Thanks to presented model we are able to find out e.g. probable area of slop or probable volume of liquid outflow into the surface water. Results of these calculations serve as inputs for evaluation of environmental risk connected with the accident.

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EVALUATION OF TECHNICAL SYSTEMS DEPENDABILITY WITH THE USE OF FUZZY LOGIC AND EXPERTS' KNOWLEDGE

Lech Bukowski
Faculty of Management, AGH University of Science and Technology
Cracow, Poland

and

Jerzy Feliks
Faculty of Management, AGH University of Science and Technology
Cracow, Poland

ABSTRACT

The paper proposes a general concept of technical systems dependability and describes a new dependability tree. In this vector based approach, the term dependability is composed of two main elements: availability, described by reliability, maintainability and maintenance support performance, as well as credibility, based on safety and security. A framework for evaluation of technical systems' dependability was developed, based on fuzzy logic and a system of rules of the „if … then" type, that were appropriately weighted. The model is based on a three-stage procedure of evaluating linguistic variables with the WinFACT tools and BORIS and FLOP simulation package. The results of the simulation, presented as 3-D graphs may be used to optimize the reliability of the system being evaluated.

Keywords: Dependability, Availability, Credibility, Safety, Security, Fuzzy Logic, Expert System.

1. INTRODUCTION

Usability of technical systems was previously characterized by three fundamental properties: functionality, performance and cost. Since late 1940s, artificial systems became more and more complicated and sophisticated, but also less and less reliable. The first generation of electronic computers used unreliable components, therefore practical techniques were employed to improve their reliability. In 1956 J. von Neumann [1], E. F. Moore and C. E. Shannon [2] developed theories of using redundancy to build reliable logic structures from less reliable components, whose faults were masked by the presence of multiple redundant components. The theories of masking redundancy were unified by W. H. Pierce as the concept of failure tolerance in 1965 [3]. In 1967, A. Avizienis integrated masking with the practical techniques of error detection, fault diagnosis, and recovery into the concept of fault-tolerant systems [3] and 8 years later work on software fault tolerance was done by B. Randell [4].

The emergence of a consistent set of new concepts and terminology resulted in the 1992 book *Dependability: Basic Concepts and Terminology* by J.-C. Laprie [5] and a new research area of "Dependable Computing" was born. Since that time, computing systems are characterized by four fundamental properties: functionality, performance, cost and dependability.

Dependability [6, 7] of a computing system is the ability to deliver service that can be justifiably trusted. The **service** delivered by a system is its behavior, as it is perceived by its user(s); a **user** is another (physical, human) system that interacts with the former one at a **service interface**. The **function** of a system is what the system is intended for and is described by system specifications. Dependability is an integrative concept that encompasses the following attributes:

Availability - readiness for correct service;
Reliability - continuity of correct service;
Safety - absence of catastrophic consequences on the user(s) and the environment;
Confidentiality - absence of unauthorized disclosure of information;
Integrity - absence of improper system state alterations;
Maintainability - ability to undergo repairs and modifications.

Security is the concurrent existence of:
a) availability for authorized users only,
b) confidentiality, and
c) integrity with 'improper' meaning 'unauthorized'.

The above attributes may be emphasized to a greater or lesser extent depending on the application: availability is always required, although to a varying degree, whereas reliability, safety and confidentiality may or may not be required. The extent to which a system possesses the attributes of dependability should be interpreted in a relative, probabilistic sense, and not in an absolute, deterministic sense. Due to the unavoidable presence or occurrence of faults, systems are never totally available, reliable, safe or secure. Definitions of availability and reliability emphasize the avoidance of failures, while safety and security emphasize the avoidance of a specific class of failures (catastrophic failures, unauthorized access or handling of information, respectively). Reliability and availability are thus closer to each other than they are to safety on one hand, and to security on the other; reliability and availability can be grouped together, and collectively defined as the avoidance or minimization of service outages.

2. GENERAL CONCEPT OF TECHNICAL SYSTEMS' DEPENDABILITY

The concept of "Dependable Computing" became very successful in the area of information technology (IT) and computer science (CS), but was not general enough, to cover all types of technical systems, e.g. production systems and logistics processes. The authors of this paper proposed at the International Conference on System Engineering in Las Vegas 2008 [8] a general concept of technical systems' dependability, which connected the computer oriented concept of dependability with experience from another areas of technical devices and equipments. We were trying to study such complex systems as:

- Intelligent building systems [9],
- Power supply and distribution systems [10],
- Manufacturing systems [11],
- Supply chain and network systems [12],

and we had many problems with defining their performance and quantitative characteristics, because every subsystem has a typical definition of attributes and characteristics (some of them even have standards, e.g. IEC 50 191, IEC 1069). The goal of this idea was to create one uniform set of attributes for all these systems as a base to analyze, design and optimize complex technical systems. The proposed general dependability tree is shown below [8].

DEPENDABILITY
- AVAILABILITY
  - Reliability
  - Maintainability
  - Maintenance Support Performance
- CREDIBILITY
  - Safety
  - Security

The various concepts included in this diagram in a hierarchical tree-type structures are defined as follows.
Dependability of a technical system is the ability to deliver service that is available and credible under given conditions at a given instant or in a given time interval.

Availability (AV) – the ability of a system to be in a state of performing a required function under given conditions at a given instant or in a given time interval, assuming that the required external resources are provided.
Reliability (REL) is a feature of the performance system achieving the required level by using elements characterized by proper values of reliability measures (frequency or time) as well as by applying proper dependability structures (e.g. surplus ones).
Maintainability (MAI) is a feature of the performance system characterizing the compliance of the system itself for detecting dangers, identifying the state as well as executing the actions (both planned and unplanned) connected with servicing the system. Maintainability indicators are both frequential (e.g. probability of servicing, temporary and average intensity of repair) and temporal (e.g. expected reparation time, p-row quintile of reparation time).
Maintenance Support Performance (MSP) is the measure of dependability of logistic processes supporting servicing the performance system. These are usually processes of providing with proper resources, while indicators of provisions of servicing are usually temporal (e.g. presumed logistics delay, p-row quintile of logistics delay).
As it derives from the above approach, the readiness of the performance system shall be expressed in a vector format, not the hitherto applied scalar one, by one of indicators such as momentary availability $A(t)$ or average availability $A(\Delta t)$.
When applying relative measures of indicators or providing balances for specified components of the vector, it is possible to find the value of availability as the scalar ratio of separate components of the vector and their balances.
Credibility (CR) – the extend to which a system is able to recognize and signal the state of the system and to withstand incorrect inputs or unauthorized access.
Credibility of the system is defined by two components:

Safety (SAF) is displayed by
- ✓ absence of critical damages (active actions),
- ✓ securing the environment against the effects of any potential critical damages (passive actions),

Security (SEC) is displayed by
- ✓ confidentiality (unavailability to unauthorized users),
- ✓ integrity (impossibility of introducing changes into the system by unauthorized users) and
- ✓ availability (accessibility for authorized users only).

It is proposed to accept the following model for a quantitative measure of dependability:

$$D = \{AV, CR\}$$

$$AV = \{REL, MAI, MSP\}$$

$$CR = \{SAF, SEC\}$$

3. FRAMEWORK FOR EVALUATION OF TECHNICAL SYSTEMS' DEPENDABILITY

For evaluating the availability of a system, it is proposed to apply linguistic variables, quantified in various ways, depending on the type of the system. Fuzzy sets were used at several stages of building experts system. Inputs for a fuzzy system are REL, MAI and MSP variables. The evaluation procedure was described in [8].

For evaluating the credibility of the system, it is proposed to also apply linguistic variables, quantified in various ways, depending on the type of the system, SAF and SEC. Examples of applying measures in the form of linguistic variables for evaluating the components of a credibility vector are presented in [13]. Methods for describing parameters with the use of linguistic variables allow using fuzzy sets as a tool for building expert systems, in which linguistic variables are used as input variables of the system. The application of fuzzy sets theory in this case is suitable because experts' knowledge can be used to build a suitable rule base.

The software WinFACT was used for building a system for evaluating the components of the availability and credibility vector. WinFACT provides FLOP tools for creating and editing fuzzy inference systems or integrating our fuzzy systems into simulations with BORIS. The fuzzy shell FLOP (Fuzzy Logic Operating Program) allows the design and the analysis of rule based systems on the basis of fuzzy logic. The program offers the following options: definition of linguistic variables and corresponding terms, creation of rule bases, realization of inference processes, evaluation of transfer characteristic curves and maps, simulation based on recorded data and creation of fuzzy controller files for the block oriented simulation system BORIS [14]. The block orientated simulation hardware BORIS allows the simulation of nearly any structured dynamic system and is therefore in - connection with the hardware interface and the optional C-code-generation - suitable for the following applications: measurement and signal analysis as well as analysis and synthesis of feedback control systems. In addition to the known conventional systems, even systems with fuzzy or neural components can be handled.

Classical fuzzy sets with trapezoidal membership functions were used in building the credibility evaluation system. Linguistic variables SAFETY (SAF) and SECURITY (SEC) were assigned five classes by defining for both of them ranges of trapezoidal membership functions. Membership ranges are shown in figure 1. Membership in class 1 in the case of the SAFETY variable indicates the highest probability of no critical failure whereas for the SECURITY variable, it indicates the highest level of protection. Thus an increase in class number corresponds to a decrease in both safety and security. Class 5 represents the lowest level of safety and security.

Class number	Safety (SAF)	Security (SEC)
Class_1	Very high (>99,99%)	Very high (>99,99%)
Class_2	High (99,7% – 99,99%)	High (99,7% – 99,99%)
Class_3	Moderate (98% - 99,7%)	Moderate (98% - 99,7%)
Class_4	Low (90% - 98%)	Low (90% - 98%)
Class_5	Very low (< 90%)	Very low (< 90%)

Figure 1. Membership ranges

The structure of the credibility evaluation system is show in figure 2.

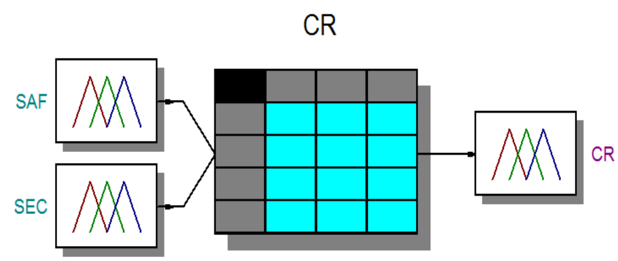


Figure 2. System structure

The definition of fuzzy sets and ranges of the membership function for the input variable SAFETY are show in figure 3.

