Evaluating the Suitability 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 the complete range of business's processess and functions, is clearly useful and economically profitable in most very large organizations which deal with great deal of data in their information systems. However, the decision for installing an ERP system in all companies is not always so clear, it will depend on the size, future profits and other features of the company. In this contribution, we shall present an process that it is useful for evaluating the suitability of installing an ERP in a company. This process is modelled as a Multi-Expert Decision Making problem where we shall use rather parameters instead of alternatives. This evaluation problem is defined over an heterogeneous context due to the fact that different parameters evolved in the evaluation of the suitability of the system are from different nature and they will be assessed in different domains. Decision making process are usually composed of two phases: (i) aggregation and, (ii) exploitation. In the current proposal the exploitation phase will not order the parameters (alternatives), furthermore it will obtain an overall value that we shall use for evaluating the suitability of installing the ERP system.

Keywords: Linguistic variables, heterogeneous information, decision process, ERP
[3]

1 Introduction

The information technologies (IT) have an enormous impact on the productivity of the organizations. Companies have implemented systems such as Enterprise Resource Planning (ERP), Material Resource Planning (MRP), Electronic Data Interchange (EDI), etc. in the last years for improving their productivity. However, ERP systems have received much attention lately for their potential in more effective decision-

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making. 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 has induced to other companies to install these costly systems hoping similar successful results. However, the installation of an ERP system is very complex, expensive and has a massive impact on the entire organization. Due to these reasons should evaluate carefully the implementation of the ERP in order to avoid unsuccessful results in its implementation [Nor00],[Shi01]. The process for evaluating the suitability of installing an ERP system can be modelled by means of a to Multi-Expert Decision Making (ME-DM) problem. The main difference is that the evaluation process will 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 [Kac86] or interval-valued [Ten98]. However, other parameters as standardization, rapid implementation, availability of personnel, etc., present a qualitative nature and are assessed by means of linguistic variables [Zad75].

A decision process is composed of two phases [Rou97]:

(i) *Aggregation phase*: that combines the individual preferences to obtain collective preferences

(ii) *Exploitation phase*: orders the collective preferences to obtain a solution set for the problem

In the evaluation process the exploitation phase will compute a measurement on the suitability of implementing an ERP in the organization.

In this contribution we shall propose a method to evaluate the suitability of the installation of an ERP system in a company based on a linguistic decision model. This evaluation problem is defined over an heterogeneous information context. In [Her02] it was defined a linguistic decision model using the 2-tuple fuzzy linguistic representation model [Her00] for solving decision making problems defined over heterogeneous information contexts. We shall use this linguistic model to manage our problem in order to evaluate the suitability of the installation of an ERP system.

This paper is structured as follows: in Section 2 we shall make a brief introduction to Enterprise Resource Planning systems; in Section 3 we review the 2-tuple linguistic representation model that it will be used to manage the heterogeneous information of our problem; in Section 4 we present the model for evaluating the suitability of installing an ERP system in a company developing an example of this model. And finally, some concluding remarks are pointed out.

2 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 [Nor00], [Shi01].

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. When an ERP system is fully developed in a business organization, it can yield many benefits: reduce cycle time, enable faster information transactions, facilitate better financial management, lay groundwork for e-commerce, and make tacit knowledge explicit.

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 improvements have produced that all world wide organizations and increasingly small- and medium-sized companies are interested in the installation of this type of product. However, the suitability of the ERP is not always profitable. Because ERP systems are very complex and have a massive impact on the entire organization. Implementing an ERP system is always very expensive and time consuming, furthermore 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 [Mae02] of the organization to decide the viability of the ERP implementation. In this paper we propose a model based on an heterogeneous linguistic decision process that evaluates the suitability of an ERP according to different parameters of each company.

3 The 2-tuple Linguistic Representation Model

This model was presented in [Her00], for overcoming the drawback of the loss of information presented by the classical linguistic computational models [Her00b]: (i) The semantic model, (ii) and the symbolic one. The 2-tuple fuzzy linguistic representation model is based on the symbolic method 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 [-0.5,0.5) that supports 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 in *S* (s_i), being [0,g] the interval of granularity of *S*.

From this concept a new linguistic representation model is developed, which represents the linguistic information by means of 2-tuples $(s_i, \alpha_i), s_i \in S$ and $\alpha_i \in [-0.5, 0.5)$.

