Adaptability Evaluation of Enterprise Information Systems Based on Object-based Knowledge Mesh

Chaogai Xue
Department of Management Engineering, Zhengzhou University, Zhengzhou, China
myrayy@zzu.edu.cn

Abstract—To apply enterprise information systems more widely, it is necessary to evaluate their adaptability. In this paper, firstly, an index set of adaptability evaluation system based on object-based knowledge mesh (OKM) is proposed and then, according to goal-question-metrics (GQM) for enterprise information systems, and the quantitative measurement is given. Second, based on similarity to ideal solution (TOPSIS), the evaluation model is built and the adaptability evaluation (AE) algorithm is proposed to evaluate enterprise information systems’ adaptability. Finally, the application of the evaluation system and AE algorithm is verified through an example, which provides quantitative references for evaluating and optimizing enterprise information systems’ adaptability.

Index terms—adaptability evaluation, enterprise information systems, object-based knowledge mesh, similarity to ideal solution

I. INTRODUCTION

With the development of science and technology, especially information technology, the environment of enterprise information systems (EIS) is changing rapidly. As the change is eternal, EIS should have the ability to adapt to various external and internal environments in order to have continuous competitive advantages. In other words, combined with the environment, EIS should have better relevant properties, like time, flexibility, reconfiguration property, etc. These properties all reflect the concept of “adaptability”, so the evaluation on adaptability is one of the important aspects in EIS optimization, which is also the main objective of this paper.

At present, there is considerable research on the adaptability of software systems, which can be briefly described as follows: 1) study on the self-adaptability of software [1-2]. 2) study on the adaptive mechanism of software systems [3-5]. 3) study on the adaptability evaluation of EIS [6-9]. As an example of 1) above, Ref. [2] studied the generic adaptive software architecture style, and as an example of 2), Ref. [3] studied an architecture-oriented mechanism for self-adaptation of software systems. These studies have laid a steady foundation for improvement on enterprise information systems’ adaptability (EISA). In terms of 3), Ref. [6] studied the evaluation index matrix with three dimensions by dividing the evaluation indexes for information system into layers. However, there are differences between the adaptability of software systems and EISA. Firstly, EIS include not only software but also business process. Secondly, the environment of software systems means the operation carrier or the development platform, but the environment of EIS means the market, external policies and the internal operation environment. Thus, the adaptability of software system isn’t equal to EISA. However little reference considers the differences between them, and the related quantitative research is even less.

In order to make quantitative evaluation research on EISA, it’s necessary to formalize EIS firstly. As is known, EIS is a kind of very complicated knowledge difficult to be represented by symbolic doctrine or connection doctrine. However, it can be represented by a mesh known as the knowledge mesh (KM), which is proposed to represent manufacturing mode in knowledgable manufacturing system (KMS) [10]. But for large scaled systems, the KM will be too huge to make further research (such as reconfiguration, etc.), thus object-based knowledge mesh (OKM) [11-13] was brought forward. OKM combines object-oriented technologies and knowledge mesh theory, realizes formal representation of information systems, software systems and manufacturing modes, and solves information explosion in the KM.

Based on OKM, EIS can be formalized. Thereafter the quantitative adaptability evaluation and further optimization of EIS can be studied. In this paper, a set of adaptability evaluation system based on OKM is proposed and the corresponding evaluation model and algorithm are given, which can help enterprises make reasonable decisions.

II. ADAPTABILITY EVALUATION SYSTEM

A. Enterprise Information System and its Formal Representation

System performance is determined by its structure. To make quantitative evaluation research on EISA, EIS
A formal representation method is used to formalize its indexes relative with its structure. In the formal representation of EIS by OKM, the mapping relationships are as follows:

1. Sub-modules of EIS including business process and software can be mapped into atom knowledge points or comprehensive knowledge points.

2. The relationships between business process and software can be mapped into the complex or information relationships in OKM.

