A Practical Framework for Business Process Management Suites Selection Using Fuzzy TOPSIS Approach

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Abstract: Nowadays, there is a growing interest in Business Process Management Suites (BPMSs) implementation in organizations. In order to implement a BPMS in an organization successfully, it is essential to select a suitable BPMS. Evaluation and selection of the BPMS packages is complicated and time consuming decision making process. This paper presents an approach for dealing with such a problem. This approach introduces functional, non-functional and fuzzy evaluation method for BPMS selection. The presented BPM lifecycle based approach breaks down BPMS selection criteria into two broad categories namely functional (process strategy development, process discovery, process modeling, process design, process deployment, process operation and analysis) and non-functional requirements (quality, technical, vendor, implementation) including totally 48 selection criteria. A facile Fuzzy Technique for Order Preference by Similarity to Ideal Solution (FTOPSIS) is customized for BPMS selection based on identified criteria. The proposed approach is applied to a local Iranian company in oil industry in order to select and acquire a BPMS and the provided numerical example illustrates the applicability of the approach for BPMS selection. The approach can help practitioners assess BPMSs more properly and have a better software acquisition decision.

1 INTRODUCTION

Many surveys implied that the gap between Information Technology (IT) and business is growing and there are also increasing reports that IT not meeting business needs (Cho and Lee, 2011). Therefore, there is a need for better communication and understanding between IT and Business needs. To overcome this gap, many companies emphasis on the importance of business processes and the role of IT. Business Process Management (BPM) has been emerged as a new breed of process-centric approaches for companies that consider processes to be fundamental business assets (Davenport, 1993). Elzinga, et al., (1995) defined BPM as systematic, structured approach to analyze, improve, control, and manage processes with the aim of improving the quality of products and services. Also, Business Process Management Suites (BPMSs) are an enabler of business innovation because of the dramatic potential for improving the performance and agility of companies (Cho and Lee, 2011). These systems simplify the development of process models and automate the process flow during process execution (Van Der Aalst and Van Hee, 2004). This approach can improve the ability of enterprises to cope with challenges like shorter product lifecycles, rising customer expectations, globalization, increasing cost pressure, and advancements in IT (Weske, 2007). The major drivers for BPM software adoption can be expressed as optimization of processes, increased productivity for process workers, the ability to model business processes, support for compliance efforts, standardize processes across divisions and regions, the ability to provide real-time visibility into key, processes, and the ability to change processes quickly and easily (Richardson, 2010).

Despite considerable investment in the area of BPMSs, most reviews report as many as 60–80% of BPM initiatives having been unsuccessful

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(Abdolvand, Albadvi, and Ferdowsi, 2008; Karim, Somers and Bhattacherjee, 2007). It is therefore not surprising that some businesses are not convinced that the BPM approach could bring significant tangible and measurable benefits (Vergidis, Tiwari and Majeed, 2008) and that the risky nature of BPM has motivated investigation of its critical success and failure factors (Al-Mudimigh, 2007; Trkman, 2010). Top management commitment, careful software selection that fits business processes, process management and improvement, change management, people management and development are among the most important BPM critical success factors (Al-Mudimigh, 2007; Trkman, 2010). Careful BPMS selection is an important factor to an extent which would be unlikely to achieve expected benefits without using a proper BPMS. The timing and selection of the BPMS, just like traditional information systems, can be problematic and even improper solutions have the potential to inhibit implementation of new processes in an organization.

The BPMS industry is one of the fastest growing sectors in the computer software industry which now includes hundreds of BPMS solutions in the market. BPM markets at $ 2.3 billion in 2010 are anticipated to reach $ 5.5 billion by 2017 (Curtiss and Eustis, 2011). The number of BPMS vendors and the range of their systems' functionality have further expanded in recent years (Hill, Cantara, Kerremans and Plummer, 2009). Hence, due to limitations in available resources, the range of functionality in BPMS, and the diversity of alternatives, selecting a BPMS that meets closely the specific needs of an organization is a time-consuming and complex task. This is a challenge especially for small and medium-sized businesses with limited know-how about such systems (Eikebrokk, Iden, Olsen, and Opdahl, 2010) which calls for some methods or models for enhancing the selection process.

The dominating school of thought assumes that IT tools are operational business resources and therefore should be chosen according to the specific characteristics, contents, and requirements of the business processes to support. However, having a review on BPMS literature, authors have found no related widely used framework for evaluating and selecting BPMS packages. Till now, practitioners selected needed BPMSs, based on some important factors, while overlooking other aspects of system or vendor. Previous experience suggests that businesses tend to focus on well-known software vendors and already used IT solutions or adhere strictly to industry best practices, which do not sufficiently match to the individual requirements of each process (Sadiq, Indulska, Bandara and Chong, 2007; Trkman, 2010). Neglecting system features in system selection phase, can lead to future problems in customization efforts which can extend project total time and cost.

