

Fuzzy Comprehensive Risk Assessment Method Based on Consistent Matrix and Information Entropy

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Abstract: To solve the following problems of information security risk assessment method: inconsistency of judgment matrix, and irrationality of expert weight, risk assessment method based on the consistent matrix and information entropy (RAMCI) is proposed, which uses the priority relationship matrix to establish consistent judgment matrix and information entropy to calculate the weight of multiple experts with an indicator score. This method was used in a case to assess the risk. The results show that: in comparison with previous assessment methods, RAMCI has the following advantages: consistency of judgment matrix not concerned; objectively reflects the statistical profile of individual risk factors. So RAMCI is a practical information system risk assessment method.

Keywords: Fuzzy comprehensive risk assessment, Information entropy, Consistent matrix.

1. INTRODUCTION

Information systems security has been greatly concerned because of the development and application of IT, the risk assessment is an important part of information system security engineering, and it is also basis and premise of establishing the system of information system security [1]. The existing risk assessment methods are classified into three main categories: the qualitative, the quantitative, and the mixed methods, in which quantitative and qualitative methods are combined. The mixed methods make up for subjectivity of the qualitative assessment method and simplicity of the quantitative assessment [2].

The Analytic Hierarchy Process (AHP) is a decision-making method combining quantitative and qualitative analysis [3], the method will make the risk factors of decision-making into target, rule, scheme and etc; and based on which, carry out decision-making method of quantitative and qualitative analysis. The risk factor weight of information security risk assessment is traditionally scored by expert; there is a lot of fuzziness in the expert evaluation. Therefore, fuzzy comprehensive evaluation method carries out quantitative treatment when comprehensive evaluation of the system is required. Nowadays the fuzzy comprehensive risk assessment methods based on AHP [4, 5] were appeared, which used membership degree of fuzzy mathematics to quantify the assessment factors, and make an overall evaluation of the things or objects restricted by many factors. So it can solve a variety of non-deterministic problems which are fuzzy and difficult to quantify [6].

Fuzzy comprehensive evaluation method based on AHP needs to construct the judgment matrix; the consistency tests of each judgment matrix are needed. If matrix does not meet consistency criteria, then the judgment matrix needs to be modified until the matrix meets consistency criteria. Characteristic root and the corresponding eigenvectors of matrix are computed during consistency tests of matrix, which is relatively time-consuming. On the other hand, expert weight needs to be calculated. If the value of weights is equal, it cannot reflect the level of expertise.

In order to solve the inconsistency of the judgment matrix and irrationality of expert weight, fuzzy comprehensive risk assessment method based on consistent matrix and information entropy (RAMCI) is proposed.

2. RELATE KNOWLEDGE

2.1. Fuzzy Consistent Matrix and Configuration

Assumed risk factor set $B = \{A_1, A_2, \dots, A_n\}$, if $0 \leq a_{ij} \leq 1$ for $\forall i, j = 1, 2, 3, \dots, n$, then $A = (a_{ij})_{n \times n}$ is called a fuzzy complementary matrix, where a_{ij} is the preference degree of A_i to A_j .

$$a_{ij} = \begin{cases} 0 & A_i \text{ is strictly inferior to } A_j \\ (0, 0.5) & A_i \text{ is inferior to } A_j \\ 0.5 & A_i \text{ is identical to } A_j \\ (0.5, 1) & A_i \text{ is superior to } A_j \\ 1 & A_i \text{ is strictly superior to } A_j \end{cases}$$

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Definition 1 If the fuzzy complementary matrix $A = (a_{ij})_{n \times n}$ is satisfied:

$$\forall i, j, k = 1, 2, \dots, n, \quad a_{ij} = a_{ik} - a_{jk} + 0.5$$

Then the fuzzy complementary matrix $A = (a_{ij})_{n \times n}$ is fuzzy consistent matrix [7].

