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A New Algorithm for ERP System Selection Based on Fuzzy DEMATEL Approach

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Hasan Jahanshahi, Behrouz Farhadzareh, Hatef Fotuhi, Abdorreza Golpour, Mohammad Bagher Mokhtari: A New Algorithm for ERP System Selection Based on Fuzzy DEMATEL Approach

ABSTRACT

In this paper, a fuzzy expert system comprehensive method is proposed for selecting proper enterprise resource planning (ERP) system by analytical network planning based on heuristic algorithm. After making the network model, the interdependencies between elements of each criteria is analyzed and the overall relation matrix (T) is built for each criteria. The relative weights of each criteria with regard to relevant criteria is obtained by applying a simple heuristic algorithm to each overall relation matrix (T). This algorithm has an acceptable accuracy and makes us independent of building supermatrix and using SUPER DECISION software and thus increases the speed and makes the problem easily done. The obtained results are analyzed by comparison between algorithm results and software outputs. Finally the algorithm will propose a fuzzy expert system with regard to relative weights of elements. To completely explain the application of this algorithm, the proposed method is implemented in one of the industrial units of Iran and the results are analyzed.

Key words: Enterprise Resource Planning, system selection, fuzzy logic, heuristic algorithm, fuzzy expert system;

Introduction

Enterprise Resource Planning system (ERP) is implemented in many organizations and industrial units. However globally and especially in Iran, many companies avoid to buy and implement ERP. The reason is the fear of industrial managers from failure in implementing the system. One of the most important reasons of these failures is lack of knowledge among industrial managers which result to select improper alternative for the organization [7]. ERP systems implementation is one of the most costly investments and the problem with adapting organization processes with ERP system [22] then it is essential to select a proper ERP system for implementing the system in organization successfully. Studies show that aligning business and IT processes is one of the most concerning issues of managers and adapting business processes with implemented IT is the most important part of a successful IT project. Thus a successful ERP system is an advantage point for organizations [21]. In this paper designing and utilizing fuzzy expert system for selecting ERP is proposed. There are different approaches to evaluate an IT system that make us to use a structured method for decision making. Expert systems analyze various cases of a subject by using a series of if-then rules and finally results to an optimal alternative [18]. Fuzzy expert system is a newer version of expert system that uses fuzzy logic for processing. In this system, a series of membership function and fuzzy logic is used for entering data instead of certain logic [14]. It seems that using fuzzy logic can leads to a decrease in the risk of selecting optimal alternative for ERP system. Evaluating alternatives and purchasing organizations terms by fuzzy logic enable us to select the optimal alternative more accurately. Expert system compare alternatives directly and in the basis of human thinking instead of doing paired comparison among them. The approach and a case study of industrial unit in Iran are described in this paper.

Various models for selecting ERP system for an organization have been proposed. Wei [20] has proposed an analytical hierarchy process (AHP) model for this purpose. There are two main criteria as proper system and proper marketer that many sub criteria have been considered for them. Another model that uses AHP method is proposed too. We can refer to a model in textile industries that select

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the best ERP alternative with regard to BSC model in which has 3 main criteria as cost, system features and supplier status with 13 sub criteria [4]. In another model that is based on 9126 standard, main criteria as system operation, system installation, maintenance capability, system efficiency, system reliability and capability with 21 sub criteria are considered [11]. In another model which is about project control we have 4 main criteria as system quality, supplier advantages, cost and time and 18 sub criteria [12]. We can refer to other approaches used in this context such as 0-1 planning model, goal programing [9,8]. Ziaee et al (Ziaee, Fathian, & Sadjadi) proposed a 0-1 planning model that considers 3 main criteria as system, project and supplier in ERP decision making. Yang et all [21] proposed a multistage approach that includes self-evaluation of the organization that wants to purchase ERP, RFB provision, evaluating ERP alternatives and negotiating contracts [3]. ANP approach is being used in one of the studies which main criteria are system and supplier features [17]. Studies show that there is not any study that uses expert system for selecting ERP system. But we must notice that there are many studies that discuss about expert system such as using fuzzy expert system economic investment analysis in Radio Frequency Identification [19], decision making in global marketing [10], and developing BSC [2]. In Iran we have some studies too, such as ranking stock market exchange using fuzzy expert system [9], analyzing stock market [5], improving the operation of wheat combine [16], steel production process [23], evaluating efficiency of health and safety system of gas [1] refinery [23].

Method:

A case study is used In order to fully explain the approach. This fuzzy expert system approach has been implemented in one of the industrial units in Iran and the results are presented in this paper.

This approach is described as follow:

First we must define alternatives and criteria of the organization and build the network model. We could define the organization alternatives for selecting proper ERP system and specify organization criteria for implementing the system by developing an expert group consist of two groups as internal and external organization consultant. Then by obtaining relative weights of each element with regard to relevant criteria, we move to the next stage. In this stage, relative weights of each element of criteria with regard to relevant criteria is obtained for designing fuzzy sets for each decision making criteria. It is essential to analyze interdependencies between elements of each criteria by fuzzy DEMATEL and building overall relation matrix for each criteria. Despite the fact that fuzzy DEMATEL approach reflects the output of interdependencies between elements, better than fuzzy-ANP, in this paper we will use fuzzy DEMATEL for analyzing cause and effect relationships between each criteria. In order to use DEMATEL approach we need to use experts opinions and these opinion consist of vague terms. Then it is essential to transform these terms to fuzzy numbers.

