FUZZY DECISION MAKING FOR SELECTION OF INFORMATION SYSTEM DEVELOPMENT APPROACH①

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ABSTRACT Since information system development(ISD) is guided by information system development approach(ISDA), its success or failure mainly depends upon whether appropriate ISDA is chosen or not. By adopting fuzzy decision making theory, a new method of evaluating alternative ISDAes to select satisfactory one was obtained, for which several mathematical models of fuzzy synthetic discrimination were created. In particular, a summarized evaluation index system was established. Finally, the application of the above method to a practical information system(IS) was illustrated.

Key words ISDA fuzzy decision making fuzzy synthetic descrimination model

1 INTRODUCTION

According to our development experience, the first problem of which information system (IS) developers meet during information system development (ISD) is to decide what development strategy should be taken and what information system development approach (ISDA) should be chosen. In the past, a quantity of IS ended in failure. Our further study showed that most of them paid little or even no attention to the selection of ISDA. Actually, every ISD, which should be directed by ISDA, can be viewed as a system engineering. So ISDA plays an important role in ISD and its decision making greatly influences the development effect of IS[1, 2]. But how to choose a satisfactory ISDA from many alternatives? Provided some models can be established, it will be sure to be more helpful to efficiently avoid the blindness of ISDA's selection. Only in this way can IS developers judge different ISDAes objectively and fairly, not having partiality for some special ones. And then, it can be guaranteed that ISD will go on successfully.

It is worth mentioning that ISDA here refers to not only typical single ISDA such as Prototyping Approach but also complex ISDA, which is combination of two or three single ones, such as Object-oriented Prototyping Approach. Meanwhile, selection of ISDA itself can also be considered as a system problem, which consequently demands some models. Therefore some researches on modelling are made in this paper based on the system thought. With the help of simulation results, decision support will be provided to IS developers for ISDA's selection.

2 ESTABLISHMENT OF EVALUATION INDEX SYSTEM

In most cases, an ISDA has its own advantages as well as its disadvantages. Hence it is very difficult to judge exactly whether an ISDA is good or not. In order to compare all possible or feasible ISDA alternatives, it seems very important to determine an evaluation standard for references. At first, it should be based on full

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discussion over all elements which may influence the evaluation result, and then only main ones are left to form the evaluation index system[3].

Generally speaking, the following aspects should be paid great attention to, because they play important roles in the evaluation and selection of ISDA:

(1) Maturity which indicates perfection of methodology itself, convenience of development tools, abundance of IS development experiences, advancement of development technology including database management system, programming language, communication softwares and application ones, standard and operational development specifications, etc.

(2) Reliability which refers to being suitable with problem domain, organizational structure and management level of IS developed. Besides these, it is required to mate with hardwares and softwares of IS. In addition, reliability of operation and manipulation, rapid retrieval of trouble, and flexibility of avoiding mistakes, and so on, are required.

(3) Simplicity which means brief documents, convenient operation, less and concise development steps, easy to be understood and be trained, simple-structured and friendly user interface, good design of input-output, easy to control development steps, understandable prompt and explanation, real time help, strong and quick man-machine interaction, etc.

(4) Economy which includes low cost of hardwares, softwares, ISD and IS operation management, low expenditure of maintaining hardwares and softwares, short development cycle, efficient development and operation, real time controlling, etc.

(5) Maintainability which infers automatic detection and maintenance of system itself, automatic programming, intelligence and learning ability, maintainability of hardwares and softwares, etc.

(6) Extendibility which indicates standard interfaces, open-structured, easy to disassemble and assemble models, compatibility of softwares, extendibility of hardwares and softwares, independence of models, etc.

(7) Suitability which means adaptability of changes in system problem domain and organizational structure, adaptability of hardwares and softwares, learning abilities, intelligence level, compatibility of softwares and hardwares, generalization, standardization of program codes, etc.

(8) Reservation support which includes support of development environment, hardwares, softwares, development tools, communication tools, finance and rear service, programming languages, computer net, man-machine interaction, maintainers, developers, theory and methodology itself, attention which leaders pay, active participation of users, etc.

Actually, different IS may have different evaluation index system, which had better be determined by the opinions given by corresponding experts. Through soliciting their opinions, the number of indexes can be fixed. Generally speaking, an evaluation committee should be set up to be responsible for it[4, 5].