The following preference of comparison is carried out between any two of the risk factors; a priority relation matrix $F = (f_{ij})_{n \times n}$ is established.

$$f_{ij} = \begin{cases} 0 & A_i \text{ is inferior to } A_j \\ 0.5 & A_i \text{ is identical to } A_j \\ 1 & A_i \text{ is superior to } A_j \end{cases} \quad (1)$$

Suppose $F = (f_{ij})_{n \times n}$ as a priority relation matrix, the matrix $R = (r_{ij})_{n \times n}$ is consistency of fuzzy complementary judgment matrix [8], where

$$r_i = \sum_{j=1}^n f_{ij}, i = 1, 2, 3, \dots, n \quad (2)$$

$$r_{ij} = \frac{r_i - r_j}{2n} + 0.5 \quad (3)$$

2.2. Information Entropy

The concept of information entropy was put forward by the Shannon [9] in “A Mathematical Theory of Communication” published in 1948. Information entropy is the measure of uncertainty of the random variable and defined as follows:

Definition 2: Discrete random variable X with possible values s_1, s_2, \dots, s_n and probability mass function $P(s = s_i) = p_i$,

$$H(X) = -C \sum_{i=1}^n p_i \log p_i$$

Where $0 \leq p_i \leq 1$, and $\sum_{i=1}^n p_i = 1$.

when $p_1 = p_2 = \dots = p_n = \frac{1}{n}$, the information entropy achieves the max value $C \log n$ [10].

The fuzzy comprehensive risk assessment method needs a lot of expertise to get fuzzy assessment of risk factor, each level of expertise is not the same, and expert weight also needs to be calculated. Large gap usually occurs among the result of risk factor assessment. In order to ensure the consistency of the results of the expert assessment, expert weight needs to be calculated.

The higher the level of expertise, the larger becomes the gap among the result of risk factor assessment. High level of expertise should play more important role in the comprehensive evaluation than low level of expertise; information entropy can reflect the degree of dispersion of the indicator

support. The coefficient of weight can be calculated as follows:

If matrix $A_{n \times m}$ denotes n experts, m level of on an indicator is assessed:

$$A = \begin{bmatrix} a_{11} & a_{12} & \dots & a_{1m} \\ a_{21} & a_{22} & \dots & a_{2m} \\ \vdots & & \dots & \vdots \\ a_{n1} & a_{n2} & \dots & a_{nm} \end{bmatrix}$$

Then the coefficient of weight is

$$\alpha_i = (1 - e_i) / (n - \sum_{i=1}^n e_i) \quad \text{where, } e_i = -\frac{1}{\log m} \sum_{j=1}^m a_{ij} \log a_{ij},$$

$$\sum_{i=1}^n \alpha_i = 1, \quad 0 \leq \alpha_i \leq 1$$

3. RAMCI

In the risk assessment process, using the priority relations matrix of the risk factor to establish a consistent judgment matrix, consistency test of conventional judgment matrix is eliminated. At the same time the use of information entropy to calculate the weight of the review’s score makes the score results of the expert more reasonable. Therefore, RAMCI carries out the following steps.

- (1) Carries out the decomposition of the system using AHP, constructing a hierarchical model.
- (2) Establishes priority relation matrix in accordance with equation (1), the priority relation matrix is transformed to a consistent matrix according to equation (2) and (3)
- (3) Calculates the total weight of each risk factor and sort.
- (4) According to the system, determines the evaluation set.
- (5) Uses information entropy to calculate the degree of membership of the each risk factor relative to evaluation set.
- (6) Calculates the result of fuzzy comprehensive evaluation.

The details of the process are shown in Fig. (1).

4. CASE STUDY

4.1. Case Computation

4.1.1 Construction of a Hierarchical Model

A hierarchical model is built in Fig. (2) [11].

4.1.2. Configuration of Priority Relation and Corresponding Fuzzy Consistent Matrix

A priority relation matrix and corresponding fuzzy consistent matrix are shown in Table 1-5, the priority relation matrix is transformed into fuzzy consistent matrix according to equation (2) and (3).

