A Ubiquitous Enterprise Performance Management Model for Performance Centered Business Activity

Xiuzhen Feng
Economics & Management School, Beijing University of Technology
Beijing, China

Yang Peng
Department of Computing, The Hong Kong Polytechnic University
Hong Kong, China

Haoran Xie
Department of Computer Science, City University of Hong Kong
Hong Kong, China

and

Yibin Hou
School of Software Engineering, Beijing University of Technology
Beijing, China

ABSTRACT

Wireless technology has truly changed people's way of doing today's business, both for individuals and companies. Applying wireless technology to the core information system like ERP system can bring ubiquitous benefits to companies. Meanwhile, the significance of integrating ERP system with business intelligence (BI) has come to more and more people's realization because it can help companies shorten the life cycle of data-to-knowledge, which is essential to decision-making. In order to capture the benefits of "mobility" and improve the timeliness of decision-making support, it is necessary and important for companies to incorporate the wireless application and BI integration to an ERP system. In this paper, we focus on how to apply the wireless technology to the ERP system and address the problem of integrating the BI as well. Based on the current ERP system, we proposed a model of Ubiquitous Enterprise Performance Management (U-EPM) system, which is expected not only to streamline the process of mobile business performance management, but also help companies to achieve better effectiveness and efficiency in doing business activities.

Keywords: Ubiquity, Business Intelligence, Business Process Management, Enterprise Performance Management, Mobile Business Performance Management

1. INTRODUCTION

Nowadays, ERP system has been widely used in companies to manage their business processes. However, few of them can achieve the full benefits from ERP system. On the one hand, companies are not organized in such a way to benefit from the new information tools provided by, and the new disciplines required of, the enterprise systems [1], and on the other hand, the ERP system has its own deficiencies, such as lack of flexibility, limitations in accessibility, disorderliness of data delivery, etc. Meanwhile, there are many technique solutions could be applied to extending the current ERP system [2]. On the one hand, wireless applications provide new opportunities for companies to equip their ERP systems with "mobility" so that users can access and manage the ERP system ubiquitously, which can meet the customers' needs of ubiquity better as well as improve the efficiency of business management [3]. On the other hand, to maximize the utilization of data in the ERP databases, it is significant to integrate the ERP system with BI, which can process the "redundant" data in ERP system to knowledge for decision-making support [4]. By adding the "mobility" and "BI" to an ERP system, not only the accessing and operating of ERP system could be ubiquitous, but also the redundant data processing in ERP databases would be eliminated. Moreover, a real-time decision-making support provided by BI analysis could be achieved. Therefore, the efficiency and effectiveness of the whole enterprise performance management inside a company could be improved significantly. Thus we are trying to identify some distinct characteristics of such a system as below:

- Ubiquity: by application of the wireless technology, users can login the system in anywhere and anytime, which meets the demands of mobile business.
- Intensiveness: since the BI can process data from the ERP system to generate KPIs and metrics analysis that feed reports or dashboards for decision-making support, the ERP system could be intensified by the BI integration.
- Instantaneousness: for the time being, the business environment is changing faster than ever before. By shortening the life cycle of data-to-knowledge and instant delivering, the real-time decision-making support can be achieved, which can help companies to have the ability of quick even instant response to the changing market.

The contributions of our paper are outlined as follows:

- We propose the model of ubiquitous enterprise performance management (U-EPM) to capture the mobility and business intelligence for an ERP system.
- We illustrate the differentiated functions of U-EPM with specific scenarios analysis.
We propose an evaluate model, and apply it to compare U-EPM with the SAP mobile, BPM, and BPA system. Thus, a brief review of related works is given in section 2, and in section 3 we sketch a general model of U-EPM and illustrate the components. Some specific scenarios are given in section 4, and in section 5, we compared it with SAP Mobile, BPM and BPA. Finally, in section 6 we draw the conclusions and provide possible future directions.

2. RELATED WORK

With the notion of extending the current ERP system by the wireless technology and business intelligence, the related researches could be mainly divided into two areas, one is applying the wireless technology to the business management systems based on the ERP system, and the other is developing the BI system with the combination of ERP system to provide timely decision-making support.

A. Mobile Business Information System

With the rapid development of wireless technology, many ERP system researchers have focused on the possibility of applying wireless technology to the ERP system or the business management system based on the ERP system, with wireless applications. Dabkowski and Jankowska [3] have developed a multi-tier framework for mobilizing ERP system, which can realize the real-time data transmission between the ERP system and a variety of wireless devices. Alternatively, Massoth and Paulus [5] have proposed a real-time sales operation and inventory management system for ERP system on the platform of BlackBerry. A mobile E-business system is designed by Zheng et al. [6], which is based on open source software to deal with the end-to-end security problem.