3 FUZZY SYNTHETIC DISCRIMINATION MODEL

It is very hard to express in a definite way how good an ISDA is. But in fact some evaluation opinions are given in a fuzzy way. According to the theory of fuzzy decision making, analysis of fuzzy evaluation is helpful to get synthetic discrimination result. A fuzzy synthetic discrimination model is elaborated as follows.

Respectively, let evaluation index matrix $\boldsymbol{U}$, remark matrix $\boldsymbol{V}$, fuzzy relation matrix $\boldsymbol{R}$ be

$$\boldsymbol{U}=(u_i)_{1\times n}(i=1,\ 2,\ \cdots,\ n) \tag{1}$$

$$\boldsymbol{V}=(v_j)_{1\times m}(j=1,\ 2,\ \cdots,\ m) \tag{2}$$

$$\boldsymbol{R}=(r_{ij})_{n\times m}(i=1,\ 2,\ \cdots,\ n;\ j=1,\ 2,\ \cdots,\ m) \tag{3}$$

where u_i is the i-th evaluation index, v_j is the j-th remark, r_{ij} is the possibility of the j-th remark according to the i-th evaluation index.

Since not every evaluation index plays the same important role in the evaluation index system, different coefficients are given. Let coefficient matrix $\boldsymbol{A}$ in view of evaluation indexes be

$$\boldsymbol{A}=(a_i)_{1\times n}(i=1,\ 2,\ \cdots,\ n) \tag{4}$$

where a is the importance degree of the i-th evaluation index and

$$\sum_{i=1}^{n} a_i = 1 \quad (5)$$

In order to take consideration over all opinions fairly, ordinary multiplication matrix algorithm is taken to calculate fuzzy evaluation result matrix $\boldsymbol{B}$. That is

$$\boldsymbol{B} = \boldsymbol{AR} = (a_i)_{1\times n}(r_{ij})_{n\times m} = (b_j)_{1\times m} \quad (i = 1, 2, \cdots, n;\ j = 1, 2, \cdots, m) \quad (6)$$

where b_j is the possibility of the j-th remark and

$$b_j = \sum_{i=1}^{n} a_i r_{ij} \quad (j = 1, 2, \cdots, m) \quad (7)$$

Suppose remark coefficient matrix $\boldsymbol{F}$ is given by

$$\boldsymbol{F} = (f_j)_{m\times 1} \quad (j = 1, 2, \cdots, m) \quad (8)$$

where f_j is the importance degree of the j-th remark and

$$\sum_{j=1}^{m} f_j = 1 \quad (9)$$

Therefore, a numeralized evaluation result can be gained, that is, fuzzy evaluation value D, which is given by

$$\boldsymbol{D} = \boldsymbol{BF} = (b_j)_{1\times m}(f_j)_{m\times 1} = \sum_{j=1}^{m} b_j f_j \quad (j = 1, 2, \cdots, m) \quad (10)$$

Finally, sorting on fuzzy evaluation value $\boldsymbol{D}$ of ISDA alternatives, the ISDA with maximum $\boldsymbol{D}$ is the optimal and the most satisfactory one.

4 IMPLEMENTATION AND MANAGEMENT OF FUZZY DECISION MAKING

The whole process of ISDA's fuzzy decision can be divided into the following steps[6-8].

Step 1: set up an expert committee

The committee will be a reliable data source for the fuzzy decision. Generally speaking, the committee had better be made up of at least 10 members, but not more than 20. Most important of all, is authority, representativity and justness should be guaranteed.

Step 2: pick out alternative ISDAes

For the purpose of choosing the most satisfactory ISDA, it is necessary to limit the comparison scope of ISDA alternatives. Through expert meeting or by Delphi investigation, all possible ISDAes should be scored by corresponding experts from the aspect of ISDA's advancement, maturity, applicability, and so on. On the basis of all opinions from the experts, at most 5 comparatively satisfactory ISDAes are picked out.

Step 3: calculate fuzzy relation matrix

Fuzzy relation matrix for each would-be-chosen ISDA had better be resulted from its remark percentage distribution table, which is counted up by the expert opinions for some certain alternative ISDA.