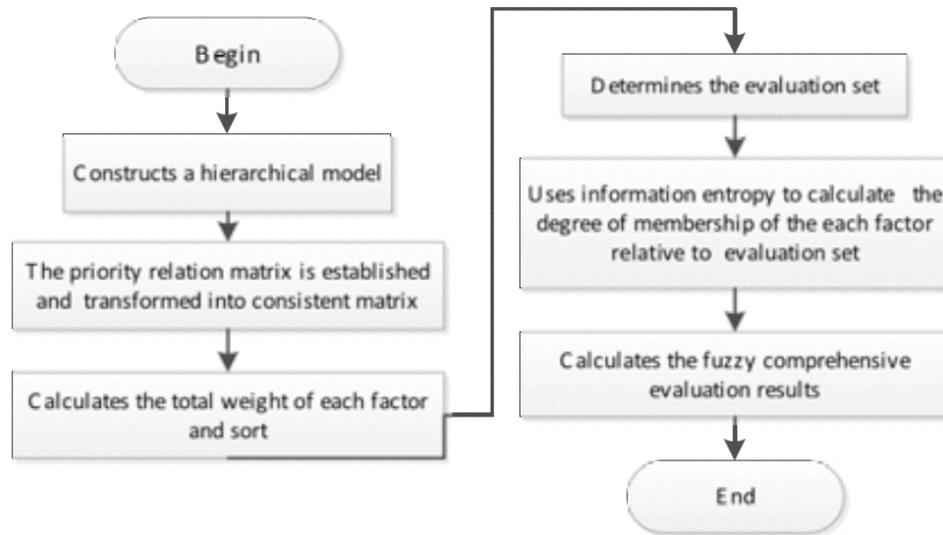


Fig. (1). Flow chart of RAMCI.

