A Linguistic Decision Process for Evaluating the Installation of an Enterprise Resource Planning System

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Abstract

The use of *Enterprise Resource Planning* (ERP) as a foundation for the integration of organization-wide information systems, is clearly useful and economically profitable in companies with big amounts of information in their information systems. However, the decision for installing an ERP system in smaller companies is not so clear. In this contribution, we shall apply a linguistic decision model for evaluating the suitability of the installation of an ERP system in a company. This decision model is able to deal with aspects assessed in different domains, due to the fact that, the variables to analyze are heterogeneous.

Keywords: Linguistic variables, heterogeneous information, decision process, ERP

1 Introduction

The installation of ERP systems in big companies has produced an optimization of the companies internal value chain and hence important advantages and profits. This success can induce to other companies to install these costly systems hoping similar results. However, the installation of an ERP system must be carefully studied because of, not always produces successful results [6, 8].

The evaluation process for installing an ERP system is similar to Multi-Expert Decision Making (MEDM) problem. The main difference is that, in the evaluation process we study different parameters of the company instead of alternatives. These parameters can have a different nature and therefore, they need to be assessed by means of heterogeneous assessments. For example, the information produced by investments or budgets presents a quantitative nature and are assessed by means of numerical values [3] or interval-valued [9]. However, other parameters as standardization, rapid implementation, availability of personnel, etc., present a qualitative nature and are assessed by means of linguistic variables [10].

A decision process is composed of two phases [7]: (i) The aggregation phase, that combines the individual preferences, and (ii) The exploitation one that obtains a solution set for the problem. In the proposed problem the exploitation phase obtains a measurement on the suitability of implementing an ERP in the organization.

In this contribution we shall propose a linguistic decision model to evaluate the goodness of the installation of an ERP system in a company. This evaluation problem is developed in heterogeneous information contexts because it presents parameters of different nature. In [2] we defined a linguistic decision model that uses the 2-tuple fuzzy linguistic representation model [1] for solving decision making problems defined in heterogeneous information contexts. We extend this model to evaluate the goodness of an ERP system.

In order to do so, this paper is structured as follows: in Section 2 we review different basic concepts; in Section 3 we present the linguistic decision model for evaluation the installation of an ERP system, afterwards, we solve an example of evaluating the suitability of installing an ERP system in a company. And finally, some concluding remarks are pointed out.

2 Preliminaries

In this section, we shall present some basic concepts, to understand our proposal. We shall introduce briefly the concept of ERP and make a brief review of the 2-tuple linguistic representation model.

2.1 Enterprise Resource Planning

An ERP system is a structured approach to optimizing a company's internal value chain. The software, it fully installed across an entire enterprise, connects the components of the enterprise through a logical transmissions and sharing of common data with an integrated ERP. When data such as a sale becomes available at one point in the business, it courses its way through the software, which automatically calculates the effects of the transaction on other areas, such as manufacturing, inventory, procurement, invoicing, and booking the actual sale to the financial ledger [6, 8].

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What ERP really does organize, codify, and standardize an enterprise's business process and data. The software transforms transactional data into useful information and collates the data so that it can be analyzed. In this way, all of the collected transactional data become information that companies can use to support their business decisions.

ERP software is not intrinsically strategic; rather, it is an enabling technology, a set of integrated software modules that make up the core engine of internal transaction processing. The installation of an ERP, implies a great investment, because of, requires major changes in the organizational, cultural and business processes. The most important changes are those referred to individual roles inside the organization. A lot of ERP products have forced the companies, to redesign their business processes for removing useless tasks and focusing the released employees in value added activities, increasing dramatically the company's productivity and hence its profits.

These results have produced that many companies are interested in the installation of this type of product. However, the suitability of the ERP is not always profitable. Because of, the investment is always high and the productivity and profits of the company can not increase dramatically in some cases. Therefore, before to install an ERP must be evaluated its suitability in each company, analyzing a set of parameters [5] of the organization to decide the viability of the ERP implementation. In this paper we propose a model based on a linguistic decision process that analyzes the suitability of an ERP.

2.2 The 2-Tuple Fuzzy Linguistic Representation Model

The 2-tuple fuzzy linguistic representation model, presented in [1], will be used in this paper to unify the heterogenous information of the decision process. This model is based on symbolic methods and takes as the base of its representation the concept of Symbolic Translation.