Utilizing the mobilized business management system can bring the benefits of ubiquity to companies, which can meet the customers’ requirements of mobility better and improve the efficiency of management inside. A research by Willis and Brown [2] indicates that mobile ERP system can help solve the problem of data capture and improve the effectiveness of business activities. A further work is done by Rodina et al. [7], which indicates that real-time knowledge of the market, sales and customer specific information could help the company shorten sales cycle, reduce cost, improve customer satisfaction, increase competitive advantage and productivity, increase revenues, and improve personnel support.

B. BI system

Through recent years, many BI researchers have focused on the architectures of developing BI, e.g., Data Warehouse Bus Architecture [8], Corporate Information Factory [9], Data Warehouse 2.0 [10], etc. Besides, there are many tools to support these architectures, such as data warehouses [11], online analytical processing (OLAP) [12], data mining [13], etc. Beyond data warehouse, Golfarelli et al. [4] introduce business process management (BPM), which is a new approach that can quantify the enterprise strategy and targets, in order to decentralize decision making for BI. After the business process management system (BPSMS), a business process analytics (BPA) is proposed by Muehlen and Shapiro [14] in a recent research, which introduces the concept of BPA and discusses three kinds of processes (first historical analytics, then real-time analytics, and finally forward-looking analytics) in BPA.

3. MODEL DESIGN

A. Conceptual Model

The conceptual model of our proposed ubiquitous enterprise performance management (U-EPM) is presented as Fig. 1. The left part is the data-to-knowledge cycle inside a company, which acts as the data source for different U-EPM functions. The right part is the functional modules including UDA, UBAF, UBPM and UBM. The four functional modules and their relationship with data sources are illustrated as follows:

- Ubiquitous data accessing (UDA) – Data & Information: it is going to provide the function of accessing data via ubiquitous techniques so that the latest and timely information could be provided to users. The related sources are information and data of the organization to UDA.
- Ubiquitous business activity facilitation (UBAF) – Information & Process: it enables the business activities ubiquitously, thus the users’ work efficiency can be improved. The corresponding sources for UBAF are information and process.
- Ubiquitous business process management (UBPM) – Information & Knowledge: it is focused on conducting BPM in real-time in order to help decision-makers. UBPM cares on knowledge and information sources.
- Ubiquitous business monitoring (UBM) – Information & Knowledge: it is mainly responsible for monitoring key processes to manage risks and ensure coherence of the business. So the UBM is based on sources of information and knowledge as well.

B. System Model

By considering traditional ERP, BI systems and existing ubiquitous technologies, we propose a four-layer model of ubiquitous enterprise performance management (U-EPM) system and presented it as follows.

Data Management layer: data sources are consisted of data from the ERP system and other data, which are required by BI analysis. To manage them more efficiently, they are stored in a center database system. Data tools, including data extractor and processor are used for real-time data extraction and preprocess from the database.

Performance management layer: it aims to manage the performance more efficiently and it is consisted of three components, which are BI analytics platform, business monitoring center and business activity invoker (BAI).

- BI analytics platform: its main function is performing BI analysis for business process management (BPM) and it contains four tools, which are the Data warehouse, OLAP
analytic cubes, data mining engine, and rule engine. The Data warehouse is used for storing the processed data by some real-time data processing tool or directly extracted from the database, and providing the right data according to the requests of the BI analytics platform. The OLAP analytic cubes, which extend two dimensional data structure to a multidimensional data model, can support viewing and analyzing data from various perspectives. The data mining engine aims at performing data mining algorithms according to different requirements. The rule engine's role is further processing the timely results from data mining engine and delivering them to users.

- **Business monitoring center**: its functions are not only monitoring some sensitive business processes (e.g., inventory, cash flows, etc.) but also examining results from the BI analytics platform. The center divides potential dangerous warning into several levels. A warning message will be sent to corresponding users in low level of warning while some functional modules will be locked in high level warning are activated.

- **Business activity invoker**: it is mainly responsible for involving the business activity in functional modules of ERP system. That is, the BAII allows valid users to access to the ERP system and conduct corresponding business activities throughout a wireless terminal.

**Access control layer**: it contains two parts, one is the Authentication agent, which can be implemented by some existing security techniques (e.g., face recognition, fingerprint recognition, etc.) to authenticate valid users, the other is Access control server, which aims at authority management so that suitable authorization are providing based on different roles.

**Interface layer**: the interface can be compatible with various terminals such as PDA, Smartphone in order to support multi-channel access.

In this section, we conduct some scenarios analysis in order to demonstrate how the four modules of conceptual model of U-EPM to enhance and improve the performance management of the enterprise.