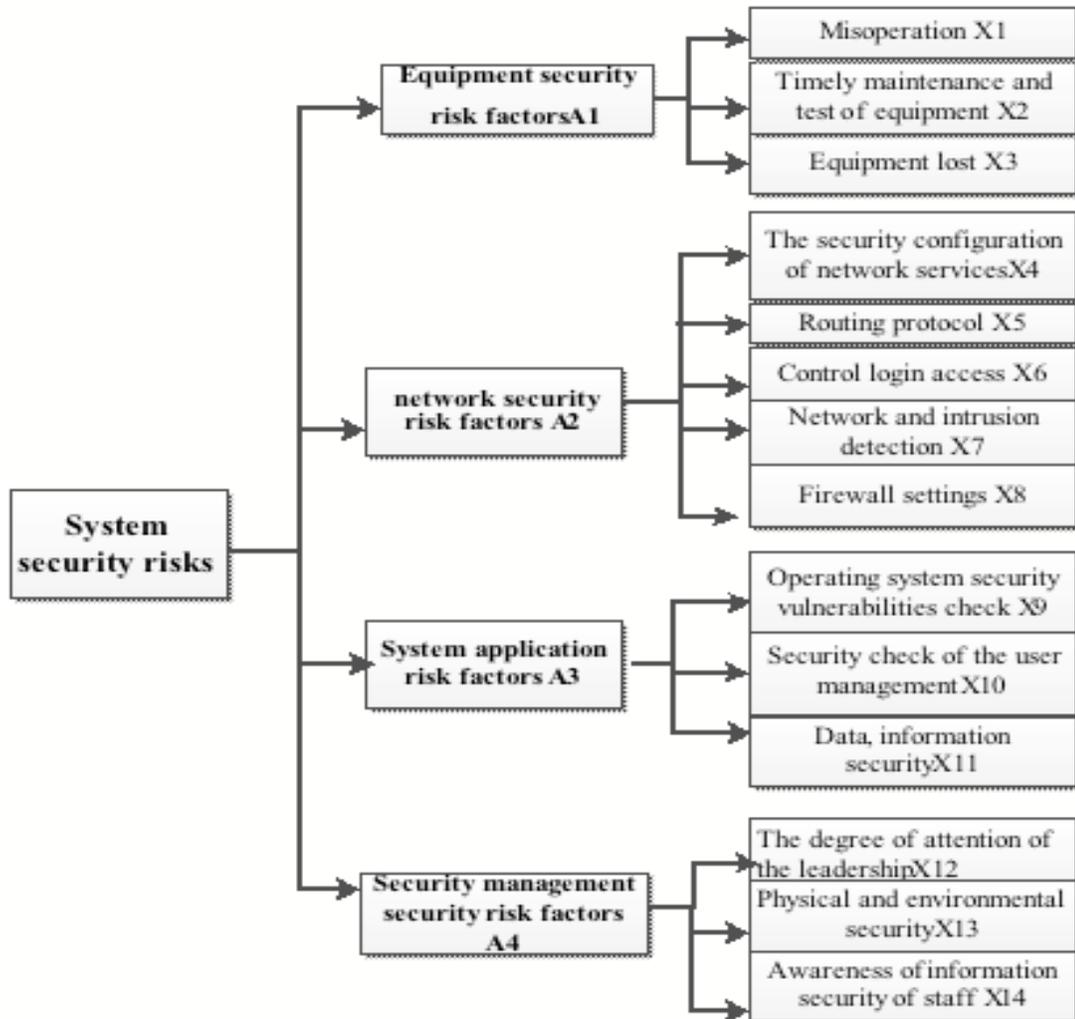


Fig. (2). Hierarchical model.

Table 1. A Priority Relation Matrix (a) and Corresponding Fuzzy Consistent Matrix (b) in Target level

Target Level	A1	A2	A3	A4
A1	0.5	0	0	0
A2	1.0	0.5	1.0	1.0
A3	1.0	0	0.5	1
A4	1.0	0	0	0.5
(a)				

Target Level	A1	A2	A3	A4
A1	0.5	1/8	0.25	3/8
A2	7/8	0.5	5/8	0.75
A3	0.75	3/8	0.5	5/8
A4	5/8	0.25	3/8	0.5
(b)				

Table 2. A Priority Relation Matrix (a) and Corresponding Fuzzy Consistent Matrix (b) in A1 Level

A1	X1	X2	X3
X1	0.5	0	1
X2	1	0.5	1
X3	0	0	0.5
(a)			

A1	X1	X2	X3
X1	0.5	0.333	0.667
X2	0.667	0.5	0.833
X3	0.333	0.167	0.5
(b)			

Table 3. A Priority Relation Matrix (a) and Corresponding Fuzzy Consistent Matrix (b) in A2 Level

A2	X4	X5	X6	X7	X8
X4	0.5	0	1.0	0	0
X5	1.0	0.5	0	1	1
X6	0	1	0.5	1	0
X7	1	0	0	0.5	0
X8	1	0	1	1	0.5
(a)					

A2	X4	X5	X6	X7	X8
X4	0.5	0.3	0.4	0.5	0.3
X5	0.7	0.5	0.6	0.7	0.5
X6	0.6	0.4	0.5	0.6	0.4
X7	0.5	0.3	0.4	0.5	0.3
X8	0.7	0.5	0.6	0.7	0.5
(b)					

Table 4. A priority Relation Matrix (a) and Corresponding Fuzzy Consistent Matrix (b) in A3 Level

A3	X9	X10	X11
X9	0.5	0	0.5
X10	1	0.5	1
X11	0.5	0	0.5
(a)			

A3	X9	X10	X11
X9	0.5	0.25	0.5
X10	0.75	0.5	0.75
X11	0.5	0.25	0.5
(b)			

Table 5. A priority Relation Matrix (a) and Corresponding Fuzzy Consistent Matrix (b) in A4 Level

A4	X12	X13	X14
X12	0.5	0.5	0
X13	0.5	0.5	0
X14	1	1	0.5
(a)			

A4	X12	X13	X14
X12	0.5	0.5	0.25
X13	0.5	0.5	0.25
X14	0.75	0.75	0.5
(b)			

Table 6. The Weight of Risk Factor

Weight	Factor	A1	A2	A3	A4	Weight
0.1478	1	0.3333				0.0493
	2	0.4537				0.0671
	3	0.2130				0.0315
0.3522	4		0.1587			0.0559
	5		0.2413			0.085
	6		0.2			0.0704
	7		0.1587			0.0559
	8		0.2413			0.085
0.2841	9			0.2738		0.0778
	10			0.4524		0.1285
	11			0.2738		0.0778
0.2159	12				0.2738	0.0591
	13				0.2738	0.0591
	14				0.4524	0.0977

“Positive law” deals with the value; the first column of fuzzy consistent matrix is normalized in Table 1 as an example.