Defining decision making criteria and building network diagram:

Defining ERP system decision making criteria is based on the following contexts:

Reviewing used criteria by former researches.

Reviewing success indicator of ERP system from the managers and users view

The main criteria are taking into the account by former approach for selecting the best ERP system

Table 1 present a series of most important criteria used in former researches. These criteria is considered by frequency and emphasis used in the researches.

Table 1: Most important criteria used in former researches Project criteria: cost, time, set up time

1	System features: adaptation with organization process, quality and reliability, being user friendly and having a good user interface, updating and developing capability Supplier state: used technology, support, training, financial stability, reputation
2	System features: software functionality, reliability, user friendly, efficiency (non-functional features), tenability Managerial criteria: supplier state, implementation cost and time
3	System compatibility, support and consult quality, system acceptance by users, set up time, maintenance and adaptation and cost
4	System features: cost, implementation time, system functionality, user-friendly and user interface, flexibility, reliability Supplier state: reputation, technical capability, support service
5	Cost: purchase cost, implementation cost System features: software functionality, flexibility, reliability, user friendly and user interface, developing and updating capability, adaptation with organization processes Supplier state: support, reputation
6	System quality: correctness, reliability, user-friendly and user interface, integration, tenability, testability Supplier state: market share, human resources, reputation, training, willingness to corporate Cost: software cost, hardware cost Set up time
7	System features: software functionality, flexibility, user-friendly and user interface, set up cost, cost, reliability Supplier state: market share, economic stability, implementation capability, support, update capability

From another aspect proper operation of the software, flexibility, being user friendly and high quality training are criteria that must be taken into account for implementing a successful ERP system

[13]. Also based on one of the studies conducted in Iran we must consider cost, supplier experience, business process reengineering, software support, software quality, adaptation with organization processes in order to success in implementing ERP system [15]. Finally according to the above topics, 3 criteria as system set up, system features and supplier status is considered as main decision making criteria.

System set up criteria: System set up criteria includes two sub criteria as cost and set up time according to their importance and emphasize.

System features criteria: There are six sub criteria for these criteria according to the literature: adaptation capability with organization current processes, flexibility, reliability, software functionality, user quality and user interface, data analysis and report capability.

Supplier status criteria: There are 4 sub criteria for these criteria as follow: supplier credit, training quality, support quality, software updating quality.

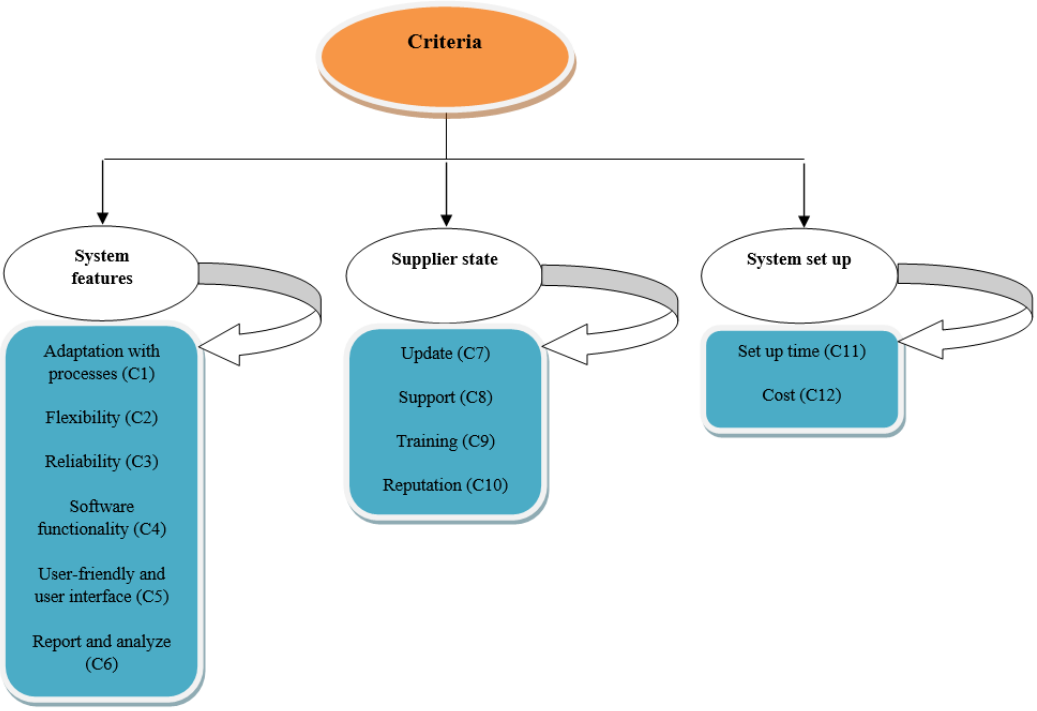

Fig. 1: Network model for criteria and subcriteria

Using fuzzy DEMATEL:

