ABSTRACT

We make the assumptions that deep knowledge based reasoning and analytical capability are necessary to effectively deal with various ongoing issues related to complex systems operations that transcend the boundary of a single discipline. Furthermore, Knowledge communication between disciplines is a prerequisite for successful interdisciplinary research projects and activities. A knowledge communication model includes providing knowledge workers with the knowledge, experiences and insights which they need to perform their tasks. We propose a multi-agent system that assists in the process of knowledge communication between concerned interdisciplinary groups. Each agent is a knowledge broker and organizer for a specialized knowledge worker group involved in an interdisciplinary activity. In addition to timely access to knowledge, it should help in understanding the motivation which underlies decisions made by other groups and/or the informational/knowledge bases for such decisions. Each agent is expected to learn about the activities, contexts of decisions, knowledge employed and experiences of other knowledge workers groups whose activities are considered to be relevant to the group it represents.

Key Words: Knowledge Communication, Multi-Agent System, Knowledge Representation.

1. INTRODUCTION

The efficient and effective communication of knowledge, experiences and insights between Knowledge Workers (KW), such as domain experts and decision makers, from various disciplines is a prerequisite for successful interdisciplinary research projects. It is also a requirement for high-quality decision-making and coordinated organizational actions [25] in organizations that deal with complex issues. Examples of situations that illustrate the importance of Knowledge Communication (KC) can be found in [26]. KC enables KWs within an organization to collect information and share their knowledge leading to actions that improve services and outcome. A KC model includes providing KW with the knowledge, experiences and insights which they need and which can be used and shared across hierarchies and functions in an organization and between organizations.

We propose a multi-agent system that assists in the process of KC between concerned interdisciplinary KW groups. Each agent is a knowledge broker and organizer for a specialized KW group involved in an interdisciplinary activity. Members of a group may not have the time to organize and manage the information/knowledge they need when making their decisions. They may not also have the capability to understand the motivation which underlies decisions made by other groups and/or the informational/knowledge bases for such decisions. The aim is to allow each agent, acting as a knowledge broker, to use dialogue in order to learn about the activities, contexts of decisions, knowledge employed and experiences of other KW groups whose activities are considered to be relevant to its group. Agents dialogue and interaction are essential in KC due to the role they play in supporting agents’ reasoning, change in their conceptual perspective [21] and updating their knowledge bases [20, 27, 28]. Hence, each agent should know about the knowledge and abilities of other agents and the tasks of the groups they support. Such knowledge can be shared with other agents that could keep their groups updated of the activities of other groups.

Each agent is expected to have the ability to initiate dialogues and maintain a knowledge base for its knowledge group in order to ensure that it is coherent with the others’ knowledge bases. This ensures that the interdisciplinary organization has naturally specialized distributed knowledge bases that interact and cooperate in order to ensure timely, well informed and well-coordinated decisions. In other words, each group, and each member of a group, could play its role and have its different view properly interconnected with others’ views.

In section 2 we discuss the basic concepts of data, information and knowledge. In Section 3 we discuss the need for a KC system in interdisciplinary work. In section 4 we present a multi-agent based system for KC. In section 5, we discuss some Knowledge Representation (KR) issues in KC.
2. DATA, INFORMATION AND KNOWLEDGE

Before discussing our proposed framework, some important concepts should be reviewed. There is a consensus among researchers that there is a distinction between data and information. Data can be considered as raw information that is meaningless to an interpreter. Information represents an understanding of the relationships between pieces of data, or between pieces of data and other information. Information relates to different forms of descriptions and definitions. Information is used to make decisions. For Data to be transformed into information, some processing must be performed while considering the context of a decision. We often have abundance of data but lack relevant information.

Unlike information, knowledge is less tangible. It is inferred from information (e.g., by humans) using methods of comparison, consequences, connections, and conversation. According to [7]:

“Knowledge is a fluid mix of framed experience, values, contextual information, and expert insights that provides a framework for evaluating and incorporating new experiences and Information. It originates and is embedded in the minds of knowers. In organizations, it often becomes embedded not only in documents or repositories but also in organizational routines, processes, practices, and norms.”

Knowledge represents a self-contextualizing pattern relation between pieces of information and/or data. It may inform us of how the pattern it represents will evolve. It encompasses what we may call strategies, practices, methods and principles. There are several types of knowledge and some of these types are difficult to distinguish from information which is somewhere between data and knowledge. To appreciate the degree of overlap, we only need to consider the scope of the notion of an information system that spans database systems and intelligent knowledge base systems. Knowledge can inform us of how the pattern it represents will evolve.