3. Comprehensive knowledge points can be decomposed into atomic knowledge points.

4. Each sub-module has specific functions.

Hence, two types of knowledge points are discussed in this paper according to OKM.

According to the representation of EIS by OKM, the following items used in the evaluation of EISA are defined.

\[ q_{BSP} \]: the comprehensive knowledge points expressing business process information. Assuming there are \( n \) basic business process, \( m \) sub-links, i.e. \( BP = \{ BP_1, BP_2, \ldots, BP_m \} \).

\[ q_{SSP} \]: the comprehensive knowledge points expressing software information. Assuming there are \( r \) software sub-modules, i.e. \( S = \{ S(1), S(2), \ldots, S(r) \} \).

According to the knowledge points above, the relationships and functions can be embodied by the knowledge points themselves or between them.

B. EISA Evaluation System based on GQM

To study EIS adaptability optimization, it is necessary to know the influencing factors of EIS adaptability as well as the corresponding index system. Fortunately, Goals-Questions-Metrics (GQM) gives a solution to this problem. GQM is a goal-oriented modeling method for measurement, and it has been successfully used in various fields.

According to GQM [9], the goals can be ensured, which include general goal and sub goals.

1. General goal: Ensure the evaluation of EIS adaptability for enterprises is correct.

2. Sub goals: According to the general goal, sub goals and the description are shown in Tab. 1.

The sub-goal A is taken as an example to show the process of the GQM method as shown in Tab. 2, and in the same way other sub goals are analyzed as follows.

<table>
<thead>
<tr>
<th>Sub Goals</th>
<th>Descriptions</th>
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<tbody>
<tr>
<td>Sub-GoalA: Time as short as possible</td>
<td>Time spent by the system to adopt to the change</td>
</tr>
<tr>
<td>Sub-GoalB: Cost as little as possible</td>
<td>Cost spent by the system to adopt to the change</td>
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<tr>
<td>Sub-GoalC: Complexity as low as possible</td>
<td>Complexity of the system to adopt to the change</td>
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<tr>
<td>Sub-GoalD: Risk as low as possible</td>
<td>System risk after adjustment</td>
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<td>Sub-GoalE: Robust as well as possible</td>
<td>System stability and reliability after adjustment</td>
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<thead>
<tr>
<th>Goals</th>
<th>label</th>
<th>Question and metrics</th>
</tr>
</thead>
<tbody>
<tr>
<td>Q1</td>
<td></td>
<td>Does the time spent in the adjustment influence EISA?</td>
</tr>
<tr>
<td>M1</td>
<td></td>
<td>Number of the business process in the adjustment</td>
</tr>
<tr>
<td>M1.1</td>
<td>( n )</td>
<td>Number of the basic business process in the adjustment</td>
</tr>
<tr>
<td>M1.2</td>
<td>( m )</td>
<td>Number of sub-process ( j ) in the basic business process ( i ) in the adjustment</td>
</tr>
<tr>
<td>M2</td>
<td>( r )</td>
<td>Number of the software module ( k ) in the adjustment</td>
</tr>
<tr>
<td>Q2</td>
<td></td>
<td>Does the time spent in adjusting elements influence EISA?</td>
</tr>
<tr>
<td>M3</td>
<td>( t(BP) )</td>
<td>Time spent in adjusting business process ( BP_q )</td>
</tr>
<tr>
<td>M4</td>
<td>( t(S(k)) )</td>
<td>Time spent in adjusting software ( k )</td>
</tr>
</tbody>
</table>

(1) \( BSP^p \): the comprehensive knowledge points expressing business process information. Assuming there are \( n \) basic business process, \( m \) sub-links, i.e. \( BP = \{ BP_1, BP_2, \ldots, BP_m \} \).

(2) \( SSP^p \): the comprehensive knowledge points expressing software information. Assuming there are \( r \) software sub-modules, i.e. \( S = \{ S(1), S(2), \ldots, S(r) \} \).