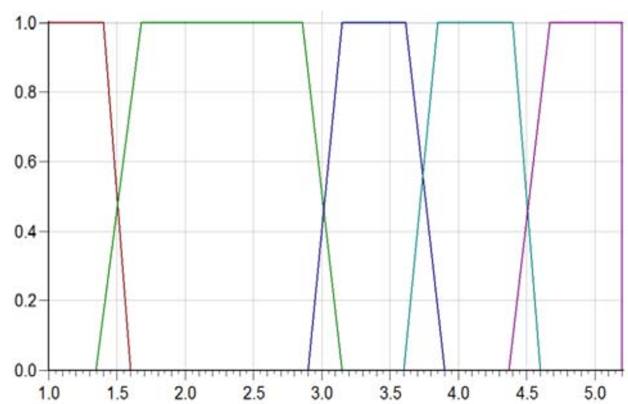


Figure 3. Definition of fuzzy sets and ranges of the membership function (SAF)

The ranges and shape of the membership function for the SECURITY variable are show in figure 4.

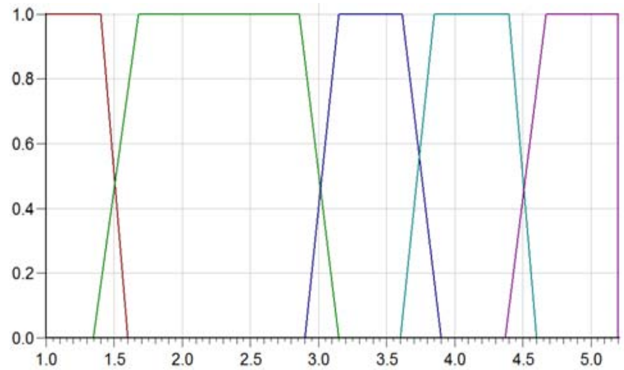


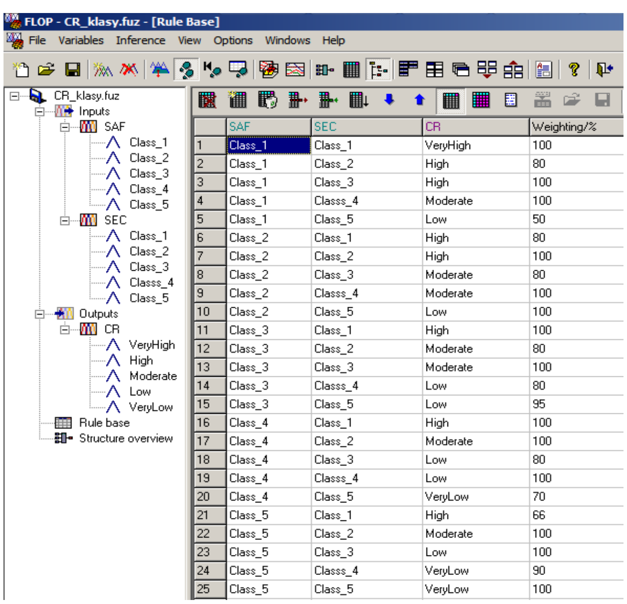
Figure 4. Ranges and shape of membership function for the security variable (SEC)

Based on input variables defined in this way for the CREDIBILITY evaluation system, an appropriate rule base was designed. Experts' knowledge can be represented in the form of "if – then" rules. A single „if – then" rule assumes the form:

if x is A then y is B (w)

where A and B are linguistic values defined by fuzzy sets. The if-part of the 'x is A' rule is called the antecedent or premise, while the then-part of the 'y is B' rule is called the consequent or conclusion. The number 'w' in the parentheses above represents weights between zero and one that can be applied to each rule if desired.

The „if … then" rules make it possible to evaluate complex fuzzy statements. The knowledge encoded in the rule base is inputted based on human experience and intuition as well on the basis of theoretical and practical understanding of the studied object's properties. The main task of this evaluation system is to calculate an approximate value of the output variable on the basis of each rule from the rule base weighted by an appropriate factor determining the degree of rule "validity"



	SAF	SEC	CR	Weighting/%
1	Class_1	Class_1	VeryHigh	100
2	Class_1	Class_2	High	80
3	Class_1	Class_3	High	100
4	Class_1	Classs_4	Moderate	100
5	Class_1	Class_5	Low	50
6	Class_2	Class_1	High	80
7	Class_2	Class_2	High	100
8	Class_2	Class_3	Moderate	80
9	Class_2	Classs_4	Moderate	100
10	Class_2	Class_5	Low	100
11	Class_3	Class_1	High	100
12	Class_3	Class_2	Moderate	80
13	Class_3	Class_3	Moderate	100
14	Class_3	Classs_4	Low	80
15	Class_3	Class_5	Low	95
16	Class_4	Class_1	High	100
17	Class_4	Class_2	Moderate	100
18	Class_4	Class_3	Low	80
19	Class_4	Classs_4	Low	100
20	Class_4	Class_5	VeryLow	70
21	Class_5	Class_1	High	66
22	Class_5	Class_2	Moderate	100
23	Class_5	Class_3	Low	100
24	Class_5	Classs_4	VeryLow	90
25	Class_5	Class_5	VeryLow	100

Figure 5. Rule base example

Fuzzy logic based systems are a kind of expert system built on a knowledge base that contains inference algorithms in the form of a rule base. What distinguishes fuzzy inference in terms of concept from conventional inference is the lack of an analytical description. The approximate inference mechanism transforms knowledge from the rule base into a non-fuzzy form. The non-fuzzy form of the result is obtained in the process of defuzzification. There are several known methods of defuzzification – the algorithms used in the FLOP software include: center of gravity, center of gravity with extender border sets, first maxima and last maxima. Defuzzification is interpreting the membership degrees of fuzzy sets into a real value. A rules base for a system with two inputs and one output, where every variable was divided into 5 linguistic categories (VeryLow, Low, Moderate High and VeryHigh), includes 25 elements. The correctness of selection of rules as well as the shape and ranges of the membership function is verified with a rules viewer and simulation. The rules viewer displays a roadmap of the whole fuzzy inference process. It also shows how the shape of certain membership functions influences the overall result. The ranges and shape of the membership function for the CREDIBILITY variable are show in figure 6.

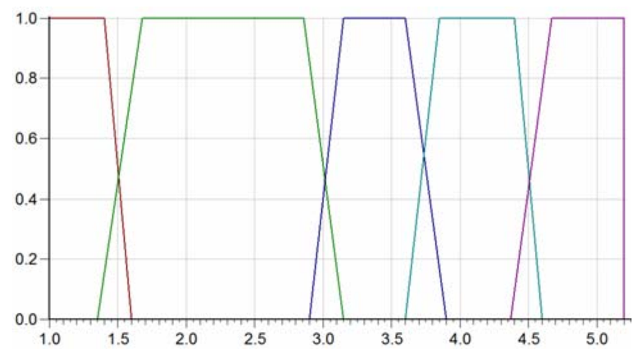


Figure 6. Ranges and shape of membership function for the credibility (CR) variable

Figure 7 presents a simulation model of a credibility evaluation system and figure 8 the results of a simulation in the form a graph showing the dependence of the output variable on the input variable.

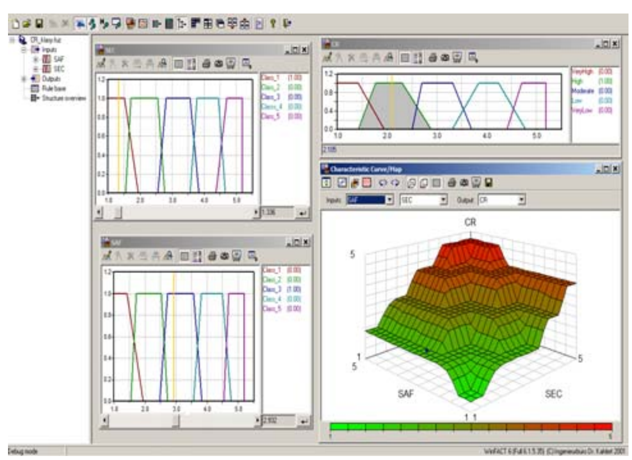


Figure 7. Credibility simulation model

The output signal of the model is a number ranging from 1 to 5 specifying class membership. Credibility expressed as a number ranging from 1 to 5 and availability also expressed as a number ranging from 1 to 5 are inputs for the dependability evaluation system. This system is implemented using fuzzy sets. Its inputs are values generated by the credibility evaluation system described above and the availability evaluation system presented in (8).

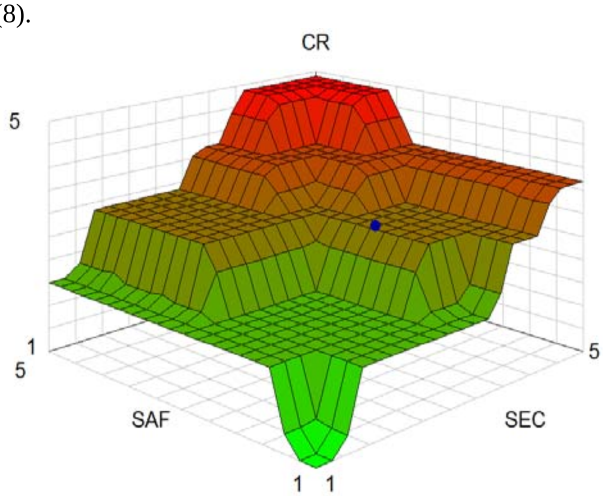


Figure 8. Credibility (CR) model simulation results

The hierarchical structure of the system for evaluation of technical systems DEPENDABILITY is show in figure 9.

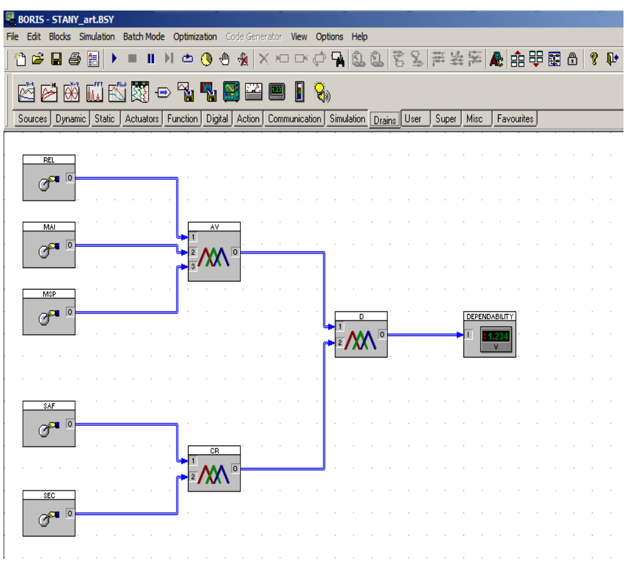


Figure 9 Model dependability (D) structure

As before, fuzzy sets with trapezoidal membership functions were used for the implementation of the model. Ranges of individual membership functions for input variables credibility and availability are shown in figure 10 and figure 11.