$$\sum_{k=1}^4 a_{k1} = 0.5 + 0.875 + 0.75 + 0.625 = 2.75$$

$$\bar{a}_{11} = \frac{a_{11}}{\sum_{k=1}^4 a_{k1}} = \frac{0.5}{2.75} = 0.1818$$

$$\bar{a}_{21} = \frac{a_{21}}{\sum_{k=1}^4 a_{k1}} = \frac{0.875}{2.75} = 0.3182$$

$$\bar{a}_{31} = \frac{a_{31}}{\sum_{k=1}^4 a_{k1}} = \frac{0.75}{2.75} = 0.2727 \quad \bar{a}_{41} = \frac{a_{41}}{\sum_{k=1}^4 a_{k1}} = \frac{0.625}{2.75} = 0.2273$$

The remaining three columns are calculated on the same principle; the normalized judgment matrix is as follows.

$$\begin{bmatrix} 0.1818 & 0.1 & 0.1428 & 0.1667 \\ 0.3182 & 0.4 & 0.3572 & 0.3333 \\ 0.2727 & 0.3 & 0.2857 & 0.2778 \\ 0.2273 & 0.2 & 0.2143 & 0.2222 \end{bmatrix}$$

Judgment matrix is normalized in term of row:

$$\bar{w}_1 = \sum_{j=1}^4 \bar{a}_{1j} = 0.1818 + 0.100 + 0.1428 + 0.1667 = 0.5913$$

$$\bar{w}_2 = \sum_{j=1}^4 \bar{a}_{2j} = 0.3182 + 0.400 + 0.3572 + 0.3333 = 1.4087$$

$$\bar{w}_3 = \sum_{j=1}^4 \bar{a}_{3j} = 0.2727 + 0.300 + 0.2857 + 0.2778 = 1.1362$$

$$\bar{w}_4 = \sum_{j=1}^4 \bar{a}_{4j} = 0.2273 + 0.200 + 0.2143 + 0.2222 = 0.8638$$

Vector \bar{w}_i is normalized to eigenvectors $w = [0.1478, 0.3522, 0.2841, 0.2159]^T$, w is weigh of four risk factors.

Fuzzy consistent matrix is constructed according to the conformance requirements matrix, so the matrix itself conforms to the consistency and does not require consistency test. Other weights are as follow.

$$w_{A_1} = [0.3333, 0.4537, 0.213]^T$$

$$w_{A_2} = [0.1587, 0.2413, 0.200, 0.1587, 0.2413]^T$$

$$w_{A_3} = [0.2738, 0.4524, 0.2738]^T$$

$$w_{A_4} = [0.2738, 0.2738, 0.4524]^T$$

4.1.3. Level Sorting and Consistency Test

The weight of risk factor is listed as Table 6.

The weight of first level of risk factor $w = [0.1478, 0.3522, 0.2841, 0.2159]^T$

The weight of second level of risk factor:

$$w_{A_1} = [0.3333, 0.4537, 0.2130]^T$$

$$w_{A_2} = [0.1587, 0.2413, 0.200, 0.1587, 0.2413]^T$$

Table 7. System Security Score Sheet

Worse(W)	Bad(B)	General(G)	Good(GD)	Better(BE)
5	4	3	2	1

Table 8. Specialist Score and Membership of Factor X1

	W	B	G	GD	BE
s1	0.1	0.25	0.5	0.1	0.05
s2	0.2	0.2	0.2	0.2	0.2
s3	0.1	0.1	0.4	0.3	0.1
s4	0.05	0.2	0.3	0.4	0.05
s5	0.1	0.2	0.3	0.2	0.2
M1	0.0839	0.1953	0.3992	0.2501	0.0715
M2	0.11	0.19	0.34	0.240	0.12

Table 9. Specialist Score and Membership of Risk Factor X2

	W	B	G	GD	BE
s1	0.3	0.1	0.2	0.2	0.2
s2	0.1	0.4	0.2	0.2	0.1
s3	0.2	0.1	0.2	0.2	0.3
s4	0.25	0.1	0.2	0.3	0.15
s5	0.1	0.2	0.3	0.2	0.2
M1	0.1706	0.2299	0.2145	0.2180	0.1671
M2	0.19	0.18	0.22	0.22	0.19