The purpose of using fuzzy DEMATEL in this method is to obtain relative weights of each criteria with regard to other criteria and making the overall relation matrix. In order to use Fuzzy DEMATEL in this method, we must go through following steps.

$$\begin{array}{c} \\ C_1 \\ C_2 \\ \vdots \\ C_n \end{array} \begin{array}{c} \begin{array}{cccc} C_1 & C_2 & \dots & C_n \end{array} \\ \begin{bmatrix} W_{c_1c_1} & W_{c_1c_2} & \dots & W_{c_1c_n} \\ W_{c_2c_1} & W_{c_2c_2} & \dots & W_{c_2c_n} \\ \vdots & \vdots & \vdots & \vdots \\ W_{c_nc_1} & W_{c_nc_2} & & W_{c_nc_n} \end{bmatrix} \end{array}$$

Fig. 2: Overall relation matrix

Building direct relation matrix between system factors as figure 1.

$$A = \begin{bmatrix} a_{11} & \cdots & a_{1j} & \cdots & a_{1n} \\ \vdots & & \vdots & & \vdots \\ a_{i1} & \cdots & a_{ij} & \cdots & a_{in} \\ \vdots & & \vdots & & \vdots \\ a_{n1} & \cdots & a_{nj} & \cdots & a_{nn} \end{bmatrix}$$

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Fig. 3: Direct relation matrix between system factors

Defuzzification of initial direct matrix: Linguistic terms must be converting to fuzzy number by one of the fuzzy spectrum. Triangular fuzzy number is used in this paper. We can use table 2 to convert vague judgments to triangular fuzzy numbers [24].

Table 2: Verbal judgments to triangular fuzzy numbers

Linguistic variable	Relevant triangular fuzzy number
Effectless	(0, 0, 0.25)
Very low effect	(0, 0.25, 0.5)
Low effect	(0.25, 0.5, 0.75)
High effect	(0.5, 0.75, 1)
Very high effect	(0.75, 1, 1)

The current paper uses CFCS approach (converting fuzzy data to certain points) proposed by Opriacovic and tzeng for defuzzy [24]. After defuzzification, expert opinions are aggregated and initial direct relation matrix is built by absolute numbers a_{ij} which is the effect of factor I on factor j.

Normalizing direct relations matrix: First we must normalize initial direct relations matrix. Normalized direct relation matrix $X = \left[x_{ij}\right]_{n*n}$ is obtained by Eq 1. All the matrix components are being applied in $0 \le x_{ij} < 1$ constraint and all the main diagonal components of the matrix are equal to zero.

$$X = s \times A \qquad (1)$$

$$s = \min\left[\frac{1}{\max_i \sum_{j=1}^{n}\left|a_{ij}\right|}, \frac{1}{\max_j \sum_{i=1}^{n}\left|a_{ij}\right|}\right] \qquad (2)$$

Building overall relation matrix: We compute sum of an infinitive sequence of direct and indirect effects of elements among each other (In addition to all possible feedbacks) as a geometric progression and on the basis of current graph rules. The sum of progression is overall relation matrix (T).

$$T=X\,(1-X)^{-1} \qquad (3)$$

Applying the heuristic algorithm:

By applying the heuristic algorithm to each overall relation matrix of criteria:, we can build the supermatrix and obtain the weights of elements of each criteria by using super decision software to calculate the limit supermatrix according to network model and output of fuzzy DEMATEL approach (overall relation matrix T) and relative weights of alternative with regard to elements of each criteria. In the presented network model, alternatives are independent from criteria and there are no dependencies between criteria. In this case the relative weights of elements of each criteria are only affected by the overall relation matrix of relevant criteria. Therefor we can apply the proposed method to each overall relation matrix (T) and obtain relative weight of each criteria with regard to relevant criteria. This algorithm has an acceptable accuracy and made us independent of building the supermatrix and using SUPER DECISION software. Therefor augment us with more speed and comfort. The accuracy of the method is compared with output of SUPER DECISION software.

The proposed method stages are as follow: first we must obtain $\overrightarrow{U'}$ from normalizing $\vec{U}$ and $\overrightarrow{S'}$ from normalizing $\vec{S}$ by Eq (4) and (5) then we can compute relative weights of each criteria with regard to relevant criteria by arithmetic average method.

$u_i = \sum_{J=1}^{n} \mathrm{w}_{C_iC_J} = 1, 2, \ldots, \mathrm{n}$ n=number of elements of relevant criteria (4)

$\mathrm{w}_{C_iC_J}$: Relative weight of element C_i with regard to element C_J

$$\vec{U} = \begin{bmatrix} u_1 \\ \vdots \\ u_n \end{bmatrix}$$

$$\overrightarrow{U'} = \begin{bmatrix} u'_1 = \dfrac{u_1}{u_1 + u_2 + \ldots u_n} \\ u'_2 = \dfrac{u_2}{u_1 + u_2 + \ldots u_n} \\ \vdots \\ u'_n = \dfrac{u_n}{u_1 + u_2 + \ldots u_n} \end{bmatrix} \qquad (5)$$