According to the knowledge points above, the relationships and functions can be embodied by the relationships and functions can be embodied by the
Q2: Does the time spent in adjusting elements influence EISA?

M3: Time spent in adjusting business process BP_j
M4: Time spent in adjusting software k

(2) Measurement of sub-goal B (Cost)

Q1: Does the cost spent in the adjustment influence EISA?

M1: Cost of the material u
M2: Cost of the resource u'
M3: Number of the staff in the adjustment BP_j
M4: Number of the staff in the adjustment K

Q2: Does the time of the element spent in the adjustment influence EISA?

M5: Time of the element in the business adjustment BP_j
M6: Time of the element in the software module adjustment k

(3) Measurement of sub-goal C (Complexity)

Q1: Does the module layered in the adjustment influence the EISA?

M1: Module layer influence
M2: Number of the comprehensive knowledge points in the i-th layer in OKM
M3: Number of the atom knowledge points in the i-th layer in OKM
M4: Number of the comprehensive knowledge points in the i-th layer in OKM

Q2: Does the interaction between modules in the adjustment influence the EISA?

M5: Relationship between module KP^g and KP^b.
M6: Relationship between module KP^g and B^g.
M7: Relationship between module KP^b and B^b.

(4) Measurement of sub-goal D (Risk)

Q1: Does the risk of adjustment influence the EISA?

M1: Value of satisfying degree
Q2: Does the difficulty of adjustment influence the EISA?
M2: Difficulty of adjustment in the transformation
Q3: Does the chaos after the adjustment influence the EISA?
M3: Orderly degree before the adjustment
M4: Orderly degree after the adjustment

(5) Measurement of sub-goal E (Robust)

Q1: Does the robust of EIS after adjustment influence the EISA?

M1: Number of the indirect layer between basic business process BP_i and BP_j

M2: Number of the indirect layer between software S(k_i) and S(k_j)
M3: Number of the adjustment elements in indirect trigger
M3.1: Number of business process with BP_i
M3.2: Number of software module with S(k)
M4: Number of the adjustment elements in direct trigger
M4.1: Number of business process with BP_i
M4.2: Number of software module with S(k)

Q2: Does the range of the adjustment influence the EISA?

M5: Number of initial software module
M6: Number of delete software module
M7: Number of revise software module
M8: Number of insert software module.

C. Index of EISA Evaluation System

According to GQM [9], the index set can be obtained, as shown in Fig. 1. It includes time, cost, complexity, risk and robust, which are set in terms of system elements. Combined with OKM, the indices can be quantified, and the results are as follows:

(1) Time

\[
T = T_1 + T_2 = \sum_{i=1}^{n} \sum_{j=1}^{m} t(BP_j) + \sum_{k=1}^{r} t(S(k))
\]  

Where, \( T_1 = \sum_{i=1}^{n} \sum_{j=1}^{m} t(BP_j) \)
and
\( T_2 = \sum_{k=1}^{r} t(S(k)) \) are the time spent on the adjustment with BSP^g and SSP^g respectively.

(2) Cost

\[
C = C_s + C_h
\]

\[
C_s = \sum_i \sum_j a_u \times t(BP_j)
\]

\[
+ \sum_i \sum_j b_u \times PN_u(BP_j) \times t(BP_j)
\]

\[
C_h = \sum_k \sum_u a_u \times t(S(k))
\]

\[
+ \sum_k b_u \times PN_u(S(k)) \times t(S(k))
\]
Where, \( a_u \) is the cost of the material \( u \) for the adjustment, \( b_{u'} \) is the cost of the workforce \( u' \) for the adjustment, \( PN_{u'}(BP_{j}) \) is the number of workforce for the business process adjustment, \( PN_{u'}(S(k)) \) is the number of workforce for the software adjustment.