As in the previous case for a system with two inputs and one output, a complete rule base made up of 25 if … then type rules was designed. Each rule was assigned an appropriate weighing factor w that was chosen by a method of “trial and error” based on simulation studies.

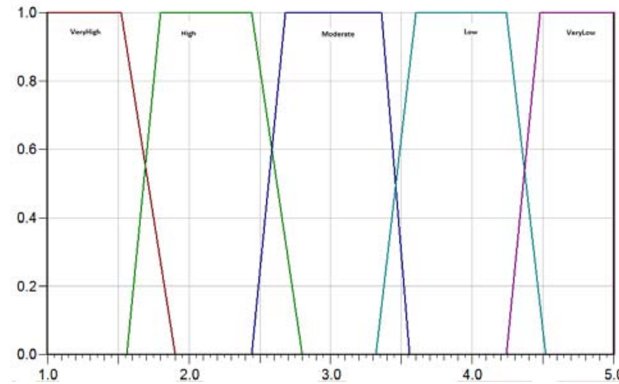


Figure 10. Availability (AV) membership functions

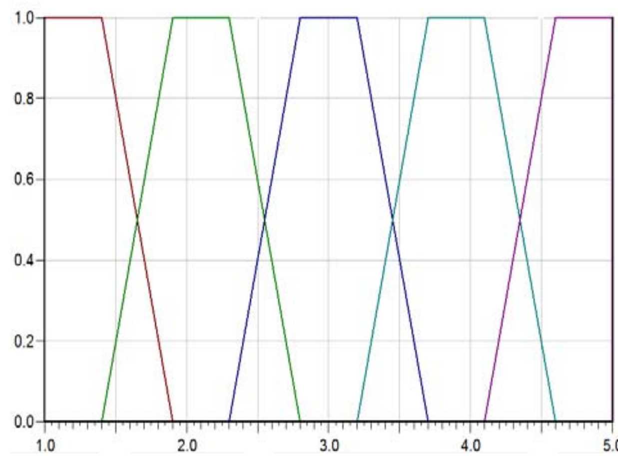


Figure 11. Credibility CR membership functions

Simulations were carried out in the BORIS software to observe the impact of changes in five input parameters on the output of the hierarchical model.

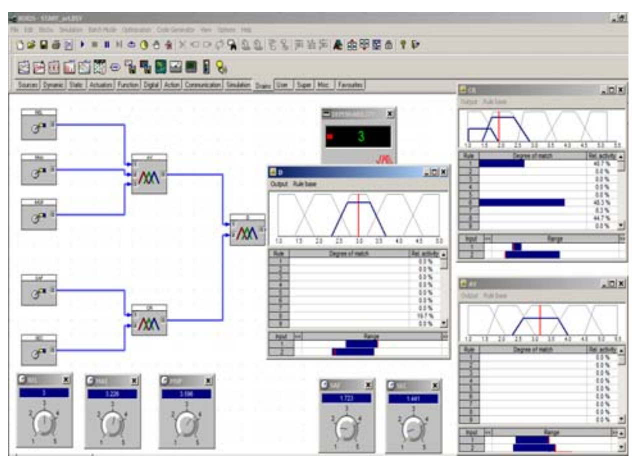


Figure 12. Dependability (D) simulation model

Each input parameter can be set at a level ranging from 1 to 5. The implemented simulation system allows for continuous observation of changes in output depending on the value of input signals. Simulation of the system can run in a specified time interval or continuously until it is ended with the press of a special button. Input signal levels are set in a range from 1 to 5 using dials operated by a computer mouse or by typing on a keyboard. In addition, during the simulation, it is possible to observe the degree to which credibility, availability and dependability variables belong to given membership functions and it is also possible to identify the rules involved in generating system output as well as changes in credibility and availability variables that are functions of changes in input values.

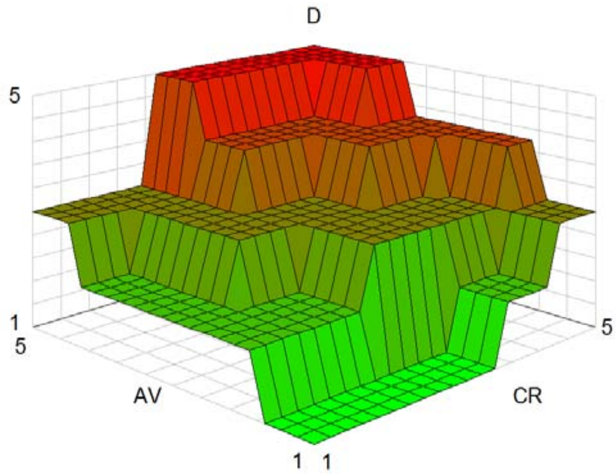


Figure 13. Model dependability D simulation results

Figure 13 shows the results of the dependability evaluation simulation model depending on values of variables credibility and availability. Dependability is evaluated on 5 levels with the first level corresponding to the highest degree of system reliability. As shown in figure 13, the variable availability, most frequently associated with the operation of objects, has a higher impact on system reliability evaluation results.

4. CONCLUSION

The framework for evaluation of technical systems dependability proposed in this paper is a universal, “shell” type model that can be applied to verifying and validating the reliability of various types of technical and sociotechnical systems, especially at the design stage. Adapting this tool to the needs of a particular type of system or a specific practical case requires the estimation of numerical values (or ranges) corresponding to each parameter class. In the case of using triangular or trapezoidal membership function models for linguistic variables, one may assume that that the measure of uncertainty in quantitative estimates is the angle of inclination of the sides of the triangles or trapezoids (a right angle corresponds to a lack of uncertainty in the estimate, and the smaller the angle, the larger the uncertainty).

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Using Data Mining for Detecting Operational Risk Factors

Nermin OZGULBAS
Department of Healthcare Management, Baskent University
Eskisehir Yolu 20. km Ankara, 06810,Turkey

and

Ali Serhan KOYUNCUGIL
Capital Markets Board of Turkey
Eskisehir Yolu 8. km Ankara, 06530, Turkey

ABSTRACT

The aim of this study is detecting operational risk factors affected financial performance of SMEs by using data mining. For this purpose we used CHAID (Chi-Square Automatic Interaction Detector) decision trees–one of the data mining algorithms -, which is one of the best ways to identify financial profiles of firms and determine operational risk factors. The study covered 1.876 Small and Medium Enterprises (SMEs) in Organized Industrial Region (OIR) of Ankara in 2008. It was found that firms should emphasize the proportion of export to sales, proportion of R&D expenses to sales, ready to Basel- II, power of competition in market, knowledge about Basel-II, partnership status, proportion of energy expenses to total expenses, awareness about finance, using financial consultant, auditing, person responsible from financial management, person responsible from financial strategies.

Keywords: Risk; Operational Risk; Financial Risk, Hedging; Data Mining; CHAID.

1. INTRODUCTION

All enterprises especially Small and Medium Enterprises (SMEs) need to think about global dimensions of their business earlier than ever. SMEs are defined as enterprises in the non-financial business economy that employ less than 250 persons. The complements of SMEs - enterprises that employ 250 or more persons - are large scale enterprises (LSEs) [1]. Within the SME sector, the following size-classes are distinguished:

- Micro enterprises, employing less than 10 persons
- Small enterprises, employing at least 10 but less than 50 persons
- Medium-sized enterprises that employ between 50 and 250 persons.

This definition is used for statistical reasons. In the European definition of SMEs two additional criteria are added: annual turnover should be less than 50 million €, and balance sheet total should be less than 43 million € [2].

SMEs play a significant role in all economies and are the key generators of employment and income, and drivers of innovation and growth. Access to financing is the most significant challenges for the creation, survival and growth of SMEs, especially innovative ones. The problem is strongly exacerbated by the financial and economic crisis as SMEs have suffered a double shock: a drastic drop in demand for goods and services and a tightening in credit terms, which are severely affecting their cash flows [3]. As a result, all these factors throw SMEs in financial distress. Therefore, to bring out the financial distress risk factors into open have a vital importance for SMEs as all enterprises.

Risk management has become a vital topic for all institutions. Risk is the threat that an event or action will adversely affect an entity's ability to achieve its objectives and/or execute its strategies successfully. With financial overview, one type of risk is financial risk, which is linked to debt, and risk, which is often linked to economic climate. The other one is business risk that a company will not have adequate cash flow to meet its operating expenses.

Nowadays, Basel II Capital Accord, which will become effective in soon, has been the center of attention of credit companies, banks and firms. Basel II is the second of the Basel Accords, which are recommendations on banking laws and regulations issued by the Basel Committee on Banking Supervision. The purpose of Basel II, which was initially published in June 2004, is to create an international standard that banking regulators can use when creating regulations about how much capital banks need to put aside to guard against the types of risks banks face [4]. Basel-II, which introduces risk-based capital management and risk-based credit pricing, would negatively/positively affect amount/price of loans to be utilized by firms. Under Basel-II banks will from now on not only consider financial risk of firms but also operational risk thereof before they grant loans to firms. With minimum financial and operational risk firms would get higher ratings from banks and independent auditing institutions thereby increasing their chances to receive loan facilities with more favorable conditions and minimum costs.

The Basel Committee on Banking Supervision [5] wants to enhance operational risk assessment efforts by encouraging the industry to develop methodologies and collect data related to manage operational risk. Although operational risk is not a new risk, deregulation and globalization of financial services, together with the growing sophistication of financial technology, new business activities and delivery channels, are making institutions' operational risk profiles more complex.

The Basel Committee on Banking Supervision [6] has adopted a common industry definition of operational risk, namely: the risk of direct or indirect loss resulting from inadequate or failed internal processes, people and systems or from external events. The definition includes legal risk, which is the risk of loss resulting from failure to comply with laws as well as prudent ethical standards and contractual obligations. It also includes the exposure to litigation from all aspects of an institution's activities. The definition does not include strategic or reputational risks.

Nowadays, measuring and detecting operational risk is a complicated task fundamental element of business success and as well as hedging financial risk. The objective of this study is detecting operational risk factors affected financial performance of SMEs by using data mining. For this purpose we used CHAID (Chi-Square Automatic Interaction Detector) decision trees – one of the data mining algorithms -, which is one of the best ways to identify financial profiles of firms and determine operational risk factors. Remaining of this paper is organized as follows: Section 2 presents definition of operational risk. Section 3 contains definition of the data mining and CHAID. Implementation and methodology is presented in Section 4. Section 5 provides the results of the study. Concluding remarks and strategies were suggested in the Conclusion Section.