$$Z_{Oracle\ system} = \frac{\int \mu_{\tilde{A}}(z).zdz}{\int \mu_{\tilde{A}}(z)dz} = \frac{\int_0^{0.32} 2z^2 dz + \int_{0.32}^{0.68} 0.64zdz + \int_{.068}^{0.82} -2z^2 + 2zdz + \int_{0.68}^{1} .36zdz}{\int_0^{0.32} 2zdz + \int_{0.32}^{0.68} 0.64dz + \int_{.068}^{0.82} -2z + 2dz + \int_{0.68}^{1} .36dz} \quad (6)$$

$$= \frac{0.248056}{0.4676} = 0.5305$$

$$\overrightarrow{S'} = \begin{bmatrix} s_1 \\ s_2 \\ \vdots \\ s_n \end{bmatrix}$$

$$\overrightarrow{S'} = \begin{bmatrix} s'_1 = \dfrac{s_1}{s_1 + s_2 + \ldots + s_n} \\ s'_2 = \dfrac{s_2}{s_1 + s_2 + \ldots + s_n} \\ \vdots \\ s'_n = \dfrac{s_n}{s_1 + s_2 + \ldots + s_n} \end{bmatrix} \quad (7)$$

$$W_{C_i} = \frac{S'_i + U'_i}{2} \qquad i = 1, \ldots, n \quad (8)$$

For better understanding the proposed method we apply this method on "system feature criteria". First we obtain relative weights of elements of "system feature" criteria with regard to "system feature".

Table 3: Overall relation matrix of system features

With regard to system feature	C1	C2	C3	C4	C5	C6
C1	0.2172	0.1489	0.0879	0.1478	0.2179	0.1371
C2	0.212	0.1151	0.1572	0.1169	0.1103	0.1981
C3	0.1241	0.2104	0.1741	0.2519	0.0761	0.231
C4	0.2412	0.1217	0.2362	0.1781	0.2471	0.1476
C5	0.1895	0.1981	0.2514	0.24517	0.1463	0.1841
C6	0.016	0.2058	0.0932	0.0636	0.2023	0.1021

$$U_1 = w_{C_1C_1} + w_{C_1C_2} + \ldots + w_{C_1C_6} = 2172 + 0.1489 + 0.0879 + 0.1478 + 0.2179 + 0.1371 = 0.9568$$

$$\vec{U} = \begin{bmatrix} 0.9568 \\ 0.9096 \\ 1.0676 \\ 1.1719 \\ 1.21457 \\ 0.683 \\ \end{bmatrix} \sum_{J=1}^{6} w_{C_iC_J} = 1, 2, \ldots, 6 \ \overrightarrow{U'} = \begin{bmatrix} 0.159374 \\ 0.151512 \\ 0.17783 \\ 0.195204 \\ 0.202311 \\ 0.113768 \end{bmatrix},$$

$$S_i = \sum_{J=1}^{n} w_{C_iC_J} \times w_{C_JC_i} \qquad i = 1, 2, \ldots, n$$

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$$S_1 = \left(w_{C_1C_1} \times w_{C_1C_1}\right) + \left(w_{C_1C_2} \times w_{C_2C_1}\right) + \ldots + \left(w_{C_1C_6} \times w_{C_6C_1}\right)$$

$$S_1 = (0.2172 \times 0.2172) + (0.1489 \times 0.212) + \ldots (0.1371 \times 0.016) = 0.16876$$

$$\vec{S} = \begin{bmatrix} 0.168786 \\ 0.154736 \\ 0.174454 \\ 0.211063 \\ 0.201503 \\ 0.121547 \end{bmatrix} , \quad \vec{S'} = \begin{bmatrix} 0.163538 \\ 0.144925 \\ 0.16903 \\ 0.204501 \\ 0.195238 \\ 0.117768 \end{bmatrix}$$

$$W_{C_i} = \frac{\vec{S}_i + \vec{U}_i}{2} \qquad i = 1, \ldots, n$$

$$W_{C_1} = \frac{S_1 + U_1}{2} = \frac{0.159374 + 0.163538}{2} = 0.16145$$

Table 4: Result comparison between super decision software and heuristic method with regard to system features criteria

Relative weights of system features criteria elements	SuperDecision output	Heuristic output
WC1	0.161456	0.161443
WC2	0.14713	0.150717
WC3	0.173827	0.173374
WC4	0.200807	0.199798
WC5	0.201742	0.198734
WC6	0.11456	0.11575

And we can obtain the other relative weights of elements with regard to relevant criteria by the same method

Table 5: Overall relation matrix of supplier state

With regard to supplier state	C7	C8	C9	C10
C7	0.263	0.4231	0.5463	0.1412
C8	0.4556	0.227	0.1384	0.2634
C9	0.1413	0.1234	0.2324	0.1412
C10	0.1413	0.2276	0.084	0.4556

Table 6: Result comparison between super decision software and heuristic method with regard to supplier state criteria

Relative weights of supplier state criteria elements	Super Decision output	Heuristic method output
WC7	0.324271	0.328704
WC8	0.295914	0.276278
WC9	0.149416	0.149639
WC10	0.230399	0.244074

Table 7: Overall relation matrix of system set up criteria

With regard to system set up	C11	C12
C11	0.7229	0.6875
C12	0.2771	0.3125

Table 8: Result comparison between super decision software and heuristic method with regard to system set up criteria

With regard to system set up criteria	Super Decision output	Heuristic method output
WC11	0.693	0.709134355
WC12	0	0.291462356

Designing fuzzy sets of decision making criteria:

In this stage three fuzzy sets as low, medium, high is designed for each decision making criteria. Fuzzy sets are designed according to obtained weights of elements and ERP purchaser organization status. We must notice that summation of relative weights of elements with regard to relevant criteria is equal to 1. For convenience, a bigger scale is considered as score scale. Fuzzy sets and membership functions are defined according to considered domain (scale) for each criteria and current score and organization relative strategy. It is notable that defined scale for each criteria, can be different.