3) Complexity

This sub-index set includes the following indexes:

1) Absolute complex degree (\( ACD \) for short)

\[
ACD = (BSP^q_i) + (SSP^q_i)
\]

Where, \( (BSP^q_i) \) is the number of \( BSP^q_i \), and \( (SSP^q_i) \) is the number of \( SSP^q_i \).

2) Relative complex degree (\( RCD \) for short)

\[
RCD = \frac{IN}{N}
\]

Where, \( IN \) is the number of the knowledge points involved in the adjustment, \( N \) is the number of knowledge points.

3) Personal numbers involved in the adjustment (\( TN \) for short)

\[
TN = \bigcup_{i,j} PT(BP_{j}) + \bigcup_{k} PT(S(k))
\]

Where, \( PT(BP_{j}) \) is the workforce types while adjusting \( BP_{j} \), \( PT(S(k)) \) is the workforce types while adjusting \( S(k) \).

4) Personal types involved in adjustment (\( PN \) for short)

\[
PN = \sum_{i} \sum_{j} \sum_{l} PN_{i}(BP_{j}) + \sum_{k} \sum_{l} PN_{i}(S(k))
\]

Where, \( \sum_{i} \sum_{j} \sum_{l} PN_{i}(BP_{j}) \) is the number of workforce while adjusting \( BP_{j} \), \( \sum_{k} \sum_{l} PN_{i}(S(k)) \) is the number of workforce while adjusting \( S(k) \).

5) Intensity-dependence between knowledge points (\( IND \) for short)

Assuming \( BSP^q_i \rightarrow BP_i \), and \( SSP^q_{j,i} \rightarrow S(i') \).
Thus, $w_j$ is the dependence degree between $BSP_i^q$ and $BP_j$, $w_j$ is the dependence degree between $SSP_{ij}^q$ and $S(i')$, $w_j$ is the dependence degree between all $BSP_i^q$ and $BP_j$, $w_k$ is the dependence degree between all the $SSP_{ij}^q$ and $BP_j$. Then

$$IND = \frac{\sum_{j} w_j + \sum_{i} w_j}{\sum_{i} w_i + \sum_{k} w_k}$$

(7)

(4) Risk

This index set includes the following sub-indices.

1) Implementation difficulty degree ($IDD$ for short)

Generally speaking, the adjusting operation for business process and software includes increasing operation, modifying operation and deleting operation. The operation object can be the relation between elements (complex relationship or information relationship) or the elements themselves. Assuming that $\lambda_1$, $\lambda_2$, $\lambda_3$ represents the difficulty of inserting, revising and deleting operation respectively, $\gamma_1, \gamma_2, \gamma_3$ are the occurrence probability in time $T$.

$$IDD = \sum_{i=1}^{3} \sum_{n=1}^{3} \lambda_m \gamma_n$$

(8)

Where, $\sum_{n=1}^{3} \gamma_n = 1$.

2) Meeting degree ($MD$ for short)

This is a qualitative index and can be classified into four levels: A (completely meet), B (Basically meet), C (Partially meet), D (hardly meet).

3) Influence degree ($ID$ for short)

Assuming there are three influence degree, promoting effect ($\delta_1$), inhibitory effect ($\delta_2$) and no effect ($\delta_3$), the importance of $BP_j$ is $x_i$ ($i = 1, 2, \ldots, n$), and the importance of $S(j)$ is $y_j$ ($j = 1, 2, \ldots, r$).

$$\text{sgn}(x_i) = \begin{cases} -1 & \text{inhibitory effect} \\ 0 & \text{no effect} \\ 1 & \text{promoting effect} \end{cases}$$

$$\text{sgn}(y_j) = \begin{cases} -1 & \text{inhibitory effect} \\ 0 & \text{no effect} \\ 1 & \text{promoting effect} \end{cases}$$

Then,

$$ID = \sum_{j=1}^{r} \sum_{i=1}^{n} \text{sgn}(x_i) \delta_i x_i + \sum_{j=1}^{r} \sum_{k=1}^{n} \text{sgn}(y_j) \delta_j y_j$$

(9)

4) Confusion degree ($CD$ for short)

It is a qualitative index, and can be quantified according to the orderly degree before and after the adjustment.