It is clear that the notion of knowledge encompasses information and data. It also seems incomplete to organize and communicate knowledge without taking into consideration the possible ways it can be manipulated in order to satisfy a goal. Thus, Knowledge communication cannot disregard embedded intelligence which is associated with the principles of generating, manipulating and applying knowledge. Furthermore, it cannot dispense with data and information because they form the basic constituents of knowledge. Other definitions of data, information and knowledge are found in [4]. For more details see [17].

3. INTERDISCIPLINARITY AND KC

Interdisciplinarity is becoming more a necessity because many problems are complex and cannot be solved using the expertise/knowledge of single disciplines. Solutions to many complicated scientific and societal issues require interdisciplinary effort and capabilities in order to be more accurate. Interdisciplinary studies involve generally various theories, methodologies and knowledge from many different disciplines. Such a practice seems to be the only way to deal with complex problems [6, 10, 14].

Whether the work is only cooperative to solve problems or accomplish some tasks [24, 5, 13], or integrative, to build a new whole [10], communication is an essential issue. It involves [2] an ability to fully understand the content of what is being negotiated from the perspective of the discipline that has proposed it. The competencies, which determine how well tasks are performed and decisions are made, are a function of the knowledge being employed, including understanding, expertise, experiences and skills. A decision is a choice of an action from a set of alternative actions.

KC is the activity of communicating insights, assessments, experiences or skills. It can be employed to transfer/exchange knowledge about how to accomplish a task (know-how), the cause-effect relationships that concern a phenomenon and other types of knowledge. In addition to relevant information, there may be a need to exchange contextual information and other constraints associated with the application of the piece of knowledge being exchanged. In other words, KWS involved in interdisciplinary communication, are required to transcend their disciplines. However, it is important to emphasize that what is important in KC is the extent to which the receiver acquires potentially useful knowledge and utilizes this knowledge in its own operations.

To be able to organize the knowledge of an interdisciplinary group, there is a need:

(K1) To identify, model and explicitly represent the group’s knowledge. This entails modeling the group’s processes, together with their control, and its decision-making.

(K2) For an interdisciplinary ontology to ensure that the represented knowledge is correctly understood and properly shared.

(K3) For a systematic approaches to designing and building knowledge-based applications and tools to support modeling, validation, verification, maintenance and constant updating of the knowledge in these applications.

(K4) For the ability to handle the computational aspects of multi-agent systems such as task allocation, interaction, coordination, process and organization representation, collective learning, consistency management, protocol, adaptation and evolution of knowledge, managing heterogeneity and achieving interoperability.

(K5) For the ability to assess the performance parameters of the system in real time with the latest knowledge to maintain pre-defined goals.

Some of the major problems that face interdisciplinarity and/or are associated with immediate knowledge transfer between experts are:
(D1) Experts are trained to be specialist in their disciplines. Hence, their ability to clarify a message or to find a weakness in an argument outside their domain of expertise or discipline is rather limited.

(D2) It is difficult to find a common language because of discipline specialization [1, 23]. Hence, interdisciplinary communication requires cooperation between the disciplines to agree on an ontology and on defining the rules of collaboration.

(D3) Incompleteness and Interdisciplinarity of the knowledge being transferred.

(D4) Inferential and reasoning abilities of the experts who are exchanging knowledge: one expert could communicate some knowledge to another who may not have the reasoning capability to make a proper use of it.

(D5) Constraints and contextual factors: There is a need to shared knowledge and shared understanding of the context and constraints in which the decision has to be made.

(D6) Time pressure: overloading an expert with more than is needed, could have the adverse effect of confusing the decision-making process.

(D7) It is important that the decision-maker knows what information/knowledge and skills it needs. It is also more important that it can assess the usefulness of the knowledge being offered to the situation being solved.

Some of these problems can be handled by employing a KC support system. The existence of a knowledge broker and organizer that can initiate dialogues with other agents representing appropriate knowledge groups/sources will be a great help. The success of such a process depends on the interplay of many conditions. Some of these are:

(i) The effectiveness of teamwork between agents through coordination, cooperation, and collaboration.

(ii) The degree to which information/knowledge is effectively networked and skillfully communicated.

Hence, lack of appropriate knowledge may lead to the inability to fulfill the requirements of some tasks. Failure occurs even in simple mundane tasks. The reasons for failure are numerous [18].