Table 10. Specialist Score and Membership of Risk Factor X3

	W	B	G	GD	BE
s1	0.3	0.25	0.2	0.2	0.05
s2	0.4	0.2	0.1	0.2	0.1
s3	0.35	0.1	0.2	0.25	0.1
s4	0.05	0.2	0.3	0.3	0.15
s5	0.1	0.2	0.2	0.25	0.25
M1	0.2594	0.1889	0.1985	0.2391	0.1140
M2	0.24	0.19	0.2	0.24	0.13

Table 11. Specialist Score and Membership of Risk Factor X4

	W	B	G	GD	BE
s1	0.2	0.25	0.2	0.3	0.05
s2	0.2	0.2	0.2	0.25	0.15
s3	0.1	0.3	0.4	0.1	0.1
s4	0.2	0.2	0.3	0.15	0.15
s5	0.1	0.2	0.3	0.2	0.2
M1	0.1391	0.2614	0.3176	0.1764	0.1056
M2	0.16	0.23	0.28	0.20	0.13

Table 12. Specialist Score and Membership of Risk Factor X5

	W	B	G	GD	BE
s1	0.6	0.15	0.05	0.1	0.1
s2	0.5	0.2	0.2	0.05	0.05
s3	0.55	0.05	0.2	0.1	0.1
s4	0.4	0.2	0.1	0.15	0.15
s5	0.3	0.2	0.1	0.2	0.2
M1	0.5285	0.1419	0.1371	0.0963	0.0963
M2	0.47	0.16	0.13	0.12	0.12

Table 13. Specialist Score and Membership of Risk Factor X6

	W	B	G	GD	BE
s1	0.15	0.15	0.4	0.15	0.15
s2	0.15	0.15	0.25	0.2	0.25
s3	0.1	0.1	0.35	0.25	0.2
s4	0.15	0.3	0.3	0.2	0.05
s5	0.2	0.2	0.3	0.2	0.1
M1	0.1429	0.1889	0.3349	0.201	0.1324
M2	0.15	0.18	0.32	0.2	0.15

Table 14. Specialist Score and Membership of Risk Factor X7

	W	B	G	GD	BE
s1	0.2	0.2	0.15	0.1	0.35
s2	0.1	0.2	0.1	0.2	0.4
s3	0.2	0.2	0.2	0.2	0.2
s4	0.15	0.15	0.25	0.25	0.2

Table 14. contd...

	W	B	G	GD	BE
s5	0.3	0.1	0.2	0.2	0.2
M1	0.167	0.1783	0.1440	0.1764	0.3343
M2	0.19	0.17	0.18	0.19	0.27

Table 15. Specialist Score and Membership of Risk Factor X8

	W	B	G	GD	BE
s1	0.15	0.2	0.3	0.2	0.15
s2	0.25	0.25	0.2	0.2	0.1
s3	0.15	0.1	0.35	0.3	0.1
s4	0.15	0.2	0.3	0.2	0.15
s5	0.2	0.1	0.3	0.2	0.2
M1	0.1727	0.1445	0.3085	0.2451	0.1291
M2	0.18	0.17	0.29	0.22	0.14

Table 16. Specialist Score and Membership of Risk Factor X9

	W	B	G	GD	BE
s1	0.5	0.2	0.1	0.1	0.1
s2	0.35	0.25	0.1	0.2	0.1
s3	0.6	0.1	0.1	0.1	0.1
s4	0.45	0.1	0.2	0.2	0.05
s5	0.3	0.2	0.1	0.2	0.2
M1	0.4995	0.1461	0.1221	0.1383	0.0941
M2	0.44	0.17	0.12	0.16	0.11

Table 17. Specialist Score and Membership of Risk Factor X10

	W	B	G	GD	BE
s1	0.1	0.2	0.2	0.1	0.4
s2	0.1	0.2	0.2	0.2	0.3
s3	0.1	0.1	0.15	0.15	0.5
s4	0.2	0.2	0.1	0.25	0.25
s5	0.1	0.15	0.3	0.2	0.25
M1	0.108	0.15	0.1823	0.1559	0.4038
M2	0.12	0.17	0.19	0.18	0.34