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Table 9: Sub criteria score

Main criteria	Sub criteria	Sub criteria score	Criteria score summation
System features	c1	0.16*100=16	100
	c2	0.15*100=15	
	c3	0.17*100=17	
	c4	20	
	c5	20	
	c6	12	
Supplier state	c7	33	100
	c8	28	
	c9	15	
System set up	c10	24	100
	c11	71	
	c12	29	

Now as we mentioned above, we must define membership functions for each criteria in current problem. Membership functions for system set up criteria are as follow:

$$\text{System features}_{\text{low}}\,(0,6,50)=\begin{cases}0 & , x<0\\ 1 & , 0<x<6\\ \dfrac{50-x}{44} & , 6<x<50\\ 1 & , x>50\end{cases} \tag{9}$$

$$\text{System features}_{\text{medium}}\,(6,50,94)=\begin{cases}0 & , x<6\\ \dfrac{x-6}{44} & , 6<x<50\\ \dfrac{94-x}{50} & , 50<x<94\\ 0 & , x>94\end{cases} \tag{10}$$

$$\text{System features}_{\text{high}}\,(50,94,100)=\begin{cases}0 & , x<50\\ \dfrac{x-50}{44} & , 50<x<94\\ 1 & , 94<x<1000\\ 0 & , x>1000\end{cases} \tag{11}$$

Membership functions for supplier state criteria:

$$\text{Supplier state}_{\text{low}}\,(0,8,50)=\begin{cases}0 & , x<0\\ 1 & , 0<x<8\\ \dfrac{50-x}{42} & , 8<x<50\\ 0 & , x>50\end{cases} \tag{12}$$

$$\text{Supplier state}_{\text{ـئmedium}}\,(8,50,92)=\begin{cases}0 & , x<8\\ \dfrac{x-8}{42} & , 8<x<50\\ \dfrac{92-x}{42} & , 50<x<92\\ 0 & , x>92\end{cases} \tag{13}$$

$$\text{Supplier state}_{high}\ (50, 92, 100) = \begin{cases} 0\ ,\ x < 50 \\ \dfrac{x-50}{42},\ 50 < x < 92 \\ 1\ ,\ 92 < x < 100 \\ 0,\ x > 100 \end{cases} \tag{14}$$

Membership functions for system set up criteria

$$\text{System set up}_{low}\ (0, 15, 50) = \begin{cases} 0\ ,\ x < 0 \\ 1\ ,\ 0 < x < 15 \\ \dfrac{50-x}{35},\ 15 < x < 50 \\ 0,\ x > 50 \end{cases} \tag{15}$$

$$\text{System set up}_{lmedium}\ (8, 50, 92) = \begin{cases} 0\ ,\ x < 15 \\ \dfrac{x-15}{35},\ 15 < x < 50 \\ \dfrac{85-x}{35},\ 50 < x < 85 \\ 0\ ,\ x > 85 \end{cases} \tag{16}$$

$$\text{System set up}_{high}\ (50, 92, 100) = \begin{cases} 0\ ,\ x < 50 \\ \dfrac{x-50}{42},\ 50 < x < 92 \\ 1\ ,\ 92 < x < 100 \\ 0,\ x > 100 \end{cases} \tag{17}$$

inputs fuzzification:

Expert system analyze presented data from supplier companies and obtained information from oral interview and determine organization optimal system score and alternatives score with regard to each element. Alternatives and organization optimal system score with regard to each criteria is obtained by summation of alternatives and organization optimal scores with regard to each element of criteria. Now for making the inputs fuzzy, membership degree of alternatives and organization optimal system in each criteria are determined by defined membership functions for relevant criteria.

Table 10: Optimal organization system score and the alternatives score for system features criteria:

Sub criteria	Score upper limit	Optimal system	Alternative1 oracle	Alternative2 Sage	Alternative3 MFG
c1	16	11	13	3	5
c2	15	12	11	5	6
c3	17	10	10	7	7
c4	20	10	18	10	14
c5	20	10	14	6	16
c6	12	5	12	7	12
sum	100	58	78	38	60

Table 11: Optimal organization system score and the alternatives score for purchaser state criteria:

sub criteria	upper limit	optimal system	alternative1 oracle	alternative2 sage	alternative3 MFG
c7	33	10	17	10	13
c8	28	20	23	10	13
c9	15	23	23	13	13
c10	24	17	26	20	20
Sum	100	70	89	53	59

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Table 12: Optimal organization system score and the alternatives score for system set up criteria:

sub criteria	upper limit score	optimal system	alternative1 oracle	alternative2 sage	alternative3 MFG
c7	71	36	5	40	31
c8	29	12	6	20	9
sum	100	48	11	60	40

Now Membership degree of the optimal system and the alternative is obtained according to defined membership function for each criteria.

