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A CONCEPTUAL FRAMEWORK FOR SELECTING ENTERPRISE SOFTWARE WITH MULTIPLE OBJECTIVES AND BOTH QUALITATIVE AND QUANTITATIVE CRITERIA

Ceyda Güngör Şen
Hayri Baraçlı
Yildiz Technical University, Faculty of Mechanical Engineering, Dept. of Industrial Engineering, Besiktas, Istanbul, Turkey

Arzum Eser
KocSistem A.Ş., Finance Dept., Camlıca, Istanbul, Turkey

ABSTRACT
The aim of this paper is to present a conceptual framework by using two dimensional analyses for selecting most suitable enterprise software. The first dimension, called "subjective suitability analysis" involves qualitative evaluation that is performed to obtain functional and non-functional suitability for software alternatives on the basis of system requirements and non-functional criteria through assigning subjective ratings. The second dimension is called "objective suitability analysis", includes quantitative evaluation of project factors, cost and implementation time. The proposed framework allows combining these subjective and objective evaluations, aggregating the decision-making assessments to obtain the final enterprise software suitability and selecting the enterprise software with the maximum total value.
Keywords: Enterprise software selection, qualitative and quantitative evaluation, decision making.

1. INTRODUCTION
Severe market competition has dramatically transformed the business environment with the result that companies need to reduce total costs, maximize return on investment, shorten lead times, and be more responsive to customer demands. Highly dynamic markets call for effective enterprise software systems to enhance competitive advantage [1]. Organizations have several options for acquiring business software applications. Acquisition through development includes development by an internal IT group or custom development by third parties. Alternatively, organizations may acquire software through the purchase of pre-developed configurable systems from software vendors. Over time this approach has become the dominant means of software acquisition, accounting for approximately 70 percent of corporate business software expenditures [2]. Due to the growth in specialized software companies, coupled with diverse skill requirements, and rapidly changing technology, organizations are increasingly purchasing enterprise software packages instead of custom developing their own software applications [3]. 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 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.
Purchasing appropriate enterprise software requires a comprehensive selection process from a finite number of alternatives that contains multiple objectives with conflicts, and involves usage of data that can be quantitative like cost and qualitative like linguistic variables. The majority of techniques for selecting Commercial Off-the-Shelf (COTS) software aim to reduce the potentially large number of comparisons needed to evaluate many applications against many requirements, either through some

process of eliminating potential solutions [4,5,6] or by letting available functionality shape requirements [7]. Other perspectives on software selection focus on the criteria that organizations consider in selecting commercial software [1], the various decision-making techniques [1,4,8], and managing the risks inherent in the selection process [3]. The common themes that emerge from these different points of view are: (i) software selection is a difficult, time consuming, and expensive activity with important consequences for the selecting firm, (ii) most of the risk associated with this process derives from the imprecision of the available information and the uncertainty of the judgment expressed, and (iii) a systematic selection framework is extremely critical in assisting executives to evaluate from the perspective of company strategies [9].
This study proposes a comprehensive enterprise software selection (ESS) framework in which the objective hierarchy is constructed and the related criteria are specified to provide detailed guidance for enterprise software evaluation. The proposed framework allows decision makers to combine their both subjective and objective evaluations, to aggregate the decision-making assessments by using "final enterprise software suitability index", and to select the enterprise software with the maximum total value.

2. CONCEPTUAL FRAMEWORK for SELECTING ENTERPRISE SOFTWARE

Our proposed conceptual framework comprises two dimensional analyses for selecting most suitable enterprise software. The first dimension, called "subjective suitability analysis" involves qualitative evaluation that is performed to obtain functional and non-functional suitability for software alternatives on the basis of system requirements and non-functional criteria through assigning subjective ratings. The second dimension is called "objective suitability analysis" and includes quantitative evaluation that aims to minimize total cost of ownership and implementation time. Figure 1 represents the dimensions of the framework, the objective hierarchy and the criteria used for the evaluation process. To clearly present the proposed ESS framework, a stepwise procedure is described. Figure 2 shows a flowchart for the ESS process. The details of each step are presented below.