Definition 1. *The Symbolic Translation of a linguistic term $s_i \in S = \{s_0, ..., s_g\}$ is a numerical value assessed in $[-.5, .5)$ that support the "difference of information" between an amount of information $\beta \in [0, g]$ and the closest value in $\{0, ..., g\}$ that indicates the index of the closest linguistic term $s_i \in S$, being [0,g] the interval of granularity of S.*

From this concept the linguistic information is represented by means of 2-tuples (r_i, α_i), $r_i \in S$ and $\alpha_i \in [-.5, .5)$.

This model defines a set of functions between linguistic 2-tuples and numerical values.

Definition 2. *Let $S = \{s_0, ..., s_g\}$ be a linguistic term set and $\beta \in [0, g]$ a value supporting the result of a symbolic aggregation operation, then the 2-tuple that expresses the equivalent information to β is obtained with the following function:*

$$\Delta : [0, g] \longrightarrow S \times [-0.5, 0.5)$$
$$\Delta(\beta) = (s_i, \alpha), \ with \left\{ \begin{array}{ll} s_i & i = round(\beta) \\ \alpha = \beta - i & \alpha \in [-.5, .5) \end{array} \right.$$

where $round(\cdot)$ is the usual round *operation, s_i has the closest index label to "β" and "α" is the value of the symbolic translation.*

Proposition 1. *Let $S = \{s_0, ..., s_g\}$ be a linguistic term set and (s_i, α) be a linguistic 2-tuple. There is always a Δ^{-1} function, such that, from a 2-tuple it returns its equivalent numerical value $\beta \in [0, g]$ in the interval of granularity of S.*

Proof. It is trivial, we consider the function:

$$\Delta^{-1} : S \times [-.5, .5) \longrightarrow [0, g]$$
$$\Delta^{-1}(s_i, \alpha) = i + \alpha = \beta$$

3 Evaluating the suitability of an ERP system

An evaluating process of the suitability of an ERP system can be represented as a problem that studies a set of parameters of the company $X = \{x_1, ...x_m\}$ that are evaluated by n experts $E = \{e_1, ..., e_n\}$ providing their evaluations in different domains, D^k, according to the nature of the parameter by means of utility vectors:

$$\{s^k_{i1}, ..., s^k_{im}\}$$

Let s^k_{ij} $(i \in \{1, ..., n\}; j = \{1, ..., m\}; k \in \{N, I, L\})$ being the evaluation assigned to the parameter x_j by expert e_i assessed in the domain D^k. Each expert provides a vector with his evaluations. The domains used in this problem to assess the evaluations are: *Numerical, Interval-valued and Linguistic.*

According to the above scheme to evaluate the goodness of the ERP system, we propose to extend the linguistic decision process presented in [2] designed for dealing with heterogeneous information.

3.1 Linguistic Decision Process

Here, we present the aggregation and exploitation phases of the linguistic decision process for evaluating the suitability of an ERP based on the process presented in [2].

3.1.1 Aggregation phase

In this phase the individual evaluation utility vectors provided by the experts are combined to obtain a collective utility vector. As the evaluations of the experts are assessed in different domains, numerical (D^N), interval-valued (D^I) and linguistic (D^L). This process is accomplished as follows:

1. *Making the information uniform.* The heterogeneous information is unified into a specific linguistic domain, called *Basic Linguistic Term Set* (BLTS) and symbolized as S_T. The BLTS is

chosen according to the conditions shown in [2]. Afterwards, each numerical, interval-valued and linguistic evaluation, s_{ij}^k, is transformed into a fuzzy set in S_T, $F(S_T)$.

(a) Transforming numerical values, s_{ij}^N in $[0,1]$, into $F(S_T)$:

$$\tau : [0,1] \rightarrow F(S_T)$$

$$\tau(s_{ij}^N) = \{(s_0, \gamma_0), ..., (s_g, \gamma_g)\}, s_i \in S_T \; and \, \gamma_i \in [0,1]$$

$$\gamma_i = \mu_{s_i}(s_{ij}^N) = \begin{cases} 0, & if\, s_{ij}^N \notin Support(\mu_{s_i}(x)) \\ \frac{s_{ij}^N - a_i}{b_i - a_i}, & if\, a_i \leq s_{ij}^N \leq b_i \\ 1, & if\, b_i \leq s_{ij}^N \leq d_i \\ \frac{c_i - s_{ij}^N}{c_i - d_i}, & if\, d_i \leq s_{ij}^N \leq c_i \end{cases}$$

Remark: We consider membership functions, $\mu_{s_i}(\cdot)$, for linguistic labels, $s_i \in S_T$, are represented by a parametric function (a_i, b_i, d_i, c_i).