Table 18. Specialist Score and Membership of Risk Factor X11

	W	B	G	GD	BE
s1	0.2	0.4	0.2	0.1	0.1
s2	0.1	0.2	0.2	0.2	0.3
s3	0.25	0.25	0.15	0.15	0.2
s4	0.2	0.2	0.1	0.2	0.3
s5	0.25	0.15	0.2	0.2	0.2
M1	0.1881	0.3009	0.1769	0.1462	0.1879
M2	0.2	0.24	0.17	0.17	0.22

Table 19. Specialist Score and Membership of Risk Factor X12

	W	B	G	GD	BE
s1	0.05	0.05	0.2	0.5	0.2
s2	0.1	0.2	0.2	0.2	0.3
s3	0.1	0.1	0.15	0.4	0.25
s4	0.05	0.1	0.1	0.45	0.3
s5	0.1	0.1	0.1	0.6	0.1
M1	0.0747	0.0909	0.1378	0.4945	0.2021
M2	0.08	0.1100	0.15	0.43	0.23

Table 20. Specialist Score and Membership of Risk Factor X13

	W	B	G	GD	BE
s1	0.05	0.05	0.2	0.6	0.1
s2	0.2	0.2	0.2	0.2	0.2
s3	0.1	0.1	0.05	0.5	0.25
s4	0.05	0.15	0.15	0.45	0.2
s5	0.1	0.05	0.1	0.65	0.1
M1	0.0773	0.0749	0.1277	0.5742	0.1459
M2	0.1	0.11	0.14	0.48	0.17

Table 21. Specialist Score and Membership of Risk Factor X14

	W	B	G	GD	BE
s1	0.05	0.15	0.2	0.4	0.2
s2	0.1	0.1	0.2	0.35	0.25
s3	0.1	0.1	0.05	0.5	0.25
s4	0.05	0.15	0.05	0.55	0.2
s5	0.1	0.05	0.1	0.55	0.2

Table 21. contd...

	W	B	G	GD	BE
M1	0.0794	0.1073	0.0952	0.5021	0.216
M2	0.08	0.11	0.12	0.47	0.22

Table 22. Degree of the Membership of the 14 Risk Factors is Listed Considering the Information Entropy (M1) and the Average Method (M2) in Table 22

Risk Factor	M1					M2				
	W	B	G	GD	BE	W	B	G	GD	BE
1	0.0839	0.1953	0.3992	0.2501	0.0715	0.11	0.19	0.34	0.24	0.12
2	0.1706	0.2299	0.2145	0.2180	0.1671	0.19	0.18	0.22	0.22	0.19
3	0.2594	0.1889	0.1985	0.2391	0.1140	0.24	0.19	0.20	0.24	0.13
4	0.1391	0.2614	0.3176	0.1764	0.1056	0.16	0.23	0.28	0.20	0.13
5	0.5285	0.1419	0.1371	0.0963	0.0963	0.47	0.16	0.13	0.12	0.12
6	0.1429	0.1889	0.3349	0.201	0.1324	0.15	0.18	0.32	0.2	0.15
7	0.167	0.1783	0.1440	0.1764	0.3343	0.19	0.17	0.18	0.19	0.27
8	0.1727	0.1445	0.3085	0.2451	0.1291	0.18	0.17	0.29	0.22	0.14
9	0.4995	0.1461	0.1221	0.1383	0.0941	0.44	0.17	0.12	0.16	0.11
10	0.108	0.15	0.1823	0.1559	0.4038	0.12	0.17	0.19	0.18	0.34
11	0.1881	0.3009	0.1769	0.1462	0.1879	0.20	0.24	0.17	0.17	0.22
12	0.0747	0.0909	0.1378	0.4945	0.2021	0.08	0.11	0.15	0.43	0.23
13	0.0773	0.0749	0.1277	0.5742	0.1459	0.10	0.11	0.14	0.48	0.17
14	0.0794	0.1073	0.0952	0.5021	0.216	0.08	0.11	0.12	0.47	0.22

$$w_{A_3} = [0.2738, 0.4524, 0.2738]^T$$

$$w_{A_4} = [0.2738, 0.2738, 0.4524]^T$$

4.1.4. Determination of Evaluation Set

Evaluation set V = {better, good, general, bad, worse} are listed in Table 7.

4.1.5. Determine Fuzzy Comprehensive Evaluation

According to evaluation set, five specialists s1, s2, s3, s4, and s5 score the risk factor X1-X14 and calculate the end result using the information entropy method (M1) and the average values method (M2), five specialists score and member of factor X1-X14 are shown in Table 8-21.