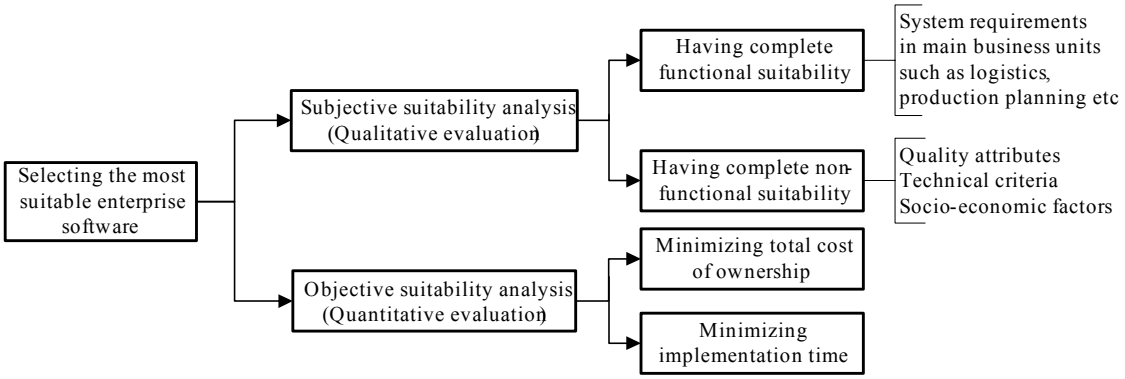

Figure 1. Dimensions of the proposed ESS framework

2.1. Form a project team and conduct business process reengineering

The first step is to form a project team that consists of decision-makers, functional experts and senior representatives of user departments. An enterprise software project is not only installing a new information technology system but also reshaping the business processes to overcome the challenges of dynamic market. Business process reengineering (BPR) is necessary to undertaken to rationalize and standardize the workflows of all business processes in advance. The project team can develop the functional characteristics of enterprise software during the BPR and then incorporate these characteristics appropriately into the decision model.

2.2. Collect information concerning software vendors and systems

A wide range of information concerning enterprise software vendors and systems should be obtained from professional magazines, exhibitions, yearbooks, the Internet, and other sources to ensure that feasible alternatives are not overlooked. The project team can eliminate the clearly unqualified vendors and thereby reduce the number of alternatives.

2.3. Identify the system requirements and non-functional criteria

In this step, project team decomposes the both functional and non-functional requirements into a hierarchical criteria set. The team members identify what they expect from enterprise software to enable as the system requirements in a list of process and business related functions. Non-functional criteria, which can be divided into quality, technical and socio-economic characteristics, express how the system behaves with respect to some observable attributes like performance. Even though, a vaster literature describes different sets of non-functional criteria, these criteria should be reviewed and selected according to system requirements and priorities by the team members [10].

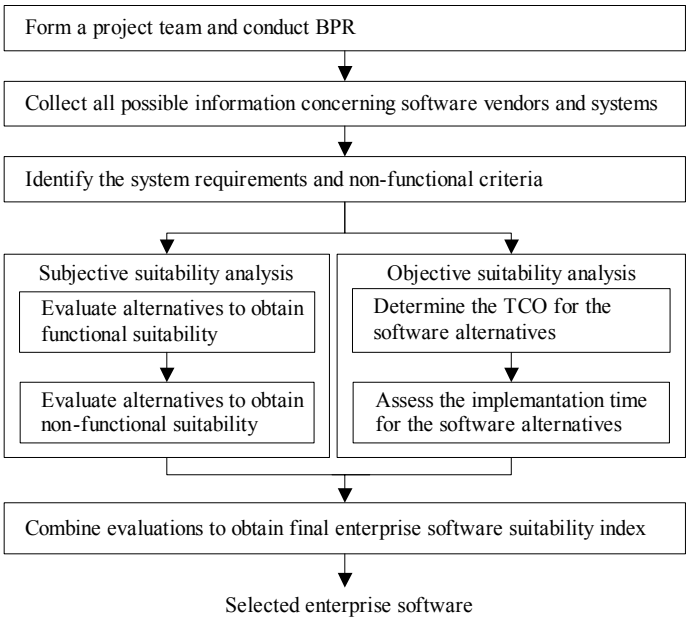

Figure 2. The proposed ESS framework

2.4. Subjective and objective suitability analyses

The aim of subjective suitability analysis is to evaluate the software alternatives by system requirements and non-functional criteria to obtain functional and non-functional suitability. This evaluation is a qualitative process that produces data on how well each alternative meets the criteria identified in the previous step. Some of the measures, for example, the risk of the project, the functional fitness, and the ability of a vendor may not be precisely defined. The weights of these criteria and evaluation ratings under these criteria are frequently assessed in linguistic terms like "high", "poor", among others. A multiple-criteria decision-making (MCDM) method like weighted sum method (WSM), analytic hierarchy process (AHP) is very useful in integrating various linguistic assessments and weights to evaluate enterprise software alternatives. In our proposed framework, functional suitability (F_i) and non-functional suitability (NF_i) for *i.* software alternative (i=1,2,…,m) are obtained by using a MCDM method on the basis of system requirements and non-functional criteria through assigning subjective ratings. Then, the functional and non-functional evaluations are combined to obtain the subjective suitability, S_i, of *i.* software alternative by equation 1. The value α is the relative importance degree of the functional suitability.