(b) Transforming linguistic terms, $s_{ij}^L \in S$, into $F(S_T)$: $\tau_{SS_T} : S \rightarrow F(S_T)$

$$\tau_{SS_T}(s_{ij}^L) = \{(c_k, \gamma_k^i) \,/\, k \in \{0, ..., g\}\}, \; \forall s_{ij}^L \in S$$

$$\gamma_k^i = \max_y \min\{\mu_{s_{ij}^L}(y), \mu_{c_k}(y)\}$$

where $\mu_{s_{ij}^L}(\cdot)$ and $\mu_{c_k}(\cdot)$ are the membership functions of the fuzzy sets associated with the terms s_{ij}^L and c_k, respectively. When the BLTS is a term set used in the context the fuzzy set that represents its linguistic terms is all 0 except the correspondent to the ordinal of the label that is 1.

(c) Transforming interval-valued, s_{ij}^I in $[0,1]$ into $F(S_T)$. Let $I = [\underline{i}, \overline{i}]$ be an interval-valued in $[0,1]$. We assume that the interval-valued has a representation, inspired in the membership function of fuzzy sets [4]:

$$\mu_I(\vartheta) = \begin{cases} 0, & if\, \vartheta < \underline{i} \\ 1, & if\, \underline{i} \leq \vartheta \leq \overline{i} \\ 0, & if\, \overline{i} < \vartheta \end{cases}$$

The transformation function is:

$$\tau_{IS_T} : I \rightarrow F(S_T)$$

$$\tau_{IS_T}(s_{ij}^I) = \{(c_k, \gamma_k^i) \,/\, k \in \{0, ..., g\}\},$$

$$\gamma_k^i = \max_y \min\{\mu_{s_{ij}^I}(y), \mu_{c_k}(y)\}$$

where $\mu_{s_{ij}^I}(\cdot)$ is the membership function associated with the interval-valued s_{ij}^I.

2. *Aggregating individual utility vectors.* For each parameter, a collective value is obtained by means of the aggregation of the above fuzzy sets on the BLTS that represents the individual evaluations assigned by the experts.
3. *Transforming into 2-tuples.* The collective utility vector expressed by means of fuzzy sets in the BLTS are transformed into linguistic 2-tuples in the BLTS. This transformation is carried out using the function χ and the Δ function (Def. 2):

$$\chi : F(S_T) \rightarrow [0, g]$$

$$\chi(\tau(\vartheta)) = \chi(\{(s_j, \gamma_j), \, j = 0, ..., g\}) = \frac{\sum_{j=0}^{g} j\gamma_j}{\sum_{j=0}^{g} \gamma_j} = \beta$$

3.1.2 Exploitation phase

Over the collective preference vector the exploitation phase, usually, obtains the best alternative(s). However, in this problem it computes an overall value expressed by means of a linguistic 2-tuple. This overall value expresses a measurement of the degree of viability for the installation of the ERP software in the company. This degree of viability is evaluated in a predefined table, such that, depending on its value it points out the suitability or unsuitability of the installation of the ERP system.

3.2 Example: Evaluating the Installation of an ERP

The evaluation of the degree of viability for the installation of an ERP takes into account a considerable amount of company's parameters. In this section, we present an example of the evaluating process that considers a subset of the total set of parameters, due to the size of the contribution. The example shows the whole evaluating process.

In this example, we take into consideration the following four parameters of the company: X_1 *Investment in IT for employee* is an interval-valued with a maximum value of 6000€; X_2 *Urgency in the implementation*, X_3 *Standard degree* are assessed by linguistic values in the linguistic term set showed in Fig. 1; X_4 *Price of the implementation* is a numerical value with a maximum value of 240000€, X_4 has not an increasing interpretation, i.e., high values indicate a minor degree of acceptance. Then, this parameter is inversely transformed before to make uniform the information. On this way, all parameters have an increasing interpretation.

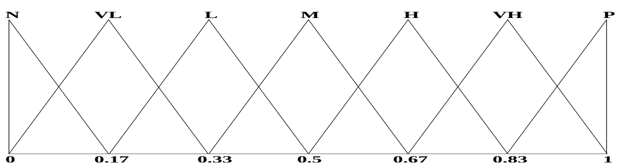

Figure 1: A set of seven linguistic terms with its semantics

In this example, four experts evaluate the suitability of the ERP providing their assessments over the parameters by means of utility vectors:

	X_1	X_2	X_3	X_4
E_1	[3500,4000]	H	M	120000
E_2	[3000,3500]	VH	M	100000
E_3	[3100,3800]	H	H	80000
E_4	[3000,3200]	M	M	100000