4. A MULTI-AGENT FRAMEWORK IN SUPPORT OF A KC SYSTEM

The primary purpose of a KC system should be to make knowledge accessible and reusable by its different components whether human or software agents [19]. The core of a KC system is a dialogue and an argument framework for collaborative autonomous agents which should allow dialogue participants to communicate effectively; convey information, generate appropriate questions that express the needs of the represented groups, annotate responses (e.g., in the form of arguments) and judge their suitability and quality [12]. The participating agents are expected to recognize their limitations and determine when they should seek help. This has the effect of allowing agents to make use of other agents' available knowledge and expertise for tasks that are outside the scope and disciplines of their represented groups.

Agents are computational entities that have the ability to acquire and manipulate (modify, derive), through reasoning, knowledge [20, 22, 27]. Each agent/participant in a dialogue has a certain well-defined role, determined by the type of dialogue, the goal of that type of dialogue, and the rules for making moves in it. Furthermore, we assume that agents are cooperative, abide by the rationality rules, such as rules of relevance [9], and they fulfill their commitments and obligations in a way that truthfully reflects their beliefs, intentions and/or desires.

We employ a partial information state-based framework for collaborative dialogue and argument between agents [11, 15]. The basic idea that underlies the use of the notion of Partial Information State (PIS) [15] is that it is useful to view dialogues in terms of the relevant information that the participants have at each stage in the dialogue. We employ, for representing and reasoning about PISs, a three-valued based nonmonotonic logic, NML3 [15] which is both sound and complete. NML3 formalizes some aspects of revisable reasoning [16].

Dialogue Games

We adopt the notion of a dialogue game in which two participants make moves to pass on relevant information with respect to their goals. Central to the model is that the agents PIS change as a result of the interpretation of the moves and that these changes trigger the production of a succeeding move. The interpretation involves some understanding (ability to make sense or use of) the presented information. It does involve an integration of the offered information with the PIS of the receiver. Context are represented as a consistent subset of an agent's PIS, namely those propositions which bear on the interpretation of the utterance on hand and on the propositions that are relevant to producing the goal(s). Interpretation relies on maintaining consistency in the context whilst adding the utterance's information. An agent can only interpret an utterance with respect to the knowledge it has available. Therefore, failure to complete the interpretation process/proof will point to those propositions which induce failure. Thus, part of a context is entirely local to an agent, and that agents may hold incompatible and inaccurate beliefs.

The idea is as follows: a move by an agent G is generated on the basis of some enabling conditions which G can infer from its information state and the need to satisfy some goal(s). The effect of this move after being interpreted by the other participant G1 is that G1's information state may/will undergo some change. This move may initiate the legality of other moves which G1 can employ as legal reply moves. It may also terminate the legality of some other moves and render them illegal reply moves. The initiation and termination of the legality of moves is a dynamic process. The legality of
moves could partly be determined by a reply structure, i.e., a protocol. Dialogue protocols provide a lower bound on the conditions needed for dialogue coherence.

In the next turn G1 may adopt the sender’s role and, subsequently, its changed information state may lead to the inference of the enabling conditions for the next move. Dialogue relevance of subsequent moves is established by the initial information states of the participants, the update rules associated with each of the primitive types of dialogue moves locations that change a particular PIS and the rules for cooperative behavior, by the participants. Dialogue coherence relations are mainly driven by dialogue history and the dynamics of the participants’ PIS with respect to the main goal of the dialogue. The coherence of a dialogue moves is tied to local interactions that are dependent on the agent’s particular situation reflected in the changes in its information states and intermediary goals judged by the agent to contribute towards the main goal. Thus, the reasoning abilities and specialized knowledge available to the agents do play an important role as they do capture the agent’s problem-solving and strategic reasoning ability that may affect the selection of the most appropriate legal move.

Within the framework of NML3, it should be possible to formalize dialogue moves and the rules of protocols of the required types of dialogue. The rules of a protocol are nonmonotonic in the sense that the set of propositions to which an agent is committed and the validity of moves vary from one move to another. The use of PIS should allow an agent to expand consistently its viewpoint with some of the propositions to which another agent involved in a dialogue is overtly committed.

Argumentation Framework
The use of arguments allows agents to justify their decisions and actions, and to engage in different dialogues, and situations, and provide support for what they infer or decide [3]. Arguments have an essential role to play in situations of conflict between communicating agents. They can be used by an agent to increase the degree of compatibility between its knowledge/beliefs and those of other agents; one agent can persuade another to adopt one or more propositions that it accepts by presenting proofs/support for those propositions. Arguments allow an agent to critically question the validity of information presented by another participant, explore multiple perspectives and/or get involved in belief revision processes.