Table 13: Optimal organization system and the alternatives membership degree in membership function of system feature criteria

		Optimal system	*Alternative1*	*Alternative2*	*Alternative3*
	obtained score	58	78	38	60
membership degree in fuzzy membership function	low	0	0	0.27	0
	medium	0.82	0.36	0.73	0.77
	high	0.18	0.64	0	0.23

Table 14: Optimal organization system and the alternatives membership degree in membership function of purchaser state criteria.

		Optimal system	*Alternative1*	*Alternative2*	*Alternative3*
	obtained score	70	89	53	59
membership degree in fuzzy membership function	low	0	0	0	0
	medium	0.52	0.07	0.93	0.79
	high	0.48	0.93	0.07	0.21

Table 15: Optimal organization system and the alternatives membership degree in membership function of system set up criteria.

		Optimal system	*Alternative1*	*Alternative2*	*Alternative3*
	obtained score	48	11	60	40
membership degree in fuzzy membership function	low	0.06	1	0	0.29
	medium	0.94	0	0.71	0.71
	high	0	0	0.29	0

Defining fuzzy expert system rules:

Reasoning center of expert system includes a set of if-then rules. In fuzzy expert system rules are expressed by a set of linguistic terms. Expert system rules compare optimal organization status with the alternative with regard to each main criteria and express coincidence degree by linguistic terms. In this fuzzy expert system, nine rule is defined for each criteria as follow:

The conformity is *high* when optimal organization system with regard to considered criteria is *low* and the alternative is *low*.

The conformity is *medium* when optimal organization system with regard to considered criteria is *low* and the alternative is *medium*.

The conformity is *low* when optimal organization system with regard to considered criteria is *low* and the alternative is *high*.

The conformity is *medium* when optimal organization system with regard to considered criteria is *medium* and the alternative is *low*.

The conformity is *high* when optimal organization system with regard to considered criteria is *medium* and the alternative is *medium*.

The conformity is *medium* when optimal organization system with regard to considered criteria is *medium* and the alternative is *high*.

The conformity is *low* when optimal organization system with regard to considered criteria is *high* and the alternative is *low*.

The conformity is *medium* when optimal organization system with regard to considered criteria is *high* and the alternative is *medium*.

The conformity is *high* when optimal organization system with regard to considered criteria is *high* and the alternative is *high*.

9 rule is defined for each criteria then we must define 27 rule in this paper. Each fuzzy expert system gives us a fuzzy outputs according to the computed membership degree for each optimal system and alternative. For example for first alternative and in system feature criteria fuzzy outputs are as follow

The conformity is high if optimal system is medium and the system is medium with regard to system features criteria

The conformity is medium if optimal system is medium and the system is high with regard to system features criteria

The conformity is medium if optimal system is high and the system is medium with regard to system features criteria

The conformity is high if optimal system is high and the system is high with regard to system features criteria

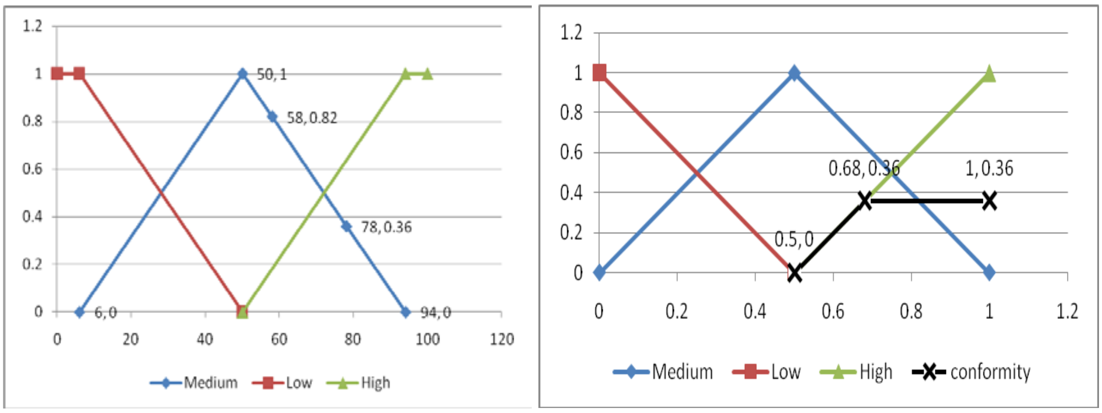

Fig. 4: Fuzzy output according to the computed membership degree for alternative and in system feature criteria by rule 5