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:

$$\Delta : [0, g] \to S \times (-0.5, .0.5)$$

$$\Delta(\beta) = (s_i, \alpha), with \quad \begin{cases} s_i & i = round(\beta) \\ \alpha = \beta - i & \alpha \in [-0.5, 0,5) \end{cases}$$

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_i) 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 following function:

$$\Delta^{-1} : S \times [-0,5, 0.5) \to [0, g]$$

$$\Delta^{-1}(s_i, \alpha) = i + \alpha = \beta$$

Remark 1. From Definitions 1 and 2 and Proposition 1, it is obvious that the conversion of a linguistic term into a linguistic 2-tuple consist of adding a value 0 as symbolic translation:

$$s_i \in S \Rightarrow (s_i, 0)$$

This model has a computational technique based on the 2-tuples were presented in [Her00]:

1. **Aggregation of 2-tuples**

The aggregation of linguistic 2-tuples consist of obtaining a value that summarizes a set of values, therefore, the result of the aggregation of a set of 2-tuples must be a linguistic 2-tuple. In [Her00] we can find several 2-tuple aggregation operators based on classical aggregation operators.

2. **Comparison of 2-tuples**

The comparison of information represented by 2-tuples is carried out according to an ordinary lexico-graphic order.

Let (s_k, α_1) and (s_l, α_2) be two 2-tuples represented two assessments:

- If $k < l$ then (s_k, α_1) is smaller than (s_l, α_2)
- If $k=l$ then
  1. If $\alpha_1 = \alpha_2$ then (s_k, α_1) and (s_l, α_2) represent the same value
  2. If $\alpha_1 < \alpha_2$ then (s_k, α_1) is smaller than (s_l, α_2)
  3. If $\alpha_1 > \alpha_2$ then (s_k, α_1) is bigger than (s_l, α_2)

4 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 they 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:

$$\{s_{i1}^k, ..., s_{im}^k\}$$

Let $s_{ij}^{k}(i \in \{1,...,m\}, j \in \{1,...,n\}, k \in \{N, I, L\}$ 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 may be: **N**umerical, **I**nterval-valued and **L**inguistic.

According to the above scheme to evaluate the suitability of the ERP system, we propose the using of the linguistic decision process presented in [Her02] designed for dealing with heterogeneous information.

4.1 Heterogeneous Decision Process

Here, we present the aggregation and exploitation phases of the linguistic decision process for managing heterogeneous information presented in [Her02] that we shall use to evaluate the suitability of an ERP.

4.1.1 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 [Her02]. 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):

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

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

$$\gamma_i = \mu_{s_i}(s_{ij}^{N}) = \begin{cases} 0 \quad if \quad s_{ij}^{N} \notin Support(\mu_{s_i}(s_{ij}^{N})) \\ \dfrac{s_{ij}^{N} - a_i}{b_i - c_i} \quad if \quad a_i < s_{ij}^{N} < b_i \\ 1 \quad if \quad c_i < s_{ij}^{N} < d_i \\ \dfrac{c_i - s_{ij}^{N}}{c_i - d_i} \quad if \quad d_i < s_{ij}^{N} < c_i \end{cases}$$

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, c_i, d_i).

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

$$\tau_{SS_T} : S \rightarrow F(S_T)$$

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

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

where $\mu_{s_{ij}^N}(y)$ and $\mu_{c_k}(y)$ 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 values, $s_{ij}^I \in [0,1]$, into F(S_T): Let $I = \left[\underline{i}, \overline{i}\right]$ be an interval value in [0,1]. We assume that the interval-value has a representation, inspired in the membership function of the fuzzy sets [Kuc00]:

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

The transformation function is:

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

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

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

where $\mu_{s_{ij}^I}(y)$ 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 aggregating the above fuzzy sets on the BLTS that represents the individual evaluations assigned by the experts using an aggregation operator.
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):

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

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

4.1.2 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 suitability for the installation of the ERP software in the company. In our proposal we compute this overall measurement aggregating the collective value for each parameter. This degree of suitability will be evaluated in a predefined table, such that, depending on its value it points out the suitability or unsuitability of installing the ERP system.