To sum up, following a holistic framework for assessing BPMS can help IT managers to deal with this problem and diminish the need for future customizations. It is noticeable that each software selection framework needs its own criteria and its computation procedures. BPMS is a state of the art issue and there is no specific and certificate based framework for BPMS selection. What is therefore needed is a holistic framework for assessing BPMSs from a variety of functional and non- functional perspectives. This paper, as a potential contribution to BPMS literature, is intended to provide such a framework and hence our goal is to develop a practical and holistic evaluation framework that is applicable to BPMS selection efforts. In practice, the results of this paper would enable IT managers to achieve a comprehensive understanding of BPMS selection criteria and help them to make a better system acquisition decision.

2 LITERATURE REVIEW

This section includes a review of software selection methods and factors, and then BPMS selection criteria are provided with regard to the nearest relevant literatures.

2.1 Related Works

Software selection problem is a particularly difficult software acquisition process and many contradictory criteria must be considered to reach a decision. In this era, the literature lacks studies that consider the evaluation of both the functional and non-functional suitability of the alternative BPMSs using various criteria. Therefore to study the generic requirements and methods, the literature of selection of enterprise software and systems is reviewed in this section. Recently, Jadhav and Sonar (2009, 2011) reviewed several criteria, techniques, tools and methods for evaluating and selecting software and systems. Their research covers many findings from past research and outlines efforts that have been made in the field of software selection. Enterprise software packages are pre-written by a vendor to provide a set of standard functions usable by a wide variety of companies, regardless of size or industry. Commercial off-the- shelf (COTS) is the other term that refers to enterprise software, such as accounting, e-commerce, human resources (HR), customer relationship management (CRM), supply chain management (SCM), and enterprise resource planning (ERP) systems.

In the literature, the primary selection process for enterprise software uses the method of eliminating potential solutions and Multi Criteria Decision Making (MCDM) techniques in the selection process of enterprise software. Software evaluation is a multi-criteria decision-making problem that refers to making preferred decisions from the available alternatives, and this problem has usually been solved by Analytical Hierarchy Process (AHP) (Colombo and Francalanci, 2004; Wei, Chien and Wang, 2005). Another approach to the evaluation and selection of software and systems is a weighted scoring method that was applied by Perez and Rojas (2000) and Le Blanc and Louis (Le Blanc and Louis, 1989). To deal with the linguistic and verbal evaluation of human decision makers in the selection of software and enterprise systems, fuzzy multiple criteria decision making (FMCDM) has been used in various studies for evaluating software (Cochran and Chen, 2005; Lee, Shen and Chih, 2004). The reasons of FMCDM popularity in software selection are at first: the tendency of selection stockholders in general expression, second: the different software approaches would be explicable with same verbal evaluation and third: the FMCDM can conduct group decision making which happen is software selection.

Beside the software selection studies as a total problem, some researchers have focused on requirement selection and prioritization as a beginning of software engineering. In recent years, it is proved that an automated measurement, evaluation and selection framework is necessary and feasible to ensure trusted and repeatable decisions for the general problem of software component and package evaluation and selection (Becker and Rauber, 2010). Another observation based on the review of the literature (Jadhav and Sonar, 2009) is that although the functional criteria for software selection are altered for different software packages, other criteria related to the quality, cost and benefits, vendor, hardware and software requirements, the opinions of different stakeholders about the software package, and the output characteristics of the software package are universal and can be used for evaluation of any software package. Furthermore, many of these methods consider only the traditional non-functional criteria, but do not offer a process that includes functional and non-functional requirements and a customized approach for BPMSs selection, especially.

2.2 BPMS Selection Criteria

BPMS is the leading integrated composition environment (ICE) to support BPM and enable continuous improvement. BPMS as an ICE usually has integrated management and administration consoles, a common security model, a common meta-model, integrated installation procedures and documentation, shared technical support, and a consistent look and feel in the UIs (Gartner, 2010). In addition, functionality within a BPMS is not duplicative. Although there may be multiple engines and servers within the suite, they address distinct needs and interoperate. A well-integrated suite "feels" like a single product to the individual using it, regardless of his or her role, because of its architectural and meta-model cohesion. Finally, BPMS artifacts move fluidly across the phases of BPM life cycle.