Firstly, we normalize the parameters X_1 and X_4 to values in $[0,1]$ and the parameter X_4 is inversely transformed:

	X_1	X_2	X_3	X_4
E_1	[.58,.67]	H	M	.5
E_2	[.5,.58]	VH	M	.58
E_3	[.52,.63]	H	H	.67
E_4	[.5,.53]	M	M	.58

Table 1: Fuzzy sets in the BLTS

	X_1	X_2	X_3	X_4
E_1	(0,0,0,1,1,0,0)	(0,0,0,0,1,0,0)	(0,0,0,1,0,0,0)	(0,0,0,1,0,0,0)
E_2	(0,0,0,1,.47,0,0)	(0,0,0,0,0,1,0)	(0,0,0,1,0,0,0)	(0,0,0,.53,.47,0,0)
E_3	(0,0,0,.88,.76,0,0)	(0,0,0,0,1,0,0)	(0,0,0,0,1,0,0)	(0,0,0,0,1,0,0)
E_4	(0,0,0,1,.18,0,0)	(0,0,0,1,0,0,0)	(0,0,0,1,0,0,0)	(0,0,0,.53,.47,0,0)

Table 2: The collective preference values

	X_1	X_2	X_3	X_4
E	(0,0,0,.97,.6,0,0)	(0,0,0,.25,.5,.25,0)	(0,0,0,.75,.25,0,0)	(0,0,0,.52,.49,0,0)

Applying the decision process:

1. **Aggregation phase**

   (a) *Making the information uniform*

   1. Choose the BLTS. In this case, is the term set showed in Fig. 1.

   2. Transforming the input information into $F(S_T)$ (see Table 1).

   3. Aggregating individual performance values. In this example we use as aggregation operator the arithmetic mean obtaining the collective values showed in Table 2.

   (b) *Transforming into 2-tuples.* The result of this transformation is:

	X_1	X_2	X_3	X_4
E	(M,.38)	(H,0)	(M,.25)	(M,.49)

2. **Exploitation phase**. We use the 2-tuple arithmetic mean operator [1] to obtain the degree of viability for the installation of the ERP:

$$(\mathbf{H}, -\mathbf{.47})$$

This overall value indicates the degree of suitability of the installation of the ERP. As usual rule, when this degree is higher than M then, the installation of the ERP can be suitable in other case the current structure of the company is more profitable. But as high as is the degree of suitability then more recommendable is the installation of the ERP.

4 Concluding Remarks

In this contribution, we have proposed the application of a linguistic decision process for evaluating of the suitability of installing an ERP system in a company. The process evaluates the parameters, of the current conditions of the company, according to the opinions of the experts. These parameters are assessed from different information domains. The method proposed combines the heterogeneous information providing by the experts, in their evaluation of the parameters, for obtaining an overall measurement of the viability for the installation of the ERP. This process improves other methods that force to the experts to provide their opinions in an unique expression domain [5].

References

[1] F. Herrera and L. Martínez. A 2-tuple fuzzy linguistic representation model for computing with words. *IEEE Transactions on Fuzzy Systems*, 8(6):746–752, 2000.

[2] F. Herrera, L. Martinez, and P.J. Sanchez. Managing heterogeneous information in group decision making. In *Proceedings Ninth International Conference IPMU 2002*, pages 439–446, Annecy (France), 2002.

[3] J. Kacprzyk and M. Fedrizzi. Group decision making with a fuzzy linguistic majority. *Fuzzy Sets and Systems*, 18:105–118, 1986.

[4] D. Kuchta. Fuzzy capital budgeting. *Fuzzy Sets and Systems*, 111:367–385, 2000.

[5] P. Maestre. Business intelligence: del erp y kim, al asp y crm. In *I Observatorio Dintel*, Madrid, 2002.

[6] G. Norris, J.R. Hurley, and et al. *E-Business and ERP. Transforming the Enterprise*. John Wiley & Sons Inc., 2000.

[7] M. Roubens. Fuzzy sets and decision analysis. *Fuzzy Sets and Systems*, 90:199–206, 1997.

[8] M.G. Shields. *E-Business and ERP. Rapid Implementation and Project Planning*. John Wiley & Sons Inc., 2001.

[9] J.F. Le Téno and B. Mareschal. An interval version of PROMETHEE for the comparison of building products' design with ill-defined data on environmental quality. *European Journal of Operational Research*, 109:522–529, 1998.

[10] L.A. Zadeh. The concept of a linguistic variable and its applications to approximate reasoning. *Information Sciences, Part I, II, III*, 8,8,9:199–249,301–357,43–80, 1975.