5) Robust

This index set includes the following sub-indices.

1) Running availability ($A$ for short)

$$A = \frac{T_v}{T_v + T_d}$$

(10)

Where, $T_v$ is the time of EIS in normal operation, while $T_d$ is the opposite.

2) Average failure rate ($\lambda'$ for short)

$$\lambda' = \frac{dr}{N dt} = \frac{r(t + \Delta t) - r(t)}{N \times \Delta t}$$

(11)

Where, $\Delta t$ is the time interval, $\Delta r(t)$ is the failure numbers of tested knowledge points in $(t, t + \Delta t)$, and $N'$ is the total numbers of knowledge points.

3) Convergence property ($CP$ for short)

Definition 1: the maximize trigger layer numbers

Assuming that $LBN(BP_d^y)$ is the layer numbers between $BP_d^y$ and $BP_d^u$, $LSN(S(i))$ is the layer numbers between $S(i)$ and $S(j)$, if $\exists BPS(r)$, which meets $BPS(r)\xrightarrow{d}BP_y$, then $LBN(BP_y^g) = 0$. If $\exists BP_{ik}^y$, which meets $BP_{ik}^y\xrightarrow{m}BP_y$ or $BP_{ak}^y\xrightarrow{m}BP_y$, then $LBN(BP_y^g) = LBN(BP_{ik}^y) + 1$, and the trigger layer number $CC_i$ is $\max\{LBN(BP_y^g)\}$, i.e.,

$$CC_i = \max\{LBN(BP_y^g)\}$$. Similarly, as to software, if $\exists BPS(r)$, which meets $BPS(r)\xrightarrow{d}S(i)$, then $LSN(S(i)) = 0$. If $\exists S(j)$, which meets
$S(j) \xrightarrow{A} S(i) \text{ or } S(j) \xrightarrow{M} S(i)$, then $\text{LSN}(S(i)) = \text{LSN}(S(j)) + 1$ and the corresponding trigger layer number $CC' = \max(\text{LSN}(S(i)))$, i.e., $CC' = \max(\text{LSN}(S(i)))$. Then, $C_1 = CC_1 + CC'$.

**Definition 2:** Assuming that the number of basic adjusting units of indirect trigger or mapping trigger is $S_{IM}$, then the ratio between $S_{IM}$ and the number of basic adjusting units of direct trigger $C_2$ is

$$C_2 = CC_2 + CC'_2 = \frac{\text{IN}(BP_j) + MN(BP_j)}{\text{DN}(BP_j)} + \frac{\text{IN}(S(i)) + MN(S(i))}{\text{DN}(S(i))}$$ \hspace{1cm} (12)

Then

$$CP = \frac{1}{\frac{1}{C_1} + \frac{1}{C_2}}$$ \hspace{1cm} (13)

Where, $C_1$ is the maximize trigger layer numbers, and $C_2$ is the ratio between indirect and direct trigger numbers.

### III. Evaluation Model and Corresponding Algorithm

#### A. Evaluation Model

Assuming that $\text{OR} = \{\theta_1, \theta_2, \ldots, \theta_b\}$ is the set of $l$ evaluation objects, and $\theta_e$ is the $e^{th}$ $(1 \leq e \leq l)$ information system. And the evaluation index set is $\text{TR} = \{t_1, t_2, \ldots, t_p\}$, where $t_f$ is the $f^{th}$ $(1 \leq f \leq p)$ aspect in the evaluation index set. So each EISA can be evaluated via $t_f = \{a_{e_1}^f, a_{e_2}^f, \ldots, a_{e_z}^f\}$, and the evaluation matrix is $A_2 = \left(a_{es}^f\right)_{l \times z}$, where $a_{es}^f$ is the $s^{th}$ $(1 \leq s \leq z)$ index value of the $e^{th}$ information system with the $f^{th}$ aspect. Adaptability evaluation (AE) algorithm is proposed in this paper based on similarity to ideal solution.