According to Abecker, et al., (2002), there are four major classes of BPM supporting software systems. Visualization tools are a simplified variant of tools for creating graphical process models. Modeling tools extend the capabilities of visualization tools by emphasizing formal correctness and supporting the analysis of process models. Therefore, these tools assist in managing the relationship between activities, data, and resources of a company. Simulation tools assist in predicting performance indicators like required time and costs. Thereby, these tools provide a foundation of further optimization. Workflow management systems assist during modeling, execution, and monitoring of automatable business processes (Carstensen and Schmidt, 2003).

2.2.1 BPMS Functional Criteria

In order of determining BPMS selection criteria, in this research, BPM life cycle (Koster, 2009) has been considered as the base of functional requirements category. Hence, the BPM life cycle has seven phases, therefore the functional criteria for BPMS is decomposed into seven areas based on this cycle as process strategy development, process discovery, process modeling, process design, process deployment, process operation and analysis (see Table 1). To verify the proposed functionalities in each category, they have been checked and approved by five experts in BPM filed. These experts were BPM project managers with more than

5 years experiences on BPM related implementation projects in global/ local organizations. The major issue in proving the necessity and sufficiency of these criteria is the conformance of them with the ISO 10244: 2010 qualifications as goal of BPMS implementation.

Table 1: Functional criteria for BPMS according to BPM lifecycle.

Functionality (Supporting)
Process strategy development
Value chain overview
Link the organization's objectives with the high-level business processes
Process discovery
High level process mapping
Process mining tools and recommendations
Process modeling
Different business process modeling languages
Interoperability between different modeling languages
Capability of defining Performance Indicators for process
Process design
Creating executable business process models
Programming languages for implementing services
Designing user interfaces
User management
Process deployment
Workflow resource patterns
Distributed business process execution engines
Process operation
Optimized execution according to some measurable criteria
Exception handling
Technical monitoring and control
Active and passive business monitoring
Business balance control
Analysis
Modeling time testing
Log data analysis
Visual data representation tools
Activity-based costing
Defining processes in taxonomies
Suggestions on improvement

2.2.2 BPMS Non-functional Criteria

The non-functional requirements are features of the BPMS that are not covered by its functional description, but are related to the capability and resiliency of the software or solution. Some researchers and practitioners have developed categories for the non-functional requirements, from different viewpoints. Jadhav and Sonar (2011) classified these criteria as quality, technical, vendor, output and opinion categories, based on ISO/IEC9126. Similarly, Sen, et al., (2009) divided these requirements into quality characteristics, technical factors and socio-economic factors (business and vendor). The current research concentrates on more recent researches of Jadhav and Sonar (2011) and Sen et, al., (2009) and then based on them, non- functional criteria for BPMSs are proposed as Table 2.

Table 2: Non-functional criteria for BPMS.

Category	Criteria
Quality requirements	Reliability Usability Maintainability Efficiency Personalizability Portability
Technical requirements	Communication protocol Platforms Database management system Programming language Documentations Standard configurations Security
Vendor factors	Vendor reputation Training and support Length of experience Consulting service
Implementation factors	License price* Implementation cost * Implementation time * Training cost*

*Cost criteria (Negative criteria)

3 THE FUZZY TOPSIS METHOD

Current research uses triangular fuzzy numbers (TFNs) for fuzzy TOPSIS because of the ease of use for decision-makers in doing calculations. Furthermore, it has been demonstrated that modeling with triangular fuzzy numbers is an effective way to formulate decision problems when the available information is subjective and inaccurate (Moalagh and Zare Ravasan, 2012). The steps of the fuzzy TOPSIS method, which were introduced by Onüt and Soner (2008), and are applied in this paper, can be summarized as follows:

Step 1: Choose the linguistic values ($x_{ij},\ i=1,2,...,n,\ j=1,2,...,m$) for alternatives concerning the criteria. The fuzzy linguistic rating (x_{ij}) keeps the ranges of normalized triangular fuzzy numbers that belong to [0, 1]; hence, there is no need for normalization.