Suppose there are X members in the evaluation committee, among them, Y persons give a remark of v_j on an ISDA from the aspect of evaluation index u_i. So the element r_{ij} in the fuzzy relation matrix $\boldsymbol{R}$ for ISDA should be Y/X.

Step 4: determinate evaluation index coefficient matrix $\boldsymbol{A}$

Evaluation index coefficient matrix $\boldsymbol{A}$ should also be resulted from the opinons of the evaluation committee. It proves a good suggestion that each evaluation index is a coefficient w given by all committee members but the sum of all w given by one person should be 1. Moreover, suppose another authority coefficient c is distributed to the committee members in view of their differerent authority. After counting up and sorting out the opinions given by the experts, the final evaluation index coefficient matrix $\boldsymbol{A}$ can be made out.

Suppose there are X members in the evaluation committee, each of whom is provided an coefficient c_j ($j = 1, 2, \cdots, X$). Let the coefficient distribution vector for the evaluation index u_i be ($w_{j1}, w_{j2}, \cdots, w_{jX}$). So the final coefficient distribution result for evaluation index u_j is

$$\sum_{j=1}^{X} w_{ij} c_j \Big/ \sum_{j=1}^{X} c_j \quad (11)$$

Step 5: determinate remark coefficient matrix $\boldsymbol{F}$

Remark coefficient matrix $\boldsymbol{F}$ can be gained in the same way as the evaluation index coefficient matrix $\boldsymbol{A}$.

Step 6: simulate and calculate

In order to increase efficiency and guarantee the accuracy of the results, all calculation can be realized through corresponding application softwares or developing some programmes on com-

puter.

It is worth to emphasizae that if there are two or more ISDA alternatives having almost the same fuzzy evaluation value, it is necessary to gather all committee members to make further analysis and finally to select out the comparatively satisfactory ISDA. Of course, it should be based on the practical situation of the object system.

5 CASE STUDY AND ANALYSIS

As verification for selection of suitable ISDA according to actual situation, we have developed a practical information system, which is called as KBIS(King Bird Information System) and be introduced briefly as below.

5.1 Introduction

The story took place in Guangdong King Bird Group Company in China, a big enterprise employing more than 8 000 staffs and workers with a turnover in the year of the project 1994 of about 0.3 billion US dollars, which was composed of more than 10 companies, whose scope of business covered high technique agriculture, clothing manufacture, advertisement services, commerce, real estate investment and management, and so on.

In the past decades, great efforts were made to realize management modernization in the company, which laid a solid foundation for ISD. Continuous appearance of new competitors and likely changes of market structure made it urgent and necessary to call for and construct IS as soon as possible to improve the company's management situation directly and efficiently. Furthermore, the company was making considerable profit, which could provide enough financial guarantee for ISD.

The group company afforded to develop a large-sized computer aided management information system. In particular, its abundant funds, good quality of staffs, much application and management experiences of computer system, and high qualified IS maintainers laid a solid foundation for successful ISD.

5.2 Fuzzy selection of ISDA

After the cooperative partner for ISD, that is, the IS developers, were chosen, two temporary organizations for the ISD were founded. They were a team of IS developers which were composed of such system developers as system analyzers, system designers and an evaluation committee of ISDA which consisted of 10 experts, 5 of whom were IS developers, 2 of them were managers of the company and the other 3 were experts specially invited. Of course, the representativity, authority and justness were taken into account when the committee was founded.

Based on full discussion, it was determined to take fuzzy decision making approach to pick out satisfactory ISDA and 8 evaluation indexes were also fixed, which were successively maturity, reliability, simplicity, economy, maintainability, extendibility, suitability, reservation support. Especially, the evaluation indexes were also distributed with different coefficients, which were shown in the evaluation index coefficient matrix $\boldsymbol{A}$ with(0.15 0.2 0.05 0.1 0.1 0.15 0.2 0.05). At the same time, the remarks of ISDA were divided into 4 levels, that is, excellent, satisfactory, OK, dissatisfactory, respectively. In particular, a coefficient matrix $\boldsymbol{F}$ for the 4 remarks was also fixed as$(0.5 \quad 0.4 \quad 0.1 \quad 0.0)^{T}$.