4.2 Evaluating the installation of an ERP

The evaluation of the degree of suitability 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. We take into account the following parameters of the company, assessed in different domains, for evaluating the suitability of the ERP system:

- X_1 Investment in IT for employee is an interval-valued with a maximum value of 6000€
- X_2 Price of the implementation is a numerical value with a maximum value of 240000€;
- X_3 Urgency in the implementation are assessed by linguistic values in the linguistic term set *A*
- X_4 Standard degree are assessed by linguistic values in the linguistic term set *C*
- X_5 Interrelation with other subsystems is a numerical value assessed in [0,1]
- X_6 Capacity of the user to specify are assessed by linguistic values in the linguistic term set *C*

- X_7 Requests of change by the user assessed by linguistic values in the linguistic term set *B*
- X_8 Availability of personnel are assessed by linguistic values in the linguistic term set *B*
- X_9 Capacity of influence of the client in the provider are assessed by linguistic values in the linguistic term set *D*

The semantics of the term sets are showed in the Table 1 and graphically in Figure 1.

Term Set A		**Term Set B**		**Term Set C**		**Term Set D**	
A_0	(0,0,12)	B_0	(0,0,.16)	C_0	(0,0,.25)	D_0	(0,0,0,0)
A_1	(0,.12,.25)	B_1	(0,.16,.33)	C_1	(0,.25,.5)	D_1	(0,.01,.02,.07)
A_2	(.12,.25,.37)	B_2	(.16,.33,.5)	C_2	(.25,.5,.75)	D_2	(.04,.1,.18,.23)
A_3	(.25,.37,.5)	B_3	(.33,.5,.66)	C_3	(.5,.75,1)	D_3	(.17,.22,.36,.42)
A_4	(.37,.5,.62)	B_4	(.5,.66,.83)	C_4	(.75,1,1)	D_4	(.32,.41,.58,.65)
A_5	(.5,.62,.75)	B_5	(.66,.83,1)			D_5	(.58,.63,.80,.86)
A_6	(.62,.75,.87)	B_6	(.83,1,1)			D_6	(.72,.78,.92,.97)
A_7	(.75,.87,1)					D_7	(.93,.98,.99,1)
A_8	(.87,1,1)					D_8	(1,1,1,1)

Table 1. Labels term sets

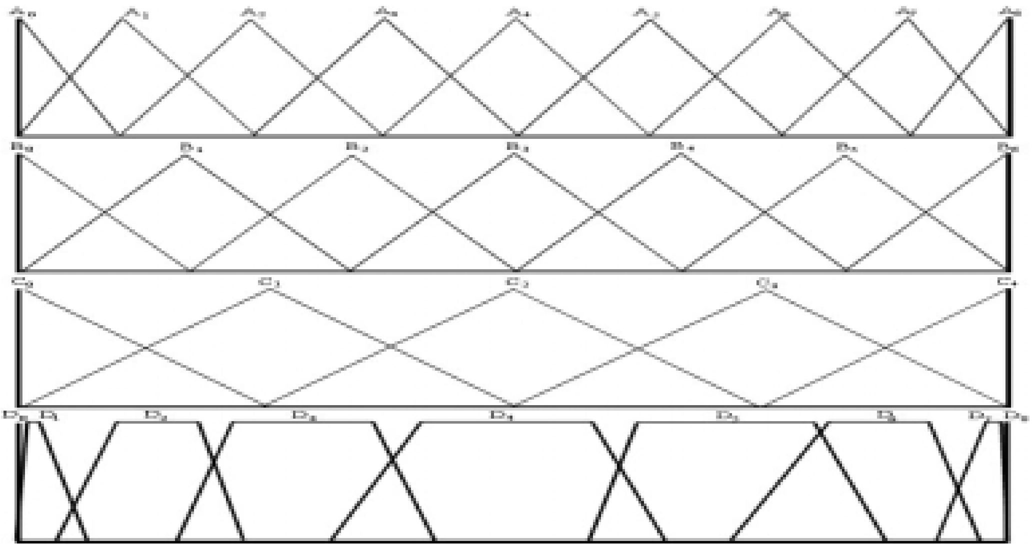

Fig1. Labels term sets

In this example, four experts evaluate the suitability of the ERP providing their assessments over the parameters by means of utility vectors (see Table 2):

	E_1	E_2	E_3	E_4
X_1	[3500,4000]	[2000,2500]	[3100,3800]	[4500,5000]
X_2	12000	18000	10000	16000
X_3	A_5	A_6	A_5	A_4
X_4	C_2	C_2	C_3	C_1
X_5	.2	.35	.75	.3
X_6	C_1	C_1	C_2	C_3
X_7	B_3	B_4	B_3	B_4
X_8	B_4	B_5	B_5	B_3
X_9	D_7	D_6	D_5	D_5

Table 2. Experts assessments

The parameters X_2, X_5, X_6, X_7, X_8 have not an increasing interpretation, i.e., high values indicate a minor degree of acceptance. Then, these parameters are inversely transformed before to make uniform the information. On this way, all parameters have an increasing interpretation.