Step 2: Compute the weighted, normalized, fuzzy-decision matrix by Equation (1)

Step 3: Determine positive-ideal (FPIS, A^*) and negative-ideal (FNIS, A^-) solutions from the equations below:

$$A^* = \{v_1^*, ..., v_i^*\} = \{(\max_j v_{ij} \mid i \in \Omega_b), (\min_j v_{ij} \mid i \in \Omega_c)\} \quad (1)$$

$$A^- = \{v_1^-, ..., v_i^-\} = \{(\min_j v_{ij} \mid i \in \Omega_b), (\max_j v_{ij} \mid i \in \Omega_c)\} \quad (2)$$

Ω_b are the sets of benefit criteria and Ω_c are the sets of cost criteria

Step 4: Calculate the distance of each alternative from A^* and A^- by the following equations:

$$D_i^* = \sum_{j=1}^{m} d(\widetilde{V}_{ij}, V_i^*) \qquad i = 1,2,...,n \quad (3)$$

$$D_i^- = \sum_{j=1}^{m} d(\widetilde{V}_{ij}, V_i^-) \qquad i = 1,2,...,n \quad (4)$$

Step 5: Compute similarities to the ideal solution:

$$FC_i = \frac{D_i^-}{D_i^- + D_i^*} \quad (5)$$

4 PROPOSED APPROACH

For many companies, the process of selecting BPMS is a main cause of stress and the final decision often comes after months of deliberation. Usually, this is due to the wide variations in available features across products and the lack of a clear understanding of which features will best suit the company's needs. However, this process can be made easier by utilizing proposed approach. In this research, fuzzy TOPSIS has been used to evaluate and select BPMS with respect to the criteria presented in Table 1 and 2. There are three stages in the evaluation and selection of the BPMS, based on evaluation criteria: 1) determining BPMSs to be evaluated as alternatives, and recognizing the criteria to be used in the assessment process; 2) structuring the fuzzy decision-matrix and assigning criteria weights; 3) computing the scores of alternatives with fuzzy TOPSIS and finally, ranking the evaluation report. In following sections, this approach is applied to solve a numerical example.

5 NUMERICAL EXAMPLE

This new approach to the evaluation and selection of BPMSs is applied to the Iranian Offshore Engineering and Construction Company (IOEC) in Iran`s oil industry to demonstrate its applicability and validity in an actual environment. IOEC is the first Iranian offshore general contractor to fabricate and install offshore facilities for the Iranian oil and gas industry. Today, IOEC is developed into an Engineering, Procurement, Construction and Installation (EPCI) contractor at international level, and is capable of providing offshore and onshore services for the industry. Due to recent achievements, the company is in the process of looking into the possibility of establishing itself as a holding company. The IOEC management, in consultation with information systems experts, decided to adopt a BPMS with the aim of optimization of processes, gaining ability to standardize and model business processes, and achieving the ability to change processes quickly and easily. According to the research steps described above, the proposed fuzzy TOPSIS approach was explained along with applications and BPMS for the company was selected using the approach.

5.1 Forming Decision-making Team

Expert teams should be formed to evaluate the functional and non-functional aspects for BPMS alternatives. The teams consisted of BPM experts in the company (five people) and one team included technical managers of company (three people) have responsibility for evaluation of non-functional criteria. Concurrently, external consultants of the company (two people) with BPM and IT technical skills, helped to evaluate the functional and non-functional requirements for considered BPMSs. The Fuzzy TOPSIS technique was introduced to them (ten people) and they were trained for filling the spreadsheets of evaluation by verbal and simple propositions.

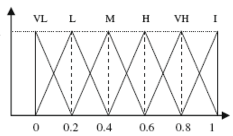
5.2 Identification of Alternatives and Criteria

If there are more BPMS alternatives in the list than expected, a pre-selection process should be used to reduce the number of alternatives to an acceptable level (five or four), so that the selection process will not be too lengthy. Therefore, sequential elimination methods are only used to separate the strong candidates among others. As a result, five BPMSs were considered for evaluation identified in the paper as BPMS I, BPMS II, BPMS III, BPMS IV and BPMS V. All of the 48 identified criteria as shown in Table 1 and 2 were used for the BPMSs assessment. These criteria were named C1, C2 … C48.

5.3 Structuring the Fuzzy Decision-matrix

Linguistic values were used for the evaluation of the alternatives and weights of the criteria. The membership functions of these linguistic values and the triangular fuzzy numbers related to these variables are shown in Table 3. In applications, it is often convenient to work with Triangular fuzzy numbers (TFNs) because of their simplicity and they are useful in promoting representation and information processing in a fuzzy environment, Therefore in the current research TFN is chosen.

Table 3: Linguistic values and fuzzy numbers.