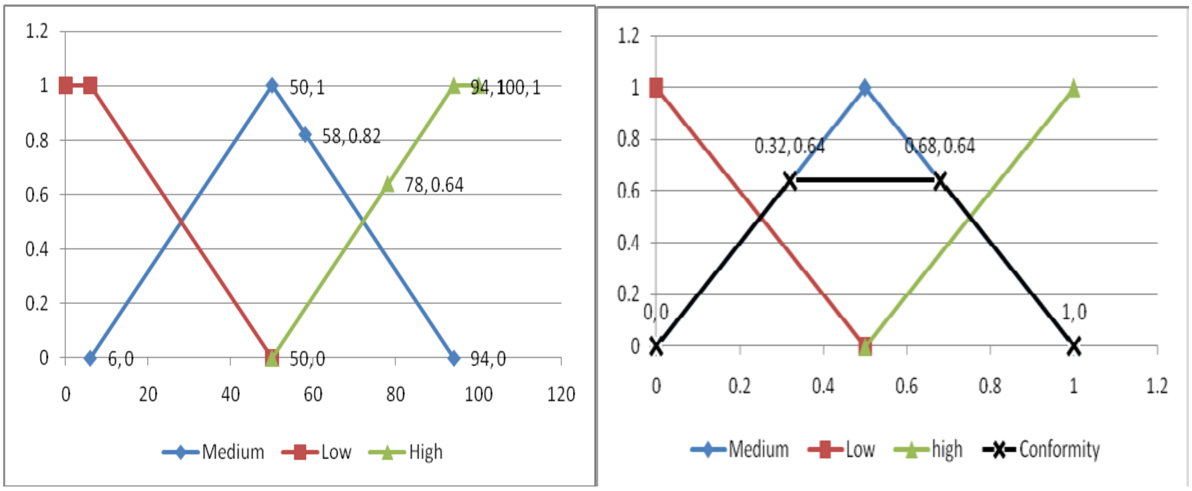

Fig. 5: Fuzzy output according to the computed membership degree for alternative and in system feature criteria by rule 6

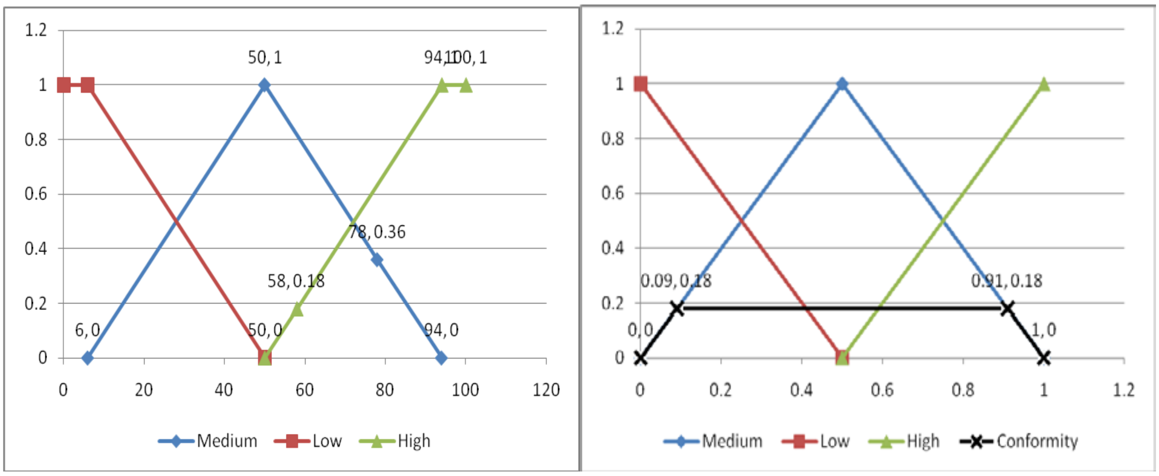

Fig. 6: Fuzzy output according to the computed membership degree for alternative and in system feature criteria by rule 8

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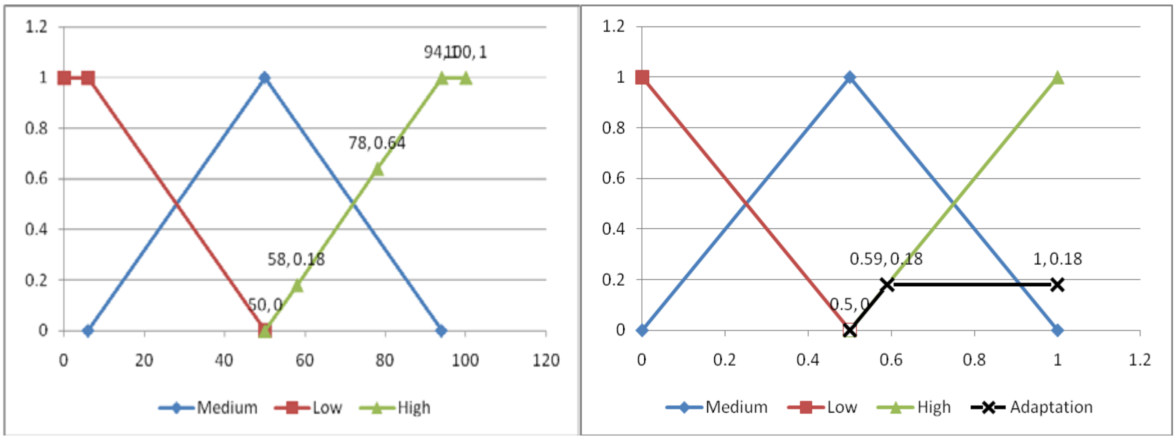

Fig. 7: Fuzzy output according to the computed membership degree for alternative and in system feature criteria by rule 3

The output is zero from the other 5 rules because the membership degree of optimal system or alternative is equal to 1 or both of them are zero.