A. **Scenario 1 (UBAF)**

Enabling the business activities ubiquitously can improve the efficiency of users' workings as well as achieve better customer satisfaction. Suppose that a sales manager is having a negotiation with the customers, and they come to an agreement that if the customer makes orders at once, he would get a discount. However, the orders contained the discount information which related to the pricing or promotion programs in the company’s ERP system can not be operated flexibly because they are tied to the financial accounts. So these orders couldn’t be accepted immediately by ERP system, unless someone modifies the pricing or promotion program modules to meet the customers’ requirements. With the U-EPM system, however, the sales manager can login to the system via his 3Gs equipped PDA or Smartphone, and access to the related functional modules in ERP system by activating the business activity invoker, then he can make the orders contained pricing or promotion information for his customers directly.

B. **Scenario 2 (UDA)**

Providing the newest and timely information can support users’ business activities better. For instance, when a sales representative meets his customers outside the company and the customers want to know more information about the product and have the intention of ordering, then the sales representative is likely to have the needs of checking some information (e.g., inventory, price, etc.) of the products to make sure that whether it can meet the requirements or not. After login to U-EPM system with his 3Gs equipped PDA or Smartphone, he can just access to the newest information by one or two easy clicks.

C. **Scenario 3 (UBPM)**

Conducting BPM in real-time can help decision-makers save time in decision-making, which is very important to business as time is money. For example, a company's CEO maybe has the possibility to get a bad news that one of the key customers is going to cease the cooperation with the company because of a lower price offered by another competitor company in the market when he is on business travel, normally he'll stop the travel and go straight to the company, convene a management board meeting to work out a solution and negotiate with the customer to persuade him to continue the cooperation by offering a new price or other benefits to him. The processes above may take a couple of days and when the CEO calls the customer's number to negotiate with him at last, the best time might be missed. With U-EPM system, the company's CEO needn't go back to his company first. Instead, he can login to U-EPM system by his personal wireless devices (e.g., PDA, Smartphone, etc) as soon as he gets the news, and access to the data/information related to the customer's order, then he can use the BI analytic platform to generate a forecasting report about the impacts on the sales revenue if the company lost such a customer and calculate the marginal profit of the product with the purpose to identify the lowest price his company can offer. So the processes of working out the solution can be done just in
several minutes. Besides, he can check the related inventory information as well as perform the mock programs in some key business performance areas if the lowest price is accepted by the customer to observe the exact changes in the future business. After maybe 5 or 10 minutes, the company’s CEO can make a phone call to the customer to have the negotiation by the efficient working with U-EPM system.

D. Scenario 4 (UBM)

Problems arising in some key processes of business such as inventory and cash flow would cause significant damages to the whole business. So monitoring these key processes ubiquitously can reduce risks and guarantee the coherence of business. For example, when a sales representative is making full orders of product A for this customer and the system detect such an event could have potential risks to business because there are great demands of product A in the market at that time and the price of raw materials of product A is rising. Therefore, the U-EPM system would inform the sales representative by sending the warning message that the full demands of product A couldn’t be met right now and provide the available quantity of product A for ordering to the sales representative. Hence a risky activity is avoided by the UBM function in U-EPM system.

5. Evaluation Model and Comparison Result

In order to compare our U-EPM system model with existing ERP & BI systems, an evaluation model is proposed based on metrics derived from an internal research report [15] by an ERP provider company. Then, we demonstrate how this evaluation model is applied to make the comparison between U-EPM and representative baseline system models such as BPM, BPA and SAP mobile.

A. Data Source

![Figure 3. Functions Needed in 3G Application Rank](image)

The data source is obtained from an internal research report, which is a survey on the needs of 3G applications in current ERP system on 34 companies in China. As summarized in Figure 2, the top 20 functions of 3G applications cared most by the middle-management of these 34 companies are provided.

B. Evaluation Model

From the data source and existing systems such as SAP mobile, BPM and BPA, we observe that there are main four functional areas including ubiquitous accessibility, real-time decision-making support, process optimization and effective business monitoring to form our evaluation model as shown in Figure 3. This model can be divided into following major steps.

- **Weights Learning**: The weight values for four functional areas are learned from the internal research report since it is unsuitable to determine weight values arbitrarily. The functions rank in Figure 2 reflects degree of importance for each function and these functions are related to four functional areas, that is, we can learn weight values by mapping the rank of functions and functional areas.

- **Items Matching**: For a specific functional area, we further divide it into some evaluation items, as shown in Table I, which can directly compare with functions of a particular system model. Then the score will be given throughout how much functions the system model contains.

- **Grades Aggregation**: The final score is aggregated from the grades from each functional area by weighted sum. The final score reflects the degree of how much the functions of a system model are satisfying enterprise common requirements.