2. DATA MINING AND CHAID DECISION TREES

The explosive growth in data and database results in the need to develop new technologies and tools to process data into useful information and knowledge intelligently and automatically. Data mining, therefore, has become a research area with increasing importance [7, 8, 9]. Kleissner [10] specified that some business trends like data explosion, business reengineering and organizational decentralization, faster product cycles and globalization and enterprise topologies have made the usage of data mining tools and services mandatory for companies.

Data mining, the extraction of hidden predictive information from large databases, is a powerful new technology with great potential to help companies focus on the most important information in their data warehouses. Data mining tools predict future trends and behaviors, allowing businesses to make proactive, knowledge-driven decisions. The automated, prospective analyses offered by data mining move beyond the analyses of past events provided by retrospective tools typical of decision support systems. Data mining tools can answer business questions that traditionally were too time consuming to resolve. They scour databases for hidden patterns, finding predictive information that experts may miss because it lies outside their expectations [11].

Nowadays main challenge in the banking and business world is therefore the implementation of risk management systems in order to identify, measure, and control business exposure. Data mining derives its name from the similarities between searching for valuable business information in a large database.

Today, data mining technology integrated measurement of different kinds of is moving into focus to measure and hedging risk. Data mining techniques have been successfully applied like fraud detection and bankruptcy prediction by Tam and Kiang [12], Lee *et al.* [13], Kumar *et al.* [14], strategic decision-making by Nazem and Shin [15], and financial performance by Eklund *et al.* [16], Hoppszallern [17],, Derby [18],, Chang *et al.* [12],, Kloptchenko *et al.,* [12],, Magnusson *et al.* [19],. Also, some earlier studies of Koyuncugil and Ozgulbas [20, 21, 22 23, 24, 25, 26], Ozgulbas and Koyuncugil [27,28] conducted on financial performance, financial risk and operational risk of SMEs and hospitals by data mining.

Fayyad *et al*. [29], proposed main steps of DM:

- Retrieving the data from a large database.
- Selecting the relevant subset to work with.
- Deciding on the appropriate sampling system, cleaning the data and dealing with missing fields and records.
- Applying the appropriate transformations, dimensionality reduction, and projections.
- Fitting models to the preprocessed data.

Data mining techniques can yield the benefits of automation on existing software and hardware platforms, and can be implemented on new systems as existing platforms are upgraded and new products developed. When data mining tools are implemented on high performance parallel processing systems, they can analyze massive databases in minutes. The most commonly used techniques in data mining are [11, 30]:

- **Artificial neural networks**: Non-linear predictive models that learn through training and resemble biological neural networks in structure.
- **Decision trees**: Tree-shaped structures that represent sets of decisions. These decisions generate rules for the classification of a dataset. Specific decision tree methods include Classification and Regression Trees (CART) and Chi Square Automatic Interaction Detection (CHAID).
- **Genetic algorithms**: Optimization techniques that use process such as genetic combination, mutation, and natural selection in a design based on the concepts of evolution.
- **Nearest neighbor method**: A technique that classifies each record in a dataset based on a combination of the classes of the k record(s) most similar to it in a historical dataset. Sometimes called the k-nearest neighbor technique.
- **Rule induction**: The extraction of useful if-then rules from data based on statistical significance.

Decision trees are used in profiling as a predictive model that, as its name implies, can be viewed as a tree. Specifically each branch of the tree is a classification question and the leaves of the tree are partitions of the dataset with their classification [31]. From a business perspective decision trees can be viewed as creating a segmentation of the original dataset (each segment would be one of the leaves of the tree). Segmentation of customers, products, and sales regions is something that marketing managers have been doing for many years. In the past this segmentation has been performed in order to get a high level view of a large amount of data - with no particular reason for creating the segmentation except that the records within each segmentation was somewhat similar to each other. In this case the segmentation is done for a particular reason - namely for the prediction of some important piece of information. The records that fall within each segment fall there because they have similarity with respect to the information being predicted - not just that they are similar - without similarity being well defined. These predictive segments that are derived from the decision tree also come with a description of the characteristics that define the predictive segment. Thus the decision trees and the algorithms that create them may be complex; the results can be presented in an easy to understand way that can be quite useful to the business user. Decision tree algorithms were suitable for profiling because they are visual and easy-to-understand, easily interpretable, and they allow establishment of rules. With the series of rules obtained from decision trees would be possible to create profiles of firms and then classify firms in terms of levels of financial distress by using such profiles. For each profile the most important financial distress signals as an early warning, which affected the financial position.

There are different decision tree algorithms. In the late 1970s J. Ross Quinlan introduced a decision tree algorithm named ID3. ID3 picks predictors and their splitting values based on the gain in information that the split or splits provide. ID3 was later enhanced in the version called C4.5. Classification and Regression Trees or CART, a relatively new and popular non-parametric analysis technique, was used after these algorithms. Another equally popular decision tree technology to CART is CHAID or Chi-Square Automatic Interaction Detector. CHAID is similar to CART in that it builds a decision tree but it differs in the way that it chooses its splits. Instead of the entropy or Gini metrics for choosing optimal splits the technique relies on the chi square test used in contingency tables to determine which categorical predictor is furthest from independence with the prediction values [32]. One of the most important differences between CHAID and the other methods is tree generating. ID3. C 4.5 and CART generate binary trees, whereas CHAID can generate nonbinary trees. CHAID works with all types of continuous or categorical variables. However, continuous predictor variables automatically categorized for the purpose of the analysis. By means of Chi-Square metrics CHAID is able to separately segment the groups classified in terms of level of relations. Therefore, leaves of the tree have not binary branches but as much branches as the number of different variables in the data. So, it was deemed convenient to use CHAID algorithm

CHAID modeling is an exploratory data analysis method used to study the relationships between a dependent measure and a large series of possible predictor variables those themselves may interact. The dependent measure may be a qualitative (nominal or ordinal) one or a quantitative indicator. For qualitative variables, a series of chi-square analyses are conducted between the dependent and predictor variables. For quantitative variables, analysis of variance methods are used where intervals (splits) are determined optimally for the independent variables so as to maximize the ability to explain a dependent measure in terms of variance components [11].

3. THE STUDY DESIGN and METHOD

This study has three phases to measure and determine the operational risk factors that affected financial performance of firms. The first phase consisted of the process of determining the levels of financial performance of firms and obtained data which used in third phase. Such data was obtained by means of financial analyses of balance sheets and income statements of companies available through Turkish Central Bank. Financial performance levels of firms were determined by ratio analysis. We used 47 different ratios (8 liquidity ratios, 17 financial position ratios, 8 turnover ratios, and 14 profitability ratios) in analysis.

Operational risk data which couldn't be access by balance sheets and income statements such financial management requirements, financial training and financial management skills of financial managers were collected in Phase 2. To collect data a questionnaire suitable for Turkish firms was designed and a field study was conducted in Organized Industrial Region (OIR). Field study covered 6,185 firms in OIR according to the records of OIR, but only 4,979 firms were found (others were closed or moved away). 2,630 firms (52,82 %) of 4,979 firms responded the questionnaire. Since our study is related with micro, middle, and small-sized enterprises, abbreviated as SMEs such 2,630 firms were classified in accordance with EU's SME criteria on basis of amount of annual turnover. When classifying the firms annual turnovers thereof were converted into Euro at average FX rate Central Bank of the Republic of Turkey (http://www.tcmb.gov.tr/) and firms with an turnover smaller then 50 million Euro (€) were classified as SME. After the classification of firms, the study covered 1,876 SMEs.

In the third phase, qualitative and quantitative data obtained through phases 1 and 2 were analyzed by data mining. The main approach in analysis is discovering different operational risk levels and identifying the factors affected financial performance. Therefore, our study focused segmentation methods. By means of Chi-Square metrics CHAID is able to separately segment the groups classified in terms of level of relations. Therefore, leaves of the tree have not binary branches but as much branches as the number of different variables in the data. So, it was deemed convenient to use CHAID algorithm method in the study. CHAID algorithms are developed on basis of two groups of variables, namely target variable and predictor variables that will explain the target variable. In the study financial performance is explained by means of operational risk variables of firms. Therefore, the financial performance indicator is considered as the target variable and operational risk variables are considered as the predictor variables.

4. RESULTS

According to the analysis in the first phase of study, it was determined that 1,300 SMEs (69.30 %) had good financial performance, and 576 SMEs (30.70 %) had poor financial performance, in other words 30.70 % of the covered firms financially distress. In the third phase, SMEs were categorized into 28 profiles on basis of operational risk factors by means of CHAID decision tree algorithm. The SPSS AnswerTree software was used in developing the CHAID algorithm and $\alpha_{merge} = \alpha_{split} = 0.10$ to obtain the decision tree, as shown in Figure 1.