	E_1	E_2	E_3	E_4
X_1	[.58,.67]	[.33,.42]	[.52,.63]	[.75,.83]
X_2	.5	.25	.58	.33
X_3	A_5	A_6	A_5	A_4
X_4	C_2	C_2	C_3	C_1
X_5	.8	.65	.25	.7
X_6	C_3	C_3	C_2	C_1
X_7	B_3	B_2	B_3	B_2
X_8	B_2	B_1	B_1	B_3
X_9	D_7	D_6	D_5	D_5

Table 3. Increasing Interpretation

Now we apply the decision process:

1. Aggregation phase

(a) Making the information uniform

1. Choose the BLTS. In this case, there are two term sets with the maximum granularity and different semantics, hence, we choose as S_T the special term set of 15 labels given in Fig. 2 according to [Her02].

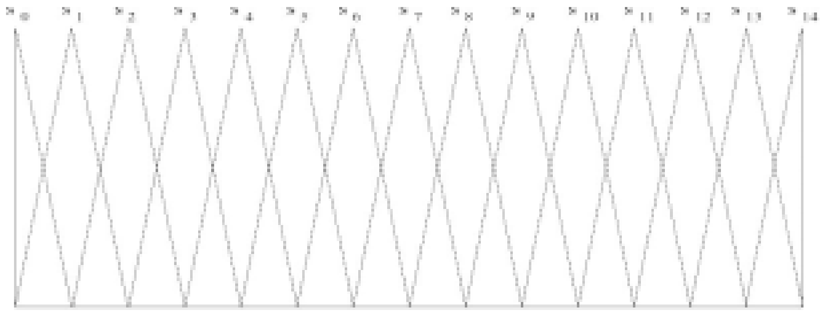

Fig 2. A BLTS with 15 terms symetrically distributed

2. Transforming the input information into $F(S_T)$ (see Table 4).

	E_1	**E_2**	**E_3**	**E_4**
X_1	(0,0,0,0,0,0,0,.86,1,.43,0,0,0,0,0)	(0,0,0,0,.43,1,.86,0,0,0,0,0,0,0,0)	(0,0,0,0,0,0,0,.71,1,.86,0,0,0,0,0)	(0,0,0,0,0,0,0,0,0,0,.43,1,.71,0,0)
X_2	(0,0,0,0,0,0,0,1,0,0,0,0,0,0,0)	(0,0,0,.57,.43,0,0,0,0,0,0,0,0,0,0)	(0,0,0,0,0,0,0,0,.86,.14,0,0,0,0,0)	(0,0,0,0,.43,.57,0,0,0,0,0,0,0,0,0)
X_3	(0,0,0,0,0,0,0,.36,.73,.89,.55,.2,0,0,0)	(0,0,0,0,0,0,0,0,.1,.45,.79,.84,.47,.09,0)	(0,0,0,0,0,0,0,.36,.73,.89,.55,.2,0,0,0)	(0,0,0,0,0,.29,.65,1,.63,.26,0,0,0,0,0)
X_4	(0,0,0,.12,.34,.56,.78,1,.78,.56,.34,.12,0,0,0)	(0,0,0,.12,.34,.56,.78,1,.78,.56,.34,.12,0,0,0)	(0,0,0,0,0,0,0,.21,.43,.65,.87,.9,.68,.45,.21)	(.21,.65,.68,.9,.87,.65,.43,.21,0,0,0,0,0,0,0)
X_5	(0,0,0,0,0,0,0,0,0,0,0,.71,.29,0,0)	(0,0,0,0,0,0,0,0,0,.86,.14,0,0,0,0)	(0,0,0,0,.57,.43,0,0,0,0,0,0,0,0,0)	(0,0,0,0,0,0,0,0,0,.14,.86,0,0,0,0)
X_6	(0,0,0,0,0,0,0,.21,.43,.65,.87,.9,.68,.45,.21)	(0,0,0,0,0,0,0,.21,.43,.65,.87,.9,.68,.45,.21)	(0,0,0,.12,.34,.56,.78,1,.78,.56,.34,.12,0,0,0)	(.21,.65,.68,.9,.87,.65,.43,.21,0,0,0,0,0,0,0)
X_7	(0,0,0,0,.12,.41,.7,1,.69,.39,.08,0,0,0,0)	(0,0,.24,.54,.83,.87,.58,.29,0,0,0,0,0,0,0)	(0,0,0,0,.12,.41,.7,1,.69,.39,.08,0,0,0,0)	(0,0,.24,.54,.83,.87,.58,.29,0,0,0,0,0,0,0)
X_8	(0,0,.24,.54,.83,.87,.58,.29,0,0,0,0,0,0,0)	(.3,.97,.95,.75,.45,.16,0,0,0,0,0,0,0,0,0)	(.3,.97,.95,.75,.45,.16,0,0,0,0,0,0,0,0,0)	(0,0,0,0,.12,.41,.7,1,.69,.39,.08,0,0,0,0)
X_9	(0,0,0,0,0,0,0,0,0,0,0,0,0,.58,.87)	(0,0,0,0,0,0,0,0,0,0,.35,.76,1,.92,.33)	(0,0,0,0,0,0,0,0,.5,1,1,1,.61,.07,0)	(0,0,0,0,0,0,0,0,.5,1,1,1,.61,.07,0)