#### B. AE Algorithm

According to the evaluation index system and model, the steps of AE algorithm are shown as follows:

**Step 1:** obtain the evaluation index matrix

$$A_2 = \left(a_{es}^f\right)_{l \times z}, \text{ where } 1 \leq e \leq l, 1 \leq f \leq p, 1 \leq s \leq z.$$ And according to the attribute of each index, if all the elements in the $f^{th}$ line are worse than those of the $j^{th}$ line, then the $j^{th}$ information system is better than the $f^{th}$ information system.

$$A_2 = \begin{bmatrix} a_{11}^{(f)} & a_{12}^{(f)} & \cdots & a_{1z}^{(f)} \\ a_{21}^{(f)} & a_{22}^{(f)} & \cdots & a_{2z}^{(f)} \\ \vdots & \vdots & \ddots & \vdots \\ a_{l1}^{(f)} & a_{l2}^{(f)} & \cdots & a_{lz}^{(f)} \end{bmatrix}$$

**Step 2:** conform the ideal solution matrix $A_{2}^{(s)}$ and the negative ideal solution matrix $A_{2}^{(-s)}$. $A_{2}^{(s)}$ and $A_{2}^{(-s)}$ are selected according to the corresponding index attributes.

**Step 3:** make indices dimensionless as $A_2 = \left(a_{es}^f\right)_{l \times z}$.

$$A_2^{(s)} = \begin{bmatrix} a_1^{(s)} & a_2^{(s)} & \cdots & a_l^{(s)} \\ a_1^{(s)} & a_2^{(s)} & \cdots & a_l^{(s)} \\ \vdots & \vdots & \ddots & \vdots \\ a_1^{(s)} & a_2^{(s)} & \cdots & a_l^{(s)} \end{bmatrix}$$

**Step 4:** make the weighted processing to $t_f$. Assuming that the weight of $P$ aspects is $w = \left(w_1, w_2, \ldots, w_p\right)$, then

$$A_2^{(s)} = \begin{bmatrix} w_1a_1^{(s)} & w_2a_2^{(s)} & \cdots & w_la_l^{(s)} \\ w_1a_1^{(s)} & w_2a_2^{(s)} & \cdots & w_la_l^{(s)} \\ \vdots & \vdots & \ddots & \vdots \\ w_1a_1^{(s)} & w_2a_2^{(s)} & \cdots & w_la_l^{(s)} \end{bmatrix}$$

**Step 5:** conform the ideal solution matrix $A_2^{(s)}$, and the negative ideal solution matrix $A_2^{(-s)}$, again.

**Step 6:** compute the distances between $A_2^{(s)}$, and $A_2^{(s)}$, $A_2^{(s)}$, and $A_2^{(-s)}$, respectively.
Step 7: compute the relative approach degree.

\[ d_e = \frac{\|A_2^e\|}{\|A_2^e + A_2^*\|} \]

Where, \(\|A_2^e\|\) is the distance between \(A_2^e\) and \(A_2^*\), \(\|A_2^*\|\) is the distance between \(A_2^e\) and \(A_2^*\), \(\|d_i^*\|\) can be measured by matrix norm.

Step 8: sort the EISA according to the relative approach degree.

IV. EXAMPLES

A. Background

The evaluation approach is exemplified through a case study as follows. There are three information systems with similar functions and it’s necessary to evaluate their adaptability in order to find a better plan. Firstly, the indexes are quantified according to Eq. (1) – (13) as shown in Tab. 3.

Take implementation difficulty degree as an example to show the evaluation method. According to historical data, the probabilities of inserting, revising and deleting operation are \(\gamma_1 = \gamma_2 = \gamma_3 = \frac{1}{3}\), and the difficulty degree are 2, 1.6 and 1.5 respectively. Then IDD of the first information system is 1.7.