$$S_i = \alpha F_i + (1-\alpha) NF_i \quad 0 \le \alpha \le 1, \quad i = 1,2,...,m \tag{1}$$

Regarding objective suitability analysis, total cost of ownership (C_i) and implementation time (T_i) for *i.* software alternative are numerically measured by team members. The values of these quantitative attributes are collected from the data by the enterprise software vendor provided or the data, which negotiated with the vendor. These crisp values must be converted into dimensionless values to ensure that these values are compatible with the linguistic ratings of the qualitative attributes. TCO_i and IT_i values are computed using the converting equations 2 and 3.

$$TCO_i = C_i^{-1} \Big/ \sum_{i=1}^{m} C_i^{-1} \quad i = 1,2,...,m \qquad (2) \qquad\qquad IT_i = T_i^{-1} \Big/ \sum_{i=1}^{m} T_i^{-1} \quad i = 1,2,...,m \qquad (3)$$

Thereafter, these measures are integrated to obtain the objective suitability, O_i, of *i.* software alternative by equation 4. The value β is the relative importance degree of total cost of ownership according to team members.

$$O_i = \beta\, TCO_i + (1-\beta) IT_i \qquad 0 \le \beta \le 1, \quad i = 1,2,...,m \qquad (4)$$

2.5. Combine subjective and objective suitabilities

In this step, preferences (subjective assessment) and measures (objective assessment) collected on several qualitative and quantitative attributes are combined to obtain final enterprise software suitability, ESS_i, of *i.* software alternative by equation 5. The value λ can be manipulated to reflect the decision makers' attitude concerning the relative importance of both data sources. Consequently, the project team can rank the software alternatives by their *ESS* values and select the alternative that has the maximum final enterprise software suitability.

$$ESS_i = \lambda S_i + (1-\lambda) O_i \qquad 0 \le \lambda \le 1, \qquad i = 1,2,...,m \qquad (5)$$

3. CONCLUSION

This study presents a conceptual framework for selecting the most suitable enterprise software. Our extension to the literature is to incorporate the characteristics of ESS considered in prior studies into a formal framework. The proposed framework considers not only quantitative data but also linguistic data. It provides a simple and intuitive procedure for integrating the subjective and objective evaluations of decision makers, thereby avoiding the use of a complex mathematical model. In addition, the values of α, β and λ can be changed to determine related changes in the prioritization of alternatives, with regard to the current business situation, to solidify the final decision.

4. REFERENCES

[1] Wei C.C., Chien C., Wang M.J.: An AHP-based approach to ERP system selection, International Journal of Production Economics 96, 2005.,

[2] Holland C., Light B.: A Critical Success Factors Model for ERP Implementation, IEEE Software 16(3), 1999.,

[3] Sherer S.A.: Purchasing Software Systems: Managing the risk, Information & Management 24, 1993.,

[4] Kontio J., Chen S., Limperos K., Tesoriero R., Caldiera G., Deutsch M.: A COTS Selection Method and Experiences of Its Use, Twentieth Annual Software Engineering Workshop, Greenbelt, Maryland, 1995.,

[5] Tran V., Liu D.B.: A Risk-Mitigating Model for the Development of Reliable and Maintainable Large-Scale COTS Integrated Software Systems, Proceedings of the Annual Reliability and Maintainability Symposium, 1997.,

[6] Lawlis P., Mark K., Thomas G., Courtheyn T.: A Formal Process for Evaluating COTS Software Products, IEEE Computer 34 (5), 2001.,

[7] Maiden C.N., Ncube A.M.: PORE: Procurement-Oriented Requirements Engineering Method for the Component-Based Systems Engineering Development Paradigm, 2nd International Workshop on Component-Based Software Engineering, Los Angels, USA, 1998.,

[8] Lai V.S., Wong B.K., Cheung W.: Group decision making in multiple criteria environment: A case using the AHP in software selection, European Journal of Operational Research 137, 2002.,

[9] Canfora G., Troiano L.: The Importance of Dealing with Uncertainty in the Evaluation of Software Engineering Methods and Tools, SEKE'02, Ischia, Italy, 2002.,

[10] Güngör Şen C., Fırdolaş T., Baraçlı H., Önüt S.: A Fuzzy QFD Approach For Determining ERP Software Selection Criteria, 35th International Conference on Computers & Industrial Engineering, Istanbul Technical University, Istanbul, Turkey, 2005.