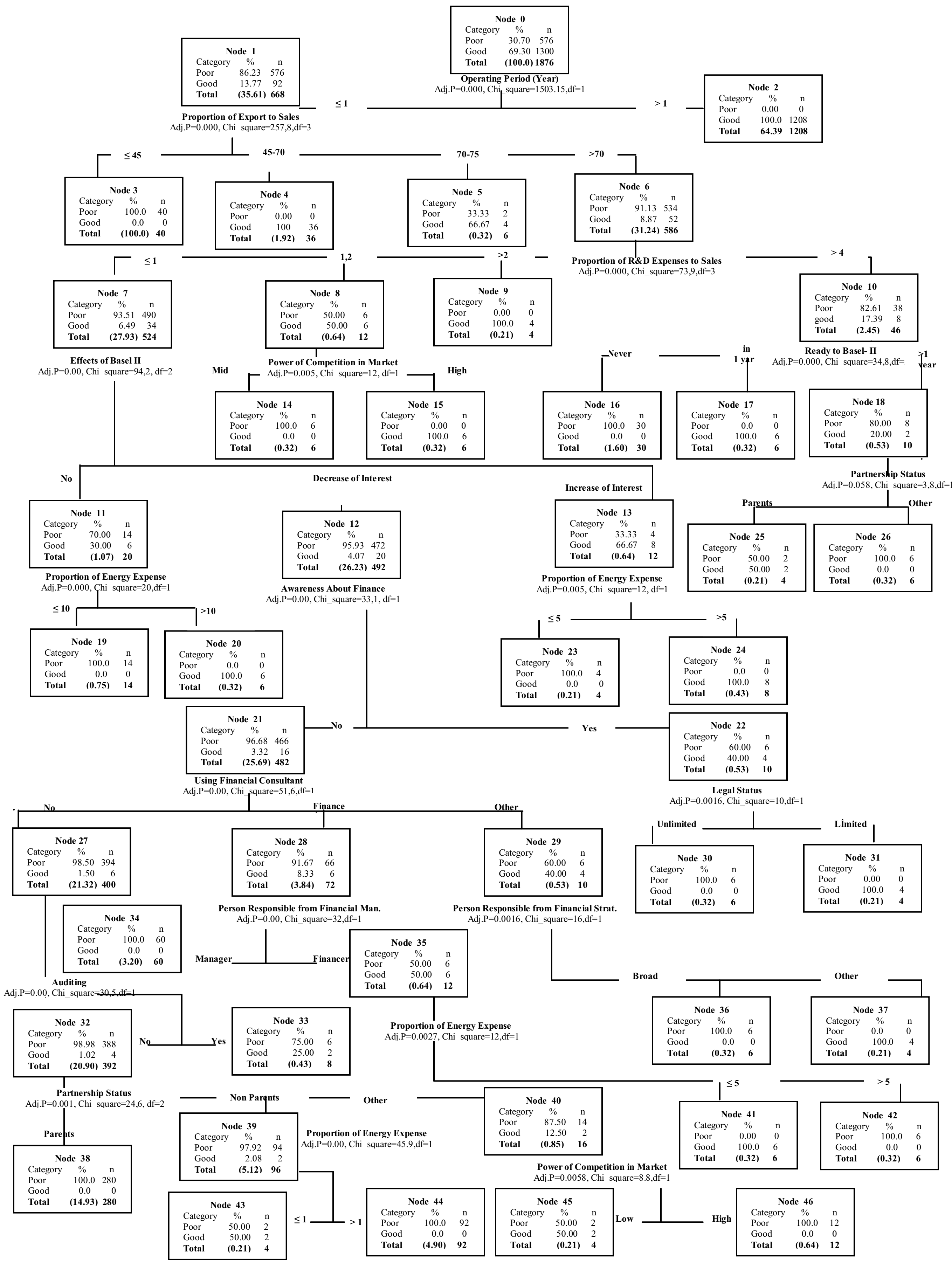

Figure1. Decision Tree obtained by CHAID

These profiles give the operational risk level of the firms. As seen in Figure 1 and Table 1, it was determined that operating period (year) ($p<0.0001$), proportion of export to sales ($p<0.0001$), proportion of R&D expenses to sales ($p<0.0001$), ready to Basel- II ($p<0.0001$), power of competition in market ($p=0.0005$), knowledge about Basel-II ($p<0.0001$), partnership status ($P=0.0001$), proportion of energy expenses to total expenses ($p<0.0001$), effects of Basel-II ($p<0.0001$), awareness about finance ($p<0.0001$), legal status, ($p<0.0001$), using financial consultant ($p<0.0001$), auditing ($p<0.0001$), person responsible from financial management ($p<0.0001$), person responsible from financial strategies ($p<0.0001$) effected financial risk of SMEs.

Table 1. Operational Risk Factors

Operational Risk Factors	p
Operating Period (Year)	<0.0001
Proportion of Export to Sales	<0.0001
Proportion of R&D Expenses to Sales	<0.0001
Ready to Basel- II	<0.0001
Power of Competition in Market	=0.0005
Knowledge About Basel-II	=0.053
Partnership Status	=0.0001
Proportion of Energy Expenses to Total Expend	<0.0001
Effects of Basel-II	<0.0001
Awareness About Finance	<0.0001
Legal Status	=0.053
Using Financial Consultant	<0.0001
Auditing	<0.0001
Person Responsible From Financial Management	<0.0001
Person Responsible from Financial Strategies	=0.0016

According to the CHAID, 1208 SMEs with high financial performance have more then 1 year operating period. Operating period affect financial risk of SMEs and financial performance was decreased in SMEs with short operating period. Other risk factor for SMES is proportion of export to sales. Best proportion of export to sales is between 45 and 70 %. 36 SMEs in this range have good financial performance. Beside this proportion, higher proportion of R&D expenses to sales (more then 2 %) and energy expenses to total expenses (more then 10 %) are decreased financial risk. Also, SMEs with high power of competition in market (6 SMEs), knowledge about Basel-II (8 SMEs) and awareness about finance (4 SMEs) have higher financial performance.

It was found that 6 SMEs that will ready to Basel- II, 10 SMEs use financial consultant, 2 SMEs have periodical auditing, 4 SMEs have unlimited legal status, 4 SMEs without family partnership and 6 SMEs use financial managers have higher financial performance.

5. CONCLUSIONS

Risk management has become a vital topic for all institutions. Benefits of risk management can summarize as early warning to avoid distress, road maps for good credit rating, better business decision making, and greater likelihood of achieving business plan and objectives. It is thought that results of the study would be of great help for the firms to measure and hedging operational risk for reaching better financial performance. Some of expected contributions of using this methodology and CHAID Decision Trees Algorithm for hedging risk can be summarized as follows:

- to determine strategies for hedging risk,
- to prevent financial crises,
- to detect early warning sing for risk and crises,
- to identify road maps for better financial performance,
- to use resources more effectively,
- to ease burdens of banks by occurring strategically monitoring probability of risk factors being key characteristic for achieving BASEL II criteria.

According to the study results, SMEs with high financial performance have:

- higher operating period
- higher proportion of export to sales,
- higher proportion of R&D expenses to sales,
- higher power of competition in market,
- higher knowledge about Basel-II and ready to Basel- II,
- a partnerships without family partnership,
- higher proportion of energy expenses to total expenses,
- awareness about finance,
- financial consultant,
- periodical auditing,
- financial managers.

For improving financial performance by hedging operational risk SMEs should take into consideration these factors.

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Information Risk Management: Qualitative or Quantitative? Cross industry lessons from medical and financial fields

Upasna Saluja CISSP, CISA, BS 25999, ISO 27001
University of Technology, Malaysia
Kuala Lumpur, Malaysia
and
Dr Norbik Bashah Idris CISSP
University of Technology, Malaysia
Kuala Lumpur, Malaysia

ABSTRACT

Enterprises across the world are taking a hard look at their risk management practices. A number of qualitative and quantitative models and approaches are employed by risk practitioners to keep risk under check. As a norm most organizations end up choosing the more flexible, easier to deploy and customize qualitative models of risk assessment. In practice one sees that such models often call upon the practitioners to make qualitative judgments on a relative rating scale which brings in considerable room for errors, biases and subjectivity. On the other hand under the quantitative risk analysis approach, estimation of risk is connected with application of numerical measures of some kind. Medical risk management models lend themselves as ideal candidates for deriving lessons for Information Security Risk Management. We can use this considerably developed understanding of risk management from the medical field towards handling risks that information infrastructures face. Similarly, financial risk management discipline prides itself on perhaps the most quantifiable of models in risk management. The concept of VaR, developed by banks is a generic measure of economic loss that could equate risk across products and aggregate risk on a port-folio basis. VaR model could be adopted to create a risk index calculated and reported by Information security departments in organizations. During the recent financial crisis many investors and financial institutions lost money or went bankrupt respectively, because they did not apply the basic principles of risk management. Learning from the financial crisis provides some valuable lessons for information risk management.

Keywords: Risk, Risk Analysis, Risk Management, Information Risk Management, Qualitative and Quantitative Approach, Risk Management in healthcare, Financial risk management

1. BACKGROUND

The very fact that one is involved in business entails RISK. Global recession has given new dimensions & meaning to Risk. Definitely, this recession has pointed to the lacunae of Risk Assessment & Risk Management methodologies especially of financial institutions [1]. Risk is a subject of much discussion ever since its oversight is believed to have triggered the recent economic crisis. [2]

What you cannot measure, you can neither control nor improve. With an endeavor to have data driven objective assessment of risks, practitioners worldwide continuously seek to apply quantitative models, means to measure and manage risk where possible. There are a few quantitative models available to address information risk. These models are considered less customizable and often need the organization to go in for commercial off the shelf software which eventually turns out to be an expensive affair. As a norm most organizations end up choosing the more flexible and easier to deploy and customize qualitative models of risk assessment. In practice one sees that such models often call upon the practitioners to make qualitative judgments on a relative rating scale which brings in considerable room for errors, biases and subjectivity.

There is a need for a reliable and proven quantitative model for risk management which needs to be practical and easy to deploy. There are numerous mature disciplines which have engaged in assessing and managing risk for considerable period of time. The practice of risk management has indeed evolved and matured in some of these disciplines. There are definite lessons that the information security discipline can draw upon from such disciplines and their practices in managing risk.

This paper seeks to first touch upon commonly used models from both Qualitative & Quantitative Risk Assessment approaches and then brings out parallels in risk management practices from other disciplines like medical and finance, from which information risk practitioners can draw lessons.

Effective Risk Assessment is the need of the day. For security consultants, it is difficult to justify new business from a prospective client when no risk analysis has been done, to show the projected payback. For an individual company, since management typically about the bottom line, it is difficult to justify improvements in security without proper financial analyses. For the IT systems administrators, it is a vicious cycle of firefighting for security issues when much more effective countermeasure proposals are beyond reach due to the lack of proper financial justification. Risk Management includes risk assessment and risk mitigation. In the domain of information management; analysis of risks pertains to loss of confidentiality, integrity and availability. Traditionally Information risk assessment tends to focus on risks in IT systems i.e. IT Risk Assessment, however recently, it has been established that Information Risk Assessment is vital which is much more comprehensive than IT Risk Assessment.

2. QUALITATIVE METHODS FOR RISK ASSESSMENT

Qualitative Risk Assessment which is more the norm does not operate on numerical data. The most common expression of qualitative risk is in terms of qualitative description of assets' value or service, determination of relative qualitative ratings for the frequency of threat occurrence and relative susceptibility for a given threat. Few Qualitative Risk Assessment methodologies discussed in this paper are FMEA/FMECA, NIST 800-30 and CRAMM.

FMEA (Failure Mode and Effects Analysis) and FMECA (Failure Mode and Effects Criticality Analysis) methods have been in existence from ages [3]. **FMEA** is an inductive (bottom-up) engineering analysis method. It is intended to analyze system hardware, processes, or functions for failure modes, causes, and effects. Its primary objective is to identify critical and catastrophic failure modes and to assure that potential failures do not result in an adverse effect on safety and system operation. It is an integral part of the design process and is performed in a timely manner to facilitate a prompt action by design organization and project management. FMEA is supposed to be one of the better methodologies since it provides a systematic evaluation and documentation of failure modes, causes and their effects. It categorizes the severity (criticality category) of the potential effects from each failure mode/failure cause. It provides input to the CIL (Critical Items List). It identifies all single point failures. The FMEA findings constitute a major consideration in design and management reviews. Results from the FMEA provide data for other types of analysis, such as design analysis of mission risk.