Linguistic variables	Fuzzy numbers	Membership Functions
Very low (VL)	(0.0,0.0,0.2)	
Low (L)	(0.0,0.2,0.4)	
Medium (M)	(0.2,0.4,0.6)	
High (H)	(0.4,0.6,0.8)	
Very high (VH)	(0.6,0.8,1.0)	
Excellent (E)	(0.8,1.0,1.0)	

Based on the linguistic variables (Table 3), alternatives and the criteria were assessed by the decision-making team, which also assigned appropriate weights to each criterion by asking experts in the field of BPMSs. A fuzzy decision-averages matrix for BPMSs was created, based on the judgment of experts

5.4 Evaluating BPMS Alternatives

After the fuzzy decision-matrix has been established, the next step is to compute the fuzzy, weighted decision-matrix. This matrix is calculated with Equation (1). Equations (2) and (3) are then applied to define the fuzzy positive-ideal solution (FPIS, A^*) and negative-ideal solution (FNIS, A^-). Then, the Euclidean distance of each alternative from A^* and A^- is computed using Equations. (4) and (5). Subsequently, the similarities to an ideal solution are solved by Equation (6). Finally, the values of each alternative (BPMS) for the final ranking are illustrated in Table 4. A comparison of $D_1^*, D_2^*, ..., D_5^*$ and $D_1^-, D_2^-, ..., D_5^-$ that reflects the capabilities of BPMSs, its strengths and weaknesses, can be seen, here. For example, it can be seen that BPMS IV has a large D_i^- , which shows a large distance from the negative ideal. It also shows that this BPMS has appropriate functional and non-functional capabilities, which enhances the BPM implementation in the organization.

Table 4: Final computation results.

BPMSs	D_i^*	D_i^-	FC_i
BPMS I	7.42	5.21	0.412311
BPMS II	7.93	4.78	0.376101
BPMS III	6.89	6.10	0.469795
BPMS IV	5.24	7.28	0.581343
BPMS V	7.10	6.11	0.462272

Based on the values of FC_i the BPMS IV was selected to be implemented in the studied case company. The proposed approach guarantees the maximum coverage of functional and non-functional requirements with respect to selection criteria.

6 CONCLUSIONS

First, in this paper, an attempt was done to elaborate on the importance of BPMS selection in successful BPM implementation efforts. It was shown that selecting the proper BPMS in adopting organizations is a difficult task with parameters that can be expressed in linguistic values. Such values are somewhat vague in essence and are subject to expert judgments which involve uncertainties. Therefore, the fuzzy TOPSIS technique was employed to deal with this problem appropriately. The fuzzy approach is an applicable technique in providing decision makers with estimated values under uncertainty in the preference judgments. So, the fuzzy TOPSIS technique has been applied in proposed BPMS selection approach. Using this approach, the different BPMSs can be evaluated and the best solution be selected for any organization plans to acquire a BPMS. The proposed framework breaks down BPMS selection criteria into two broad categories namely functional (process strategy development, process discovery, process modeling, process design, process deployment, process operation, and analysis) and non-functional requirements (quality, technical, vendor, implementation) including totally 48 selection criteria.

The proposed approach was then applied to a local Iranian company in the field of oil industry. Five BPMSs were considered for evaluation using the approach and the most merit one is proposed for the company. The main novel points and merits of the paper are as follows. First, this paper, as a first attempt in BPM literature, demonstrated the significance of BPMS selection in successful BPM implementation projects. Second, a BPMS selection approach has been proposed using both functional and non-functional criteria. Third, fuzzy TOPSIS based approach for software selection has been proposed to contribute to the current literature in the BPMS field. This approach can handle the inherent uncertainty and imprecision of human decision-making. Fourth, this paper presents an application of the proposed approach to a real selection case. The authors suggest that the proposed approach and results of the paper can help practitioners assess BPMSs more properly and have a better software acquisition decisions.

The proposed approach is a practical and usable solution for real case problems. But, it suffers from some limitations. The main limitation of the approach is that the usability of the model and the validity of the achieved results were heavily dependent on experts' competence and proficiency in the both BPMS field and IT technical issues. Another limitation of the study is that the approach presented here does not consider all the possible factors and criteria might be associated with BPMS selection.

Although the provided numerical example helps to understand the applicability of the approach for BPMS selection, we believe that room still remains for future validation and improvement. So, further research is necessary to fine tune the proposed approach and assess its validity in others cases. Applying other MCDM methods in a fuzzy environment to BPMS selection and comparing the results of these methods is also recommended for future research. Also, mathematical models or meta-heuristics can be combined with the existing method. Furthermore, since the proposed method involves a large amount of numerical computations, a user-friendly intelligent decision support system (DSS) or an expert system (ES) have to be developed to save time and efforts in both doing calculations and interpreting the results of the fuzzy TOPSIS. Besides, developing a group decision-making system proves useful, so, the different opinions of different authorities can be taken into account. As the proposed approach draws upon the BPM lifecycle, future works may extend the main categories of this approach by adding new sorts of factors especially in functional category based on organizational survey and customization of unique internal and executive functional requirements.

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