B. Example Analysis

According to AE algorithm, the data in Table 1 is processed as follows:

(1) According to step 1, evaluation index matrix is obtained.

\[
A_2 = \begin{bmatrix}
30 & 50 & 20 & 0.5 & 10 & 50 & 0.6 & 1.7 & 0.5 & 0.6 & 0.05 & 0.08 \\
25 & 45 & 18 & 0.5 & 10 & 45 & 0.4 & 1.5 & 0.5 & 0.8 & 0.03 & 0.1 \\
35 & 40 & 25 & 0.6 & 8 & 30 & 0.45 & 1.2 & 0.5 & 3 & 0.85 & 0.02 & 0.15
\end{bmatrix}
\]

As the index values in the second line are better than those of the first line according to index attributes, so the second information system is better than the first information system.

(2) According to step 2, the ideal solution matrix and the negative ideal solution matrix are obtained.

\[
A^+(e) = \begin{bmatrix}
25 & 40 & 18 & 0.5 & 8 & 30 & 0.4 & 1.2 & 5 & 0.5 & 3 & 0.85 & 0.02 & 0.08 \\
25 & 40 & 18 & 0.5 & 8 & 30 & 0.4 & 1.2 & 5 & 0.5 & 3 & 0.85 & 0.02 & 0.08 \\
25 & 40 & 18 & 0.5 & 8 & 30 & 0.4 & 1.2 & 5 & 0.5 & 3 & 0.85 & 0.02 & 0.08
\end{bmatrix}
\]

\[
A^-(e) = \begin{bmatrix}
35 & 50 & 25 & 0.6 & 10 & 50 & 0.6 & 1.7 & 5 & 0.6 & 3 & 0.6 & 0.05 & 0.15 \\
35 & 50 & 25 & 0.6 & 10 & 50 & 0.6 & 1.7 & 5 & 0.6 & 3 & 0.6 & 0.05 & 0.15 \\
35 & 50 & 25 & 0.6 & 10 & 50 & 0.6 & 1.7 & 5 & 0.6 & 3 & 0.6 & 0.05 & 0.15
\end{bmatrix}
\]

(3) According to step 3, the indices are made dimensionless.

\[
A_2 = \begin{bmatrix}
1.20 & 1.00 & 1.40 \\
1.25 & 1.13 & 1.00 \\
1.11 & 1.00 & 1.39 \\
1.00 & 1.00 & 1.20 \\
1.25 & 1.25 & 1.00 \\
1.67 & 1.50 & 1.00 \\
1.50 & 1.00 & 1.13 \\
1.42 & 1.25 & 1.00 \\
1.00 & 1.00 & 1.00 \\
1.20 & 1.00 & 1.00 \\
1.00 & 1.00 & 1.00 \\
0.71 & 0.94 & 1.00 \\
2.50 & 1.50 & 1.00 \\
1.00 & 1.25 & 1.88
\end{bmatrix}
\]

(4) According to step 4, the evaluation sub-index sets are weighted. The weight of the five aspects is \(w = (w_1, w_2, \ldots, w_5) = (0.15, 0.25, 0.20, 0.25, 0.15)\) according to Delphi, and the weighted matrix is
(5) According to step 5, the ideal solution matrix and the negative ideal solution matrix of the present matrix are obtained. According to index attributes, the ideal solution matrix is:

\[
A_{2}^{(e)} = \begin{bmatrix}
0.18 & 0.15 & 0.21 \\
0.31 & 0.28 & 0.25 \\
0.22 & 0.20 & 0.28 \\
0.20 & 0.20 & 0.24 \\
0.25 & 0.25 & 0.20 \\
0.33 & 0.30 & 0.20 \\
0.30 & 0.20 & 0.23 \\
0.36 & 0.31 & 0.25 \\
0.25 & 0.25 & 0.25 \\
0.30 & 0.25 & 0.25 \\
0.25 & 0.25 & 0.25 \\
0.11 & 0.14 & 0.15 \\
0.38 & 0.23 & 0.15 \\
0.15 & 0.19 & 0.28
\end{bmatrix}
\]