Fuzzy inference:

Fuzzy inference is the most important stage of fuzzy expert system process and is conducted by defined rules. A fuzzy set of conformity of optimal organization system with the alternative with regard to the relevant criteria defined by integrating fuzzy outputs obtained from conformity degree of optimal organization system with the alternative with regard to one criteria with 9 defined rule for that criteria. In this paper we have 3 main criteria that create 3 fuzzy set for each alternative.

Fuzzy set for first alternative with regard to system features are equal to:

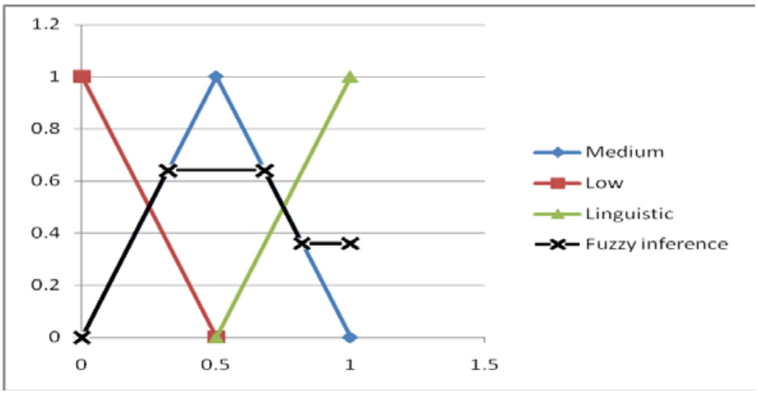

Fig. 8: Fuzzy set for first alternative with regard to system features

Defuzzification:

It is converting fuzzy set to a numeral value. In this method If $\tilde{A}$ is a fuzzy set, numeral value is as follow:

$$Z^{*} = \frac{\int \mu_{\tilde{A}}(z).zdz}{\int \mu_{\tilde{A}}(z)dz} \tag{18}$$

In this stage, we have 3 fuzzy set for each alternative. Numeral value of created fuzzy sets for first alternative with regard to system features is as follow:

$$\mu_{\tilde{A}}(Z) = \begin{cases} 2z, z \in [0, 0.32) \\ 0.64, z \in [0.32, 0.68) \\ -2z + 2, z \in [0.68, 0.82) \\ 0.36, z \in [0.82, 1) \end{cases} \tag{19}$$

$$Z_{Oracle\ system} = \frac{\int \mu_{\tilde{A}}(z).zdz}{\int \mu_{\tilde{A}}(z)dz} = \frac{\int_0^{0.32} 2z^2 dz + \int_{0.32}^{0.68} 0.64zdz + \int_{.068}^{0.82} -2z^2 + 2zdz + \int_{0.68}^{1} .36zdz}{\int_0^{0.32} 2zdz + \int_{0.32}^{0.68} 0.64dz + \int_{.068}^{0.82} -2z + 2dz + \int_{0.68}^{1} .36dz} = \frac{0.248056}{0.4676} = 0.5305$$

Alternative ranking:

After defuzzification a numeral value is obtained for each alternative with regard to each criteria. If criteria have equal weights from manager's view, Arithmetic mean of the values obtained with each alternative with regard to criteria is the analyzing method for the alternative. Thus by considering equal weights for criteria we have:

Table 16: Final score of alternatives

alternative	feature conformity	status conformity	set up conformity	final score
Oracle	0.5305	0.5547	0.5009	0.6566
Sage	0.6232	0.5647	0.6277	0.6052
MFG	0.6566	0.5646	0.6292	0.6168

If criteria do not have equal weight from manager's view we need to use paired comparison method of saaty to obtain their weights and after applying it to the relevant value, the final score will be computed.

Conclusion:

In this paper, a comprehensive method with a heuristic algorithm based on analytical network process is presented to select an optimal enterprise resource planning system. In decision making by fuzzy expert system with regard to fuzzy logic, having an error in computing optimal value of an element, do not undermine decision making processes because all the considered elements determine optimal value of organization in each decision criteria.

Fuzzy expert system rules review alternative conditions according to organization demands and the ranking is applied without direct comparing of alternatives with optimal conditions of organization and therefore alternative adaptation with optimal organization condition is the base for selecting the optimal alternative and optimal alternative will be selected based on organization desirability not suppresses to the other alternatives. In this approach selected alternative is based on organization demand.

In the presented network model criteria are independent from alternatives and there is no dependency between criteria. In this case relative weights of each criteria with regard to relevant criteria is only affected by overall relation matrix (T). Therefore we can apply this algorithm for each overall relation matrix to obtain relative weights of each criteria with regard to relevant criteria. This algorithm has an acceptable accuracy and makes us independent of building super matrix and the decision making is done more quickly and easily. The algorithm results are compared with software outputs. The comparisons proves the accuracy of the algorithm. Finally a fuzzy expert system is presented according to relative weights of elements. This expert system has been implemented in one of the industrial units in Iran and the results is presented.

Integrating this method with other ERP selecting methods (like Fuzzy MADM) is suggested to reduce vulnerability and achieve higher effectiveness. Evaluating the outputs of ERP selection by this comprehensive method and improving criteria and their elements is a significant issue

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