C. Baseline System Models

![Figure 5. SAP Netweaver and SAP Mobile system model](image)

We propose the following three baseline system models in our evaluation.

- **BPM**: Business Process Management, which quantifies the enterprise strategy and aims, is introduced in [4].

- **BPA**: Business Process Analytics (BPA), which supports real-time analytics, is proposed in [14].
SAP-M: SAP Mobile, which is a new product by SAP, and its features and model are described in [16]. The Figure 4 shows the genetic system model of SAP Mobile.

Note that we only consider the genetic model of SAP Mobile as shown in Figure 4 rather than the concrete product in our comparison since BPA, BPM and U-EPM are genetic system models.

D. Comparison & Results

<table>
<thead>
<tr>
<th>Functional Areas</th>
<th>Function Rankings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Ubiquitous accessibility</td>
<td>1, 8, 10, 11, 13, 14, 17</td>
</tr>
<tr>
<td>Real-time decision-making support</td>
<td>3, 5, 6, 9, 12, 18</td>
</tr>
<tr>
<td>Process optimization</td>
<td>3, 4, 5, 7, 15, 18, 19, 20</td>
</tr>
<tr>
<td>Effective business monitoring</td>
<td>2, 11, 13, 15, 16</td>
</tr>
</tbody>
</table>

To learn the weight value of four functional areas in the evaluation model as illustrated in Figure 4, we also did the mapping between these functional areas and the function rankings in Figure 2, and the mapping results are presented as Table I.

After doing mapping between functional areas and functional rankings, we calculate the sum of Reciprocal Rank (RR) score which is commonly used in information retrieval and then normalize it by the sum of all RR score from the four areas and the equation is shown in Equation (1) as follows.

$$W_j = \frac{\sum_{F_i \in A_j} \frac{1}{FRank_i}}{\sum_{j \forall \forall j} S(A_j)}$$  \hspace{1cm} \text{Eq. (1)}

where $FRank_i$ denotes the function $F_i$ rank in the Figure 2, $A_j$ denotes the area $j$, $S(A_j)$ is sum of RR score for each area $j$ without any normalization, and $W_j$ represents the sum of RR score after normalization.

After learning the weighted values for each functional area, we then match the functions of each system model to evaluation items in all areas. The result of item matching is shown in Table II. For a specific system model $S_a$, we can compute the grade $G_j$ for each area.

$$G_j(S_a) = \sum_{E_i \in A_j} M(E_i, S_a)$$  \hspace{1cm} \text{Eq. (2)}

where $S_a$ is a system model (e.g., ERP, BI), $E_i$ is an evaluation item in function area $A_j$, and $M(\cdot)$ is a matching score piecewise function in Equation (3).

$$M(E_i, S_a) = \begin{cases} 
1, & \text{if } S_a \text{ contains } E_i \\
0.5, & \text{if } S_a \text{ partially contains } E_i \\
0, & \text{if } S_a \text{ does not contain } E_i 
\end{cases}$$  \hspace{1cm} \text{Eq. (3)}

where 1, 0.5 and 0 denote score for three different cases: the system model $S_a$ contains, partially contains or does not contain the evaluation item $E_i$.

Finally, we calculate the $FScore$ for each system model, and the equation for calculate it is shown in Equation (4) as follows.

$$FScore(S_a) = \sum_{i \forall j} W_j \times G_j(S_a)$$  \hspace{1cm} \text{Eq. (4)}

where $W_j$ from Equation (1) and $G_j(S_a)$ from Equation (2). It can be represented as the following piecewise function. Note that $FScore$ scale is ranged from 0 to 1, and higher the value is, the better performance of system’s function is.

![Figure 6. Scores for four different functional areas](image)

![Figure 7. FScore for U-EPM, SAP M., BPA and BPM System Models](image)
6. CONCLUSION

In this paper, we have proposed a four-layer model of U-EPM system, which comprises the ERP system, the data warehousing, the BI analytics platform, the access control and the 3G network applications. As the current ERP system is restricted by its own shortcomings, it offers an innovative way of extending the current ERP system with both "mobility" and "business intelligence" that can improve the efficiency and effectiveness of enterprise performance management for companies. More importantly, the U-EPM system has distinct advantages in doing performance centered business activities compared to traditional ERP system, and some specific scenarios are given by us.

Through proposed evaluation model, we compared the U-EPM with the SAP mobile, BPM and BPA system, and it performs the best in our evaluation. For future works, a possible direction is identifying the suitable business metrics for companies in different industries to increase the personalization of the system.

ACKNOWLEDGMENT

We would like to thank Prof. Paul Grefen (Eindhoven University of Technology), Dr. Michel Ehrenhard (University of Twente) and Dr. Lai Xu (Bournemouth University) for their valuable review comments on this article.

REFERENCES