Therefore, degree of the membership of the 14 risk factors is listed in Table 22 using the information entropy (M1) and the average method (M2).

4.1.6. Fuzzy Comprehensive Evaluation

The fuzzy evaluation is calculated in descending to ascending order on the hierarchy and the results of the comprehensive evaluation are obtained. A weighted average of

the model operator “.” is used in this paper. Comprehensive evaluation matrix is calculated using the degree of membership calculated by information entropy method as follows.

$$B_1 = w_{A_1}^T \cdot R_1 = w_{A_1}^T \cdot [x_1 \ x_2 \ x_3]^T = (0.1606 \ 0.2096 \ 0.2727 \ 0.2332 \ 0.1239)$$

$$B_2 = w_{A_2}^T \cdot R_2 = w_{A_2}^T \cdot [x_4 \ x_5 \ x_6 \ x_7 \ x_8]^T = (0.2464 \ 0.1767 \ 0.2478 \ 0.1786 \ 0.1507)$$

$$B_3 = w_{A_3}^T \cdot R_3 = w_{A_3}^T \cdot [x_9 \ x_{10} \ x_{11}]^T = (0.2371 \ 0.1902 \ 0.1644 \ 0.1484 \ 0.2599)$$

$$B_4 = w_{A_4}^T \cdot R_4 = w_{A_4}^T \cdot [x_{12} \ x_{13} \ x_{14}]^T = (0.0775 \ 0.0939 \ 0.1158 \ 0.5198 \ 0.1930)$$

$$B = w_0^T \cdot R = w_0^T \cdot \begin{bmatrix} B_1 \\ B_2 \\ B_3 \\ B_4 \end{bmatrix} = (0.1946 \ 0.1675 \ 0.1992 \ 0.2517 \ 0.1869)$$

Comprehensive evaluation matrix are calculated using the degree of membership calculated by average method (0.1947 0.168 0.1976 0.24740.1923).

4.1.7. Calculation of the Result of Fuzzy Comprehensive Evaluation

According to corresponding value of the level of risk and the normalized results, rate of risk of information system is calculated as follows.

$$\text{Total}=0.1946*5+0.1675*4+0.1992*3+0.2517*2+0.1869*1=2.9312$$

Rate of risk of information system using average values method is 2.9255.

Rate of risk of information system is nearly 3, value-at-risk is general and the result is consistent with the center of network security situation.

4.2. Case Analysis

4.2.1. Conclusion Analysis

Using average values method and entropy method to calculate the expert weight, the level of risk factor of system is found to be the same. It means that few lower level of expert cannot affect level of risk of the entire system. However, few low levels of expertise among specialist will affect the result of a single risk factor when using average values method and entropy method, for example, risk factor X5. Information entropy can reflect the degree of dispersion of the risk factor; therefore, when considering the risk profile of individual risk factors, the information entropy method more truly reflects the risk profile of the risk factor than the average method.

4.2.2. Advantage of Method

RAMCI is tested in practice; its main advantage is reflected in the following three aspects:

(1) Priority relation matrix transformed into consistent matrix avoid the consistency test of the in the literature [1].

(2) Using the analytic hierarchy process, in accordance with the requirements of ISO / IEC 27002 standard, information systems risk factors were decomposed, it is the universal significance of the information system of risk assessment, to avoid the limitations of the method in the literature [12].

(3) Using the information entropy to calculate the weight of expert ratings is suitable for overall assessment of the information system, and more suitable for considering the risk profile of individual risk factors.

5. CONCLUSION

To solve the following problems of information security risk assessment method: inconsistency of judgment matrix, and irrationality of expert weight, RAMCI is proposed, which uses the priority relationship matrix between risk factors to establish a consistent judgment matrix and information entropy to calculate the weight of multiple experts with an indicator score. In comparison with previous assessment methods, RAMCI has the following advantages: it does not bother about the consistency of judgment matrix and objectively reflects the risk profile of individual indicators. So RAMCI is a practical information system risk assessment method.

CONFLICT OF INTEREST

The authors confirm that this article content has no conflicts of interest.

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