Table 4. Input information into $F(S_T)$

3. Aggregating individual performance values. In this example we use as aggregation operator the arithmetic mean obtaining the collective values showed in Table 5.

X_1	(0,0,0,0,.11,.25,.22,.39,.5,.32,.11,.25,.18,0,0)
X_2	(0,0,0,.14,.22,.14,0,.25,.22,.04,0,0,0,0,0)
X_3	(0,0,0,0,0,.07,.16,.43,.55,.62,.47,.31,.12,.02,0)
X_4	(.05,.16,.17,.29,.39,.44,.5,.61,.5,.44,.39,.29,.17,.11,.05)
X_5	(0,0,0,0,.14,.11,0,0,0,.25,.25,.18,.07,0,0)
X_6	(.05,.16,.17,.26,.3,.3,.3,.41,.41,.47,.52,.48,.34,.23,.11)
X_7	(0,0,.12,.33,.59,.72,.68,.65,.39,.28,.17,.06,0,0,0)
X_8	(.15,.49,.54,.51,.46,.40,.32,.32,.17,.10,.02,0,0,0,0)
X_9	(0,0,0,0,0,0,0,0,.25,.5,.59,.69,.56,.41,.30)

Table 5. Aggregated data

(b) Transforming the collective values into 2-tuples in S_T. The result of this transformation is:

	X_1	X_2	X_3	X_4	X_5	X_6	X_7	X_8	X_9
E	$(S_8,0)$	$(S_6,-.19)$	$(S_9,-.23)$	$(S_7,-.07)$	$(S_9,-.32)$	$(S_8,-.18)$	$(S_6,-.03)$	$(S_4,-.1)$	$(S_{11},-.02)$

Table 6. Aggregated data in 2-tuples

2. Exploitation phase.

In this phase we obtain an overall suitability value for the installation of the ERP that will be evaluated according to the following recommendation table:

Degree of suitability	***Recommendation***
$< S_4$	Not install
$> S_4$ and $< S_6$	The installation is not suitable
$> S_6$ and $< S_9$	The installation is feasible
$> S_9$ and $< S_{11}$	The installation is suitable
$> S_{11}$	The installation is very suitable

Table 7. Table of suitability

We use the 2-tuple arithmetic mean operator [Her00] to obtain the degree of suitability for the installation of the ERP:

$$(S_7,-.07)$$

Therefore in this example the installation of the ERP is feasible but is not suitable.

4 Concluding Remarks

In this contribution, we have proposed the application of a linguistic decision process for evaluating 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 in 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 suitability for the installation of the ERP. This process is more flexible than other ones that force to the experts to provide their opinions in an unique expression domain [Mae02].

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