And the negative ideal solution matrix is

\[
A_{2}^{(i)} = \begin{bmatrix}
0.21 & 0.21 & 0.21 \\
0.31 & 0.31 & 0.31 \\
0.28 & 0.28 & 0.28 \\
0.24 & 0.24 & 0.24 \\
0.25 & 0.25 & 0.25 \\
0.33 & 0.33 & 0.33 \\
0.30 & 0.30 & 0.30 \\
0.36 & 0.36 & 0.36 \\
0.25 & 0.25 & 0.25 \\
0.30 & 0.30 & 0.30 \\
0.25 & 0.25 & 0.25 \\
0.11 & 0.11 & 0.11 \\
0.38 & 0.38 & 0.38 \\
0.28 & 0.28 & 0.28
\end{bmatrix}
\]

(6) According to step 6, the distance between \(A_{2}^{(e)}\) and \(A_{2}^{(i)}\) is calculated, as well as \(A_{2}^{(e)}\) and \(A_{2}^{(i)}\). Let \(A = A_{2}^{(e)} - A_{2}^{(i)}\) and \(A^* = A_{2}^{(i)} - A_{2}^{(e)}\), can be obtained.

(7) According to step 7, the relative approach degree between \(A_{2}^{(e)}\) and \(A_{2}^{*}\) is calculated, as well as \(A_{2}^{(e)}\) and \(A_{2}^{*}\).

\[
\left\|d_{1}\right\| = 0.1517, \left\|d_{2}\right\| = 0.2447, \left\|d_{3}\right\| = 0.3114, \\
\left\|d'_{1}\right\| = 0.3216, \left\|d'_{2}\right\| = 0.1584, \left\|d'_{3}\right\| = 0.1715
\]

So according to AE algorithm and the data in Tab. 3, the three EIS relative approach degrees are as follows.

\[
d_{1} = \frac{\left\|d'_{1}\right\|}{\left\|d_{1}\right\| + \left\|d'_{1}\right\|} = 0.6795 \\
de_{2} = \frac{\left\|d'_{2}\right\|}{\left\|d_{2}\right\| + \left\|d'_{2}\right\|} = 0.3930 \\
de_{3} = \frac{\left\|d'_{3}\right\|}{\left\|d_{3}\right\| + \left\|d'_{3}\right\|} = 0.3551
\]

As \(d_{1} < d_{2} < d_{3}\), the third EISA is the best, and the first EISA is the worst. Therefore, the enterprise can adopt the third enterprise information system, or improve its designed system, so that its information system can meet the changing environment better.

V. CONCLUSIONS

The adaptability is an important quality for an enterprise to survive in the dynamic environment. Enterprises with better adaptability can have continuous growth and improvement. With the advent of information age, the adaptability of enterprise information systems becomes an important factor to judge their competitive advantage.
In this paper, a set of adaptability index system is proposed, including five aspects: time, cost, complexity, risk and robust. On the basis of the index system, the evaluation model is built and the corresponding algorithm is given, so the EISA can be evaluated. In practice, enterprises can combine the better information systems with their own conditions to fully understand and design or improve their own information systems with better adaptability. The evaluation model and algorithm are helpful in understanding the adaptability and in laying the foundation for enterprises to make effective decisions.

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REFERENCE


Chaogai Xue was born in September, 1978, Dengzhou, Henan Province. Xue received the B.S. and M.S. degree in material science and engineering from the Northwestern Polytechnical University, Xi’an, China, and the Ph.D. degree in Southeast University, Nanjing, China, in 2005. Her research interests include CIMS, information systems.