After the analysis of the object system which would be developed, all committee members agreed to take the following 5 ISDAes as alternatives. They were Structured Prototyping Approach(SPA), Soft System and Structured Prototyping Approach(SSSPA), Soft System and Structured Life Cycle Approach(SSSLCA), Soft System and Object-oriented Prototyping Approach(SSOOPA), Soft System and Prototyping Approach(SSPA), respectively. On the basis of detailed and further investigation of the object system and the IS developers, every committee member made a fuzzy decision over each alternative ISDA. Then all opinions given by the committee members were counted up and 5 fuzzy relation matrixes $\boldsymbol{R}_1$, $\boldsymbol{R}_2$, $\boldsymbol{R}_3$, $\boldsymbol{R}_4$, $\boldsymbol{R}_5$, respectively for the 5 alternatives were reached as follows:

$$R_1=\begin{bmatrix}0.8&0.1&0.1&0.0\\0.2&0.3&0.4&0.1\\0.4&0.4&0.1&0.1\\0.2&0.3&0.3&0.2\\0.5&0.2&0.2&0.1\\0.4&0.2&0.3&0.1\\0.1&0.3&0.3&0.3\\0.8&0.1&0.1&0.0\end{bmatrix}$$

$$R_2=\begin{bmatrix}0.6&0.2&0.1&0.1\\0.3&0.5&0.2&0.0\\0.3&0.4&0.2&0.1\\0.2&0.2&0.4&0.2\\0.5&0.3&0.1&0.1\\0.4&0.2&0.3&0.1\\0.3&0.3&0.2&0.2\\0.7&0.2&0.1&0.0\end{bmatrix}$$

$$R_3=\begin{bmatrix}0.6&0.2&0.1&0.1\\0.3&0.4&0.2&0.1\\0.1&0.5&0.2&0.2\\0.1&0.2&0.5&0.2\\0.2&0.3&0.2&0.3\\0.4&0.2&0.2&0.2\\0.1&0.2&0.4&0.3\\0.7&0.1&0.1&0.1\end{bmatrix}$$

$$R_4=\begin{bmatrix}0.2&0.3&0.3&0.2\\0.4&0.4&0.1&0.1\\0.2&0.5&0.2&0.1\\0.0&0.3&0.4&0.3\\0.6&0.2&0.1&0.1\\0.5&0.3&0.2&0.0\\0.5&0.3&0.1&0.1\\0.4&0.2&0.2&0.2\end{bmatrix}$$

$$R_5=\begin{bmatrix}0.6&0.2&0.1&0.1\\0.3&0.4&0.2&0.1\\0.3&0.4&0.2&0.1\\0.3&0.4&0.3&0.0\\0.4&0.2&0.2&0.2\\0.3&0.3&0.1&0.3\\0.2&0.3&0.3&0.2\\0.7&0.2&0.1&0.0\end{bmatrix}$$

Therefore the final fuzzy evaluation result matrixes B_1, B_2, B_3, B_4, B_5, for the 5 alternative ISDAes were calculated as follows:

$B_1 = AR_1 = (0.37 \quad 0.24 \quad 0.26 \quad 0.13)$

$B_2 = AR_2 = (0.39 \quad 0.3 \quad 0.205 \quad 0.105)$

$B_3 = AR_3 = (0.3 \quad 0.26 \quad 0.25 \quad 0.19)$

$B_4 = AR_4 = (0.375 \quad 0.315 \quad 0.185 \quad 0.125)$

$B_5 = AR_5 = (0.355 \quad 0.305 \quad 0.195 \quad 0.145)$

Finally, the fuzzy evaluation values for the 5 alternatives were computed as follows:

$D_1 = B_1F = 0.307$; $D_2 = B_2F = 0.3355$;

$D_3 = B_3F = 0.279$; $D_4 = B_4F = 0.322$;

$D_5 = B_5F = 0.319$

Obviously, the second alternative ISDA, SSSPA, nearly had the same fuzzy evaluation value as the fourth, SSOOPA. At this time, it was necessary to carry out further analysis over them. Considering that the IS developers had not accumulated many Object-oriented development experiences and that Object-oriented Approach itself was not perfect in the aspect of theory, the evaluation committee agreed to develop this IS by the second alternative ISDA.

6 CONCLUSION

The development of KBIS showed us the great importance of choosing appropriate ISDA at the beginning of ISD. With the support from the theory of fuzzy decision making, it has proved that fuzzy synthetic discrimination models are in great help for the selection of satisfactory ISDA.

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