FMECA is similar to a FMEA; however, FMECA provides information to quantify, prioritize and rank failure modes. It is an analysis procedure which identifies all possible failure modes, determines the effect of each failure on the system, and ranks each failure according to a severity classification of failure effect. FMECA is a two-step process: Failure Modes and Effects Analysis (FMEA) and secondly Criticality Analysis (CA). MIL-STD-1629A, Procedures for Performing a FMECA, discusses the Criticality analysis can be done quantitatively using failure rates or qualitatively using a Risk Priority rating Number (RPN). CA using failure rates requires extensive amount of information and failure data. A RPN is relatively simple measure which combines relative weights for severity, frequency, and detectability of the failure. It is used for ranking high risk items.

The process of IT risk assessment according to **NIST SP 800-30** methodology [4] is divided into 9 basic phases:

- Selection of systems which are subject to evaluation
- Definition of the scope of evaluation, collection of needed information
- Identification of threats of evaluated systems
- Identification of susceptibility of evaluated systems
- Analysis of applied and planned mechanisms of control and protections
- Specification of probabilities of susceptibility usage by identification of the source of threats (probability is defined as: low, medium, high);
- Analysis and determination of incidents impact on system, data and organization (impact defined in three degree scale: high, medium, low)
- Determination of risk level with the help of a matrix – Risk Level Matrix – for the entire risk for identified threats. This matrix is created as a result of multiplication of probabilities of incidents occurrence (high probability receives 1,0 weight, medium – 0,5, and low – 0,1) and strength if incident impact (high impact receives 100 weigh, medium – 50, and low – 10). On the basis of matrix there is defined level of whole risk for every identified threat, determined as high for product from range (50,100], medium for range (10,50] and low for product from range [1,10].

CRAMM (CCTA Risk Analysis and Management Methodology) [5] has been accepted as the governmental standard for risk analysis and management. The process of risk management according to this methodology consists of three stages; asset identification and valuation wherein the goal is to identify and value assets, threat and vulnerability assessment in order to assess the CIA risks to assets and countermeasure selection and recommendation which identifies the changes required to manage the CIA risks identified.

This methodology uses dedicated software as an integral element supporting the three stages. The concepts of CRAMM applied via formal methods ensure consistent identification of risks and countermeasures, and provides cost justification for the countermeasures proposed [6].

3. QUANTITATIVE METHODS FOR RISK ASSESSMENT

Under the quantitative risk analysis approach estimation of risk is connected with application of numerical measures of some kind. These numerical values could be - the value of resources defined in dollar terms, the periodicity of threat occurrence in the number of instances, risk by the value of loss probability. These quantitative measures present the risk analysis outcome in the shape of indicators like a risk index of some sort. Some examples of quantitative methods in risk assessment include - Annual Loss Expectancy, Courtney's and Fisher's methods, ISRAM model etc [7].

Basic formula for IT risk assessment is -

$R = N \times L \times V$ where (R = Risk Score; N = Number of times the incident or accident is expected to happen in a defined period of time; L = Value of loss to an asset / information system because of a single incident of threat exploiting the existing vulnerability; V = Measures the possibility that a specific threat would exploit the existing vulnerability)

The most commonly used quantitative method for Risk Assessment is **Annual Loss Expected (ALE) model**. This involves calculation of single loss expectancy (SLE) of an asset. The SLE is calculated as the loss of value to asset because of a single incident. Then Annualized Rate of Occurrence (ARO) is calculated for that asset. ARO is an estimate that how frequently a threat would be exploiting vulnerability successfully. Subsequently, the Annualized Loss Expectancy (ALE) is calculated which is calculated as a product of single loss expectancy multiplied by the annual rate of occurrence. This tells the organization that how much an organization could estimate to lose from that asset based on the risks, threats, and vulnerabilities identified. In Risk Mitigation, different countermeasures are explored to address this risk which invariably leads to cost-benefit analysis to justify expenditure to implement / enhance countermeasures in order to mitigate risks faced by the asset. Sum of predicted annual losses provide Annual Predicted Loss of a company [8].

It is presented as ALE = ARO x SLE or ALE = (Probability of event) x (value of loss)

There exist many other models of IT risk evaluation and assessment, based on above method. In business it is imperative to be able to present the findings of risk assessments in financial terms. Robert Courtney proposed a formula for presenting risks in financial terms. The **Courtney's Formula** was accepted as the official risk analysis method for the US governmental agencies. The formula proposes calculation of ALE (annualized loss expectancy) and compares the expected loss value to the security control implementation costs (cost-benefit analysis). He emphasized on the approach that requires recognition that a control should not be implemented if it costs more than tolerating the problem. Further, no control should be implemented which is more costly or less effective or displaces less potential loss than does some other control [9]. **Fisher** proposed one of the first requirements oriented methods for information security design. He built on Courtney's checklist to develop a complete water-fall style design method [10].

4. POTENTIAL FOR LESSONS FROM OTHER EVOLVED DISCIPLINES

Risk Management across disciplines has been attempted both qualitatively and quantitatively. Quantitative Risk assessment has its inherent challenges since risks most often are not tangible. How do you quantify loss of an incident that has not occurred? Loss expectancy is believed to be one of the key measure in expressing risk quantitatively. The following sections describe approaches to Risk Analysis by bringing out the potential to derive lessons in risk assessment from other disciplines which have had a track record in managing risks, namely the medical and financial disciplines.

5. INFORMATION RISK MANAGEMENT LESSONS FROM THE DISCIPLINE OF RISK MANAGEMENT IN HEALTHCARE

Medical risk management models lend themselves as ideal candidates for deriving lessons for Information Security Risk Management. Since times immemorial man has struggled to fight disease, build better drugs as measures to augment the body's natural immune systems which fight disease and increase human survivability. The medical fraternity has constantly attempted to ward off the risks that the body faces in terms of diseases due to external factors and some intrinsic weaknesses (genetic defects, or other pre-dispositions) in the body. Since the medical fraternity needs to determine long term impacts of various drugs on fighting disease there is a considerable emphasis on empirical studies with well documented causal impact and associated effects. This empirical nature of the medical field and the constant endeavor on the part of practitioners to fight disease has led to considerably large body of data on risks faced by the body, probable causes of disease, diagnostics possible drugs and prevention measures As can be seen, the medical field lends itself wonderfully for understanding the gamut of identifying, analyzing, mitigating and managing risk. We can use this considerably developed understanding of risk management from the medical field towards handling risks that information infrastructures face. Take information assets to be patients, different incidents including hacking, malicious programs as diseases, while technical controls to mitigate risks could be considered as medicines and different processes, policies and practices can be considered as treatment protocols [11].

Over years a lot of data has been gathered in the medical field allowing for application of statistics and statistical modeling. Application of the risk management principles derived from their use in medical field depends considerably upon knowledge of the probability distribution associated with successful attacks on information assets. Do we have such historical data available to us for us to derive probability distribution of attacks on information assets? The fact is that even today, we don't have enough real data to rely on. The solution to this non availability of data lies in use of sampling theory to arrive at statistically valid estimations of the probability distributions required.

In medical field, different groups of patients are studied by statistically analyzing the expected / observed results of usage of different medicines & different protocols. The statistical methods which are used in medical field could also be used in Information Technology provided adequate data on non-availability of assets / systems over periods of time is collected & analyzed. This would help derive statistically valid estimations for underlying probability distributions. Analysis of this data can yield non-parametric estimates of the probability distributions related to the reasons of non-availability.

Independence is an assumption applicable to the statistical methods. It is critical to see that the collectable data while conducting Risk Analysis is defined in such a manner that key data sets are independent. In this scenario, failure time data is collected & is used for estimation of the uptime function. This is similar to survival time for a patient in case of medical industry. Log-rank & Wilcoxon tests are available to compare the survival functions of two groups. This can test the hypothesis that the underlying probability of failure is due to chance and not improved security. A semi -parametric approach can also be used to prove that assets for which controls to mitigate risks are implemented remain available for longer times than those that do not enjoy the advantage of such controls. The net benefit of the proposed control is the difference in expected losses less the cost of the measure to be adopted (control to be implemented).

Attempts to learn from the human body and eventually the ability to mimic the intrinsic response of the human immune system would be the ultimate goal for information security risk practice. A network that can detect the minutes of adverse changes and respond to it just as the human immune system does is highly desirable and could be considered an ultimate goal in creating self-surviving systems or networks. There have been attempts to create self-healing networks and systems much in the same way as the human tissue and other organs of the human body self-heal however we are fairly far way from being able to mimic the human body in this ability. Ideally, mimicking the way immunity works in biological organisms the system should be able to dynamically adapt to embrace new risk situations and dynamically create and learn new risk models as it encounters new risk situations. Some of heuristics based learning intrusion detection systems, anomaly detection systems and malware detection systems have achieved some degree of success in replicating some elements of survivability that the human body possesses. While these are steps in the right direction, we are far from there in creating truly responsive self-healing or self-surviving systems and network.

6. PARALLELS FOR INFORMATION RISK MANAGEMENT IN FINANCIAL RISK MANAGEMENT

The recent financial crisis and mortgage triggered downturn has brought to focus the failure of risk management across the financial industry. While the debate on regulation, over-regulation or deregulation continues, financial organizations are taking a hard look at their risk management practices and models. Finance industry has boasted of a fairly evolved set of risk management models and techniques. Credit risk in particular has had considerable work happening in defining the criteria, parameters and indicators of risk. Credit risk is risk resulting from uncertainty in a counter party's ability or willingness to meet its contractual obligations. Run up to the recent crises saw lenders throwing risk assessment to the winds and offering mortgaged loans to borrowers irrespective of their propensity or capacity to repay. Financial risk management discipline prides itself on perhaps the most quantifiable of models in risk management. Risks in Financial industry were naturally expected to be termed in dollar terms and the research and quantitative models developed in that manner.

Financial risk management has been a concern of regulators and financial executives for a long time. One of the key concepts in Financial Risk management is termed Value at Risk (VaR). VaR was a concept that gained ground sponsored by a large number of U.S. banks in the last two decades of the last century as the derivative markets developed. With VaR, banks developed a generic measure of economic loss that could equate risk across products and aggregate risk on a port-folio basis. VaR is defined as the predicted worst-case loss at a specific confidence level over a certain period of time. [14]. For a given portfolio, probability and time horizon, VaR is also defined as a threshold value such that the probability that the mark-to-market loss on the portfolio over the given time horizon exceeds this value (assuming normal markets and no trading in the portfolio) in the given probability level [15].