An Argumentation Framework (AF) system should capture and represent the constituents of arguments (e.g., the propositions which are taken into consideration). These may include facts, definition, rules, regulations, theories, assumptions and defaults. They can be represented as (possibly ordered) sets of formulae. It should also capture the interactions and reactions between arguments and constituents of arguments such as undercutting. Furthermore, some notion of preference over arguments may be needed in order to decide between conflicting arguments.

5. KNOWLEDGE REPRESENTATION FOR KC

Knowledge and expertise are essential ingredients for experts and decision-makers in order to competently handle tasks, provide innovative approaches to solve problems and evaluate the consequences of decisions and actions. Hence, there is a need to investigate how knowledge can be acquired/generated and how it can be represented so that different applications can make optimal use of it according to what is needed. The knowledge should also be accessible, modifiable and understandable to different types of users who need knowledge to perform their tasks. The emphasis should be on a Knowledge Representation (KR) that is open to:

(C1) assessment to ensure that there is an adequate understanding of the knowledge in the application and for inspection/verification processes. Continuous monitoring and evaluation may help to decide whether there is a need for revision, update and learning new knowledge.

(C2) modification to allow an update of the knowledge as needed to meet the requirements of the applications and the needs of users.

It has been said in [19] that:

“We need additional research to expand the use of artificial intelligence and knowledge based systems in Knowledge Management (KM). We need to know what forms of knowledge representation appears to work best for particular types of knowledge”.

KC is only important if it enhances KW’s ability to perform each of the objectives mentioned above. However, this requires a broad view of the different roles that a KR could play, bearing in mind that its central role is capturing the complexity of the real world. We believe, following [8], that a KR can offer:

(KR1) A description, of the world, which enables a reasoner to determine the consequences by reasoning about it.

(KR2) A set of ontological commitments which could form a basis for defining the appropriate ontologies.

(KR3) A (possibly incomplete) theory of intelligent reasoning, expressed as:

(i) the representation of fundamental conception of intelligent reasoning.

(ii) the set of inferences the representation sanctions.

(iii) the set of inferences it recommends.

(KR4) A means of communication.


Furthermore, representation and reasoning are entangled. The recognition that a (particular) representation embeds a (possibly incomplete) theory of intelligent reasoning encourages diversity because what the reasoning theory,
embedded in one representation, may have ignored or overlooked, would be emphasized in the reasoning theory of another representation. Hence, diversity could be a step towards completeness if an integrative approach to KR is employed. By combining representations within a unified reasoning theory, good use of both the similarities and differences could be beneficially exploited.

We may distinguish, along another dimension, between a static (possibly timeless) representation of knowledge, which is particularly useful for knowledge re-use and a dynamic representation of knowledge needed for knowledge creation. The degree of adaptability of a KC system is dependent upon its capability of sensing complex patterns of change in the reasoning environment(s) and using that information for adapting the appropriate knowledge to guide decision-making processes and actions.

The dynamic view is based upon the ongoing re-interpretation of data, information and assumptions while pro-actively deciding how the decision-making process should be adjusted to deal with future possibilities. It also allows for diversity of interpretations of the same information across different contexts and at different times. Allowing for diversity in representing the same situation is one of the keys to success in properly managing and making an optimal use of the knowledge available. The diversity of representations allows for a deeper and a better understanding of the different patterns and characteristics of a situation, and naturally supports cooperative work.

Effective cooperation is essential in interdisciplinary problem solving which:

(1) assumes no omniscience (i.e., cooperation is a necessity).

(2) enables a group to accomplish a task that would be infeasible for any of them to achieve individually.

(3) combines different expertise.

(4) allows the application of multiple problem-solving strategies and heuristics to a given problem.

(5) facilitates the application of multiple perspectives on a given problem.

Cooperative work is distributed in time, space and logic (control). The pattern of interaction and cooperation changes dynamically with the requirements and constraints of the situation.

6. CONCLUDING REMARKS

To be effective, there is a need for a sound decision-making capability to efficiently resolve complex and uncertain conditions to which interdisciplinary work on dynamic complex systems are constantly exposed. The success is highly dependent upon the availability and accessibility of knowledge acquired and employed by KW. It is difficult, if not impossible, to make available a comprehensive interdisciplinary knowledge base about a complex dynamic system.

This paper has highlighted the importance of KC in interdisciplinary problem solving.

7. REFERENCES