One of the key benefits of VaR-based risk management is the improvement in systems and modeling it forces on an institution. Per Philippe Jorion the greatest benefit of VAR lies in the imposition of a structured methodology for critically thinking about risk.

For addressing risk in information security this VaR model could be adopted to create a risk index calculated and reported by Information security departments in organizations. Just as publishing a daily number, on-time and with specified statistical properties holds every part of a trading organization to a high objective standard in the financial industry, the risk index could keep the security departments in the Information risk management discipline alive to the prevailing risk posture. To ensure that VaR is under limits, robust backup systems and default assumptions must be implemented. Similarly in Information Risk management robust controls to handle critical aspects like disaster recovery and Information Security Management Systems need to be created and monitored for effectiveness. Just as in the financial industry positions that are reported, modeled or priced incorrectly, data feeds that are inaccurate or late and systems that are too-frequently down stand out; in the information security practice anomalies in user behaviour and traffic patterns need to stand out and responded to using detective measures like Security Incident and Event Management Solutions. In the Finance industry anything that affects profit and loss that is left out of other reports will show up either in inflated VaR or excessive VaR breaks, similarly anything that impacts risk (due to access issues or traffic anomalies) in the network or information infrastructure needs to show up as an increase in the information risk index [16].

Another factor of “structured finance” has been recently mentioned as the main cause of the latest financial crisis. However, structured finance and its complex products as such did not trigger the financial crisis. It was the risk management policies and practices employed by institutions engaged in structured finance that were the issue which eventually brought on and propagated the huge economic crisis worldwide.

After 2001, there was a major, rapid transformation of financial markets, as U.S. banks and other retail institutions extended their loans to risky borrowers (subprime loans) and transferred these risks to the overall financial market using credit risk transfer instruments via securitization. During this period, securitization transformed low-grade assets into investment-grade assets by using complex financial instruments. This brings in an important lesson for information risk management. Whenever we transfer risk or consider other mitigating controls that reduce the overall risk, we must question whether we are getting “real reduction in risk” or merely a “perceived reduction in risk” while the actual risk gets transferred to another area with net residual risk staying well above the acceptable risk levels.

Further the crisis was accelerated because banks were under pressure from the financial market to increase the supply of high-risk mortgages in order to generate assets with high yields in a period of low interest rates. As an information security practitioner the core challenge managers face in information security risk management is maintaining the risk goggles (risk oriented perspective) while managing conflicting pressures with business demand for flexibility on the one hand conflicting with the security requirements of the organization which are on the information security department’s goal sheets.

7. MAPPING SOME OF THE LESSONS FROM THE FINANCIAL CRISIS TO INFORMATION RISK MANAGEMENT

During the recent financial crisis many investors and financial institutions lost money or went bankrupt respectively, because they did not apply the basic principles of risk management. Firstly, risk appetite was not well stated in many firms. This is a key issue in Information risk management too. It is very often not clear how much residual risk is the management ready to take. Many senior management executives charged with taking decisions on risk appetite often skirt the issue rather than addressing it head on. Secondly, enterprise risk management was not well defined or used. Information Risk Management too needs to be viewed holistically as part of the larger business risk or the Enterprise risk framework. Where information risk management operates in a silo and does not roll up into Enterprise or Organizational risk management there is a chance that the overall import of it may be lost and business may not prioritize resources required to handle it well. Thirdly, relevant risk-management policies were not supported by top decision makers. In fact, risk management in many organizations appears to have been cyclical, peaking only after the crisis reached full-blown proportions. As many security practitioner report information security initiatives launched with overtly visible senior management support are more often likely to succeed than those without. Fourthly, the increasing complexity of structured finance created challenges in terms of efficient management and the dissemination of information. This relates to Information security directly where in more complicated the control greater is the difficulty in understanding the risk picture. In security too the KISS principle works well – Keep it Simple Simon. Lastly in the final analysis, more due diligence with respect to risk is absolutely necessary both for senior management and investors. In information security too it is absolutely vital that appropriate due diligence is exercised both for senior management and users [17].

8. CONCLUSION

The debate over qualitative and quantitative models in risk management continues to rage across disciplines with practitioners. Factors that have made practitioners choose the qualitative models over quantitative ones have included ease of deployment, customizability and cost of implementation. However, the drawbacks in qualitative models in terms of reliance on expert opinion, qualitative ratings with inherent biases and subjectivity, have led to a constant endeavor among researchers and practitioners to look for quantitative models that are easy to use and implement. Mature disciplines such as the medical profession and finance have long relied on risk management practices to prevent operational losses. Information Risk practitioners need to draw from other such disciplines where risk management practices have evolved and matured with time. Considerable more work needs to be undertaken to identify such opportunities for adoption of risk management models and customizing them to suit the ephemeral world of often "virtual risks" in the information risk management discipline.

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Cryptographic Multi-Tenancy: Reducing Risk in Cloud Computing Environments

Robert JOHNSON
Distinguished Engineer, Unisys Corp.
Malvern, PA, U.S.A.

ABSTRACT

In today's cloud computing environments, applications and data for multiple tenants are hosted within a common network, compute, and storage infrastructure. The risk of intermixing data on networks and storage media is typically mitigated through virtualization techniques including firewalls and virtual local area networks (VLANs) for data in motion and using storage virtualization for data at rest. Non-cryptographic techniques such as these rely on trusting system-level software such as hypervisors and virtual appliances to prevent tenant-to-tenant attacks. They do little, however, to prevent insider attacks from the cloud provider itself. Using cryptography, however, to isolate and contain tenants within their own communities of interest can further mitigate the multi-tenancy and provider-insider risks. The paper examines some of the attack surfaces present in simple network and storage virtualization schemes. It also shows how cryptography (encryption and authentication) and robust identity and access management, when controlled and managed by the individual tenants, greatly reduces the attack surface and thereby mitigates the risks associated with cloud computing.

Keywords: cloud computing, cryptography, multi-tenancy, communities of interest, virtualization.

INTRODUCTION

Cloud computing is a new compute paradigm that is sweeping through the IT industry. Driven mainly by the need for IT departments to cut their costs, especially capital expenses, they are increasingly pushing applications and data into the hands of third-party cloud providers. While many enterprises have migrated non-mission-critical systems off-premises, IT departments have mostly resisted moving those core applications and data that are fundamental to the operation of enterprises into the cloud. There are very good reasons for such reluctance.

This paper will define and explain the cloud computing paradigm and look at the security risks associated with cloud computing. A Cloud Security Architecture that addresses those security risks will then be presented. A fundamental principle of cloud computing, the isolation and containment of multiple tenants who share the same physical resources, is then examined, along with the standard usage of Virtual Local Area Networks (VLANs) and firewalls to accomplish that separation. The standard methods can be enhanced with a variety of cryptographic methods. Some of those methods are then discussed.

WHAT IS CLOUD COMPUTING?

According to the National Institute of Standards and Technology (NIST), cloud computing is defined as having five essential characteristics: on-demand self-service, broad network access, resource pooling, rapid elasticity, and measured service; three service models: Infrastructure as a Service (IaaS), Platform as a Service (PaaS), and Software as a Service (SaaS); and four deployment models: private cloud, community cloud, public cloud, and hybrid cloud.

Essential Characteristics of Cloud Computing

New tenant subscription, configuration of virtual machines (VMs), assignment of cloud resources, and deployment of VMs into the cloud should be as light-weight as possible. To avoid manual processing, on-demand portals are employed for these functions. Orchestration of all of the background processing involved in standing up a set of VMs for a particular tenant should be fully automated to keep the deployment time to a minimum and to keep the provider's operational costs low.

For public clouds, VMs should be accessible from anywhere on the internet, with proper authorization. For private clouds, access to VMs may be restricted to enterprise network users, but should be easily reachable from within the enterprise's intranet.

The strict definition of resource pooling states that compute (processors and memory), network, and storage resources should be allocated to tenants from common availability pools. This does not necessarily imply that individual compute, network, or storage resources need to be shared among multiple tenants. A cloud provider could, for example, allocate entire physical servers, network switches, and storage arrays to each tenant. In practice, however, this does not take advantage of the efficiencies and higher resource utilizations gained by virtualization of servers, networks, and storage. In practice, all cloud providers draw multiple tenants' VM, network, and storage resources from common resource pools, thereby intermixing them within the same compute media.

In order to meet the demands of rapidly changing workloads, either within a single tenant, or across many tenants, the cloud infrastructure must be elastic enough to be able to rapidly "spin-up" and "spin-down" resources to meet fluctuating demand.

The last essential characteristic of cloud computing environments is pay-as-you-go, or measured service. The primary motivation for IT departments to migrate applications into a cloud is to reduce operational costs. Capital expenditures (CapEx) are reduced since hardware is owned by the cloud provider. Maintenance and administration costs are also reduced. Those cost reductions are offset, however, by the fact that the cloud providers must charge a fee for the use of the hardware they are managing. In keeping with the cloud's shared-use computing model, a shared-use cost model is typically also employed. Basically, each tenant pays for the amount of shared resources they use during a billing cycle. This rental fee structure shifts an enterprise's cost from CapEx to operational expense (OpEx).

Cloud Service Models

Of the three service models, IaaS is most similar to traditional IT. Individual VMs are defined by the tenant administrator with their complement of operating systems (OSes), applications, and databases. IaaS differs from traditional IT, though, in that once defined, VMs can be replicated and instantiated as demand requires. Another difference is that often there is a menu of base VMs with a particular OS at a particular release level already installed. There may also be agents for basic security functions (anti-virus, firewall, etc.), backup/restore/archival, or other common software. For example, a virtual desktop could be preconfigured with Windows 7, Office 2007, and Symantec Endpoint Protection. Alternatively, the administrator may simply choose from a list of available softwares and the deployment orchestration process could install those that are not part of a standard template. Amazon Elastic Compute Cloud (EC2) and Rackspace CloudServers are examples of IaaS.

PaaS raises the compute environment away from issues of OS levels, firewall rules, etc. Rather, PaaS provides a set of application programming interfaces (APIs) that represent an abstract programming environment, complete with object models for multi-threaded processes, transaction processing queues, and high-level storage objects. PaaS is an extension of Microsoft's .NET or Java J2EE into the cloud. Microsoft Azure and Google Apps are examples of PaaS.

SaaS abstracts the compute environment even higher to a single application suite. In this model, instances of a multi-tiered application are created for each tenant. All transactions and data are specific to that particular application. SaaS providers manage all infrastructure related to OS, networking, data management, load balancing, etc. Often SaaS is implemented within a PaaS or IaaS cloud. An example of SaaS is SalesForce.com (Force.com is the underlying PaaS that supports SalesForce).

Cloud Deployment Models

A cloud's deployment model is basically determined by who owns the equipment. A private cloud employs a cloud management stack operating on equipment owned and hosted by an enterprise. Private clouds are useful for large enterprises that have many department, business units, or other internal entities that require segregation.

A community cloud is less well-defined. It is a cloud that provides services, typically PaaS or SaaS, for a group of users with common interests. Social network sites can be considered community clouds. Multi-tenancy within community clouds involves both the segregation of tenants (users) from each other, and the selective sharing of data among tenants.

A public cloud is what is most often referred to by the term "the cloud." Public clouds host multiple tenants within a shared infrastructure that is accessible from anywhere across the Internet.

Finally, a hybrid cloud combines attributes of public and private clouds. Hybrid clouds are primarily private clouds that can "burst" applications and data into a public cloud if the workload exceeds the capacity of the private cloud resources.

WHAT ARE THE RISKS?

The basic risk associated with cloud computing is the loss of control over corporate assets. Applications and data are given over to a cloud provider, and the owner of those assets must trust that the provider will protect and preserve them.

The act of preserving applications and data may itself change the risk profile. Cloud providers often backup and migrate applications and data between sites to ensure continuous operation. Replication of applications and data introduces additional risk in the form of data "in the wild" – copies of sensitive data out of the tenants' control. Likewise, if proprietary processing is embodied in applications, those applications become as sensitive as the data they act on. Additionally, there may be licensing issues associated with replicating third-party software.

Risks to the business, rather than the data itself, include lack of compliance with required regulations and industry standards. If a cloud provider is not Payment Card Industry Data Security Standard (PCI-DSS) compliant, and any aspect of an enterprise's payment card processing is done in the cloud, that enterprise is no longer PCI-DSS compliant. The same holds true for Health Information Portability and Accountability Act (HIPAA) or any government regulation that pertains to personally identifiable information (PII).

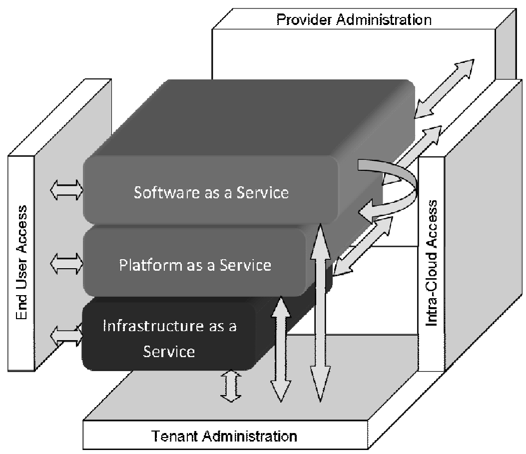
It should be well understood that transferring PCI-DSS, HIPAA, or any other regulated information to the cloud does not transfer the risk or liability associated with that data, even if the cloud provider is compliant with the applicable rules.

Finally, regarding added risk, enterprises must be cognizant of any jurisdictional laws or regulations relating to the type of data placed in a cloud. Many governments prohibit PII data from crossing national or other jurisdictional boundaries, even if the data is encrypted. When choosing a cloud provider, one must be aware of how and where backup copies are stored, and where VMs may be moved to by the provider.

A CLOUD SECURITY ARCHITECTURE

Figure 1 depicts a cloud security model encompassing a set of secure access planes surrounding the three service models arranged in tiers of increasing abstraction.

Figure 1 – Cloud Security Model



In the cloud security model depicted in Figure 1, the four access planes represent different administrative, end user, or cloud application roles.

The Provider Administration plane allows authorized access to the cloud management tools and utilities that control the underlying cloud infrastructure, independent of tenants. Functions such as setting load balancing parameters, harvesting log data, or adjusting data store sizes are the type that are invoked through the provider administration access plane.

Similarly, the Tenant Administration plane allows the invocation of tenant-specific administration functions. For example tenant administrators need to control the maximum number of VMs that can be replicated to handle workloads. They also adjust settings that govern the maximum compute, memory, I/O, and data storage resources that may be consumed.

The End User access plane authorizes access by authenticated user to the APIs and user interfaces provided by the tenants' applications or the providers' PaaS or SaaS services.

Often, applications within the cloud need to communicate with other applications or services running within the same cloud. Those applications need to be authenticated and authorized as end users need to be. The Intra-Cloud access plane authorizes communications between assets in the cloud.

MULTI-TENANCY

As discussed earlier, clouds are multi-tenant operating environments where the physical resources of the cloud are shared dynamically among the various active tenants' virtual resources. To ensure a secure operating environment, each tenant must be isolated from each other, and the effects of any particular tenant's activities must be contained within that tenant's operational space.

This notion of isolation and containment is fundamental to secure multi-tenancy. There are many ways to achieve proper isolation and containment. The most common method is to use virtual firewalls and routers to isolate tenants' traffic from each other and virtual local area networks (VLANs) to contain network traffic so it can only be delivered to other entities owned by the same tenant.

Although the same multi-tenancy requirements exist for data at rest on physical storage, there is no "standard" method supplied by cloud providers for ensuring isolation and containment of data at rest.

Identity and access management is also a key component of a secure multi-tenant computing environment. Especially when accessing administrative functions, proper authentication and authorization technologies must be employed. It is the tenant's responsibility for identifying and credentialing administrative users, but it is the provider's responsibility for ensuring that only those duly authorized users have access to administrative functions. Integration of these distinct responsibilities into a cohesive and secure identity and access management system can be accomplished by federating the cloud provider's identity management with each tenant's. Federation can be accomplished through explicit trust relationships, although this method may not scale well enough. Newer methods such as Security Assertion Markup Language (SAML) support a highly-scalable distributed and trusted identity management and single-sign-on capability.

In addition to isolation and containment concerns, and identity and access management requirements, the lack of visibility into cloud providers' processes and operations can increase an enterprise's risk exposure. Many cloud providers do not disclose much about their internal processes for hiring and firing of employees, backup and archival of audit data, etc. In some instances, it is not even made clear whether such operational aspects of the cloud have rigorous processes. There are, however, also cloud providers who do provide transparency deep into their operations, and who have a wide range of process and data center oriented certifications to their credit. When choosing a cloud provider for hosting compliance-sensitive applications and data, their process visibility and transparency should be carefully considered.

CRYPTOGRAPHIC ISOLATION AND CONTAINMENT

As mentioned above, standard methods of isolating and containing tenants' network traffic employ virtual firewalls and routers, and VLANs. There are weaknesses to these methods, however.

VLANs are, by nature, location specific. They define a topologically-contiguous set of network endpoints. VLANs are not aware of the identity of users of those network endpoints. Also, VLANs can be spoofed, i.e. a member of one VLAN can, in some cases, masquerade as a member of a different VLAN. This may require very low-level manipulation of network data packets to mimic the protocols used within the hypervisor, however. There are also the risks of currently unknown zero-day attacks against hypervisors, virtual firewalls, routers, and switches.

More mundane risks include misconfiguration of firewall rules, or the old standby – the insider threat. In the case of cloud computing, however, the insiders with most access, especially to storage data, are outsiders to the tenants, namely provider administrators. A rogue provider administrator could, theoretically, collect whatever network traffic and/or read any storage data he wishes.

A non-standard approach to isolation and containment is the user of cryptographic communities of interest (Crypto-COIs). Crypto-COIs allow members of a COI to communicate with each other, while excluding non-members. The enforcement of COI membership is done through cryptographic algorithms and protocols.

Crypto-COIs can be identity-based, rather than topology-based, and can span wide networks. Indeed, a crypto-COI can be viewed as a virtual network segregated from other COIs which share a common network infrastructure. This allows for the possibility of a virtual network (i.e. COI) that spans public clouds, private clouds, and the Internet.

Crypto-COIs and standard VLANs/firewalls are not necessarily mutually-exclusive. Both methods of isolation and containment can be employed for a “belt-and-suspenders”, or defense-in-depth approach. When applied to network communications, crypto-COIs use strong encryption/decryption and authentication algorithms.

Crypto-COIs can define sets of applications that inter-communicate. In this case, application-layer network security protocols such as Secure Sockets Layer (SSL) or Transport Layer Security (TLS) can be used. Browser-to-website traffic often uses SSL/TLS for secure transactions. It should be noted, however, that unless both endpoints are mutually authenticated, SSL/TLS is susceptible to man-in-the-middle attacks.

When all traffic between endpoints within a COI is to be secured, a lower-layer protocol such as Internet Protocol Security (IPsec) can be used. IPsec itself does not have the notion of allowing or disallowing communications between endpoints, however. Additional protocols or manual means of setting IPsec policies are required to enforce crypto-COIs.

There are also non-standard, proprietary crypto-COI solutions available which integrate the definition of COI membership and the policies associated with particular COIs with the tenants’ identity management system. This allows a common, centralized management point for adding/deleting COIs and their members.

Crypto-COIs for storage could be viewed as more important than network COIs. Network data is, by its nature, ephemeral. Packets pass from point to point, but once delivered, they cease to exist. Storage data, on the other hand, may be required by law to last for years. The longer sensitive data lingers, and the more backup copies of it are made, the more vulnerable it becomes. In a cloud environment, the possibility of a rogue administrator increases with time, also. Combining these two risk factors requires that data at rest be cryptographically secured. Indeed, emerging compliance regulations such as the Federal Risk and Authorization Management Program (FedRAMP) [FED001] require the encryption of sensitive data (e.g. PII).

As with network crypto-COIs, storage crypt-COIs can be implemented at the application layer where individual applications encrypt their own data, at the database layer where PII fields can selectively be encrypted, or at the I/O layer. When implemented at the I/O layer, crypto-COIs for storage secure all data written through the I/O layer, regardless of the sensitivity level. Unlike network security protocols like IPsec, there are no standards for securing storage data. Instead, application writers, database vendors, and I/O appliance vendors build their products around proprietary protocols, algorithms, and processes.

CONCLUSION

We have shown that migrating IT applications and data to cloud computing environments, as defined by NIST, represents significant risks. Those risks can be mitigated, however, through secure methods of isolation and containment of network and storage data. We have also shown that employing cryptographic algorithms to enforce membership in well-defined communities of interest adds an additional layer of security above and beyond the industry-standard techniques: VLANs and firewalls for network data, and no standard techniques for storage data.

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