Network Security Assessment Model of Coupling Empowerment

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Abstract. By means of accelerating the fuzzy Analytic Hierarchy Process(AHP) screening index of genetic algorithm, this paper constructs evaluation index system of computer network security, puts forward the information entropy with objective and subjective empowerment and improved AHP coupling weighting, sequences the influence factors of network security, the network safety evaluation model is established with the fuzzy comprehensive evaluation method. Application results show that the evaluate results of this model are objective and reasonable.

Introduction

Along with the rapid development of information technology in various fields of economic and social, hackers, computer viruses continuous generation and dissemination, have resulted in significant economic losses to individuals, businesses and countries. How to build a scientific and rational evaluation of network security system, a comprehensive, objective, scientific evaluation of network security situation, is the focus of the protection of information security. Entropy is the important tools of information theory to describe the uncertainty of the information and the random variable, the law of entropy weight is an objective weighting method, its principle is based on the degree of variability of evaluation values reflected in the size of the amount of information to determine the weight of. In this paper, based on a combination of objective and subjective weighting improved Analytic Hierarchy Process (Analytic Hierarchy Process, AHP) with information entropy coupling weighting method to establish a computer network security evaluation model.

The establishment of the network security evaluation model

Set the index system of evaluation elements.

In this paper, based on accelerating genetic algorithm fuzzy Analytic Hierarchy Process (Accelerating Genetic Algorithm Fuzzy AHP, AGA-FAHP) screening, the establishment of evaluation index. The specific approach: ask the experts on the evaluation of the importance of the two indicators for comparison, the establishment of fuzzy complementary judgment matrix

\[ P = (p_{ij}) \]

requiring

\[ 0 \leq p_{ij} \leq 1, p_{ij} + p_{ji} = 1 \]

( shows the extent i better than j). If P does not have a satisfactory consistency, you need to fix. N bits can ask experts to independently establish N rights fuzzy complementary judgment matrix P, N group AGA-FAHP solution evaluation in order to improve the reliability of the indicators screening \[ w_{k,j}(j = 1, 2, \cdots, M ; k = 1, 2, \cdots, N) \] , the average weight of elected evaluation is

\[ \bar{w}_j = \frac{1}{N} \sum_{k=1}^{N} w_{k,j} \]

the largest m indicators composed the ultimate computer network security evaluation index system \[ x_i(i = 1, 2, \cdots, m) \]. The evaluation index system obtained by the above screening computer network security is shown in Table 1.
Table 1. Computer network security evaluation index system

<table>
<thead>
<tr>
<th>Primary indicators</th>
<th>Secondary indicators</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical security B1</td>
<td>Line safety C11, physical equipment safety C12, environmental safety C13</td>
</tr>
<tr>
<td>Management security B2</td>
<td>Organization system C21, system construction C22, safety training plan C23</td>
</tr>
<tr>
<td>Software security B3</td>
<td>Operating system security C31, application software security C32, antivirus software C33</td>
</tr>
<tr>
<td>Hardware security B4</td>
<td>Firewall C41, intrusion detection system C42</td>
</tr>
<tr>
<td>Data security B5</td>
<td>Data backup C51, access control C52, Identity C53, data encryption C54</td>
</tr>
</tbody>
</table>

The determination of comment set.
According to the actual needs of the evaluation decision, determine the comment set: \( V = \{ \text{very safe, safe, safer, basic safe, unsafe} \} \). Assignment to the comment set is \( V = \{ 95, 85, 75, 65, 55 \} \).

The determination of entropy and the improved coupling weight of AHP.
Supposing there is \( m \) evaluation index, \( n \) evaluation object, the form of the original data matrix is \( X = (x_{ij})_{m \times n} \). Entropy weight calculation steps are: (1) Normalization processing the \( X' \) index value, get matrix \( X' = (x'_{ij})_{m \times n} \).

\( p_{ij} = x'_{ij} / \sum_{j=1}^{n} x'_{ij} \).

(2) Calculated j-th evaluation indicator weight under i-th indicator:
\( e_i = -k \sum_{j=1}^{n} p_{ij} \ln p_{ij}, k = \frac{1}{\ln n} \).

(3) Calculated i-th indicator entropy:
\( w_i = W_i w_i / \sum_{i=1}^{m} W_i w_i \).

(4) Coupling entropy weights and improved AHP empower:
Coupling weights corrected each evaluation, at the ultimate computer network security evaluation index system indicators.

Fuzzy Comprehensive Evaluation.
Evaluating each single factor indicators by the evaluation experts (n persons), we can get the single factor membership \( (n_1/n_2/n_3/n_4/n_5/n_1/n_2/n_3/n_4/n_5/n) \). So, we can get \( C_i (i = 1, 2, 3, 4, 5) \). Then, according to the multistage comprehensive evaluation method is obtained in each subset evaluation decision matrix, and finally get the computer network security evaluation result.

An application example

The determination of index weight at all levels.
We take the three secondary indicators C11, C12 and C13 of the primary indicators B1 as example.
(1) Inviting experts make comparison of the three factors of two importance, building the complementary judgement matrix \( F_{c1} \) and turning it into fuzzy consistent matrix \( F'_{c1} \), i.e:

\[
F_{c1} = \begin{pmatrix}
0.5 & 1 & 0 \\
0 & 0.5 & 0 \\
1 & 1 & 0.5
\end{pmatrix}, \quad F'_{c1} = \begin{pmatrix}
0.5 & 0.67 & 0.33 \\
0.5 & 0.5 & 0.17 \\
0.67 & 0.83 & 0.5
\end{pmatrix}, \quad W_{c1} = (0.333, 0.213, 0.454).
\]

(2) To the physical security three evaluation index, invited 10 experts on each index of the important degree to grade raw data matrix:

\[
X_{c1} = \begin{pmatrix}
0.6 & 0.3 & 0.1 \\
0.5 & 0.3 & 0.2 \\
0.4 & 0.4 & 0.2
\end{pmatrix}, \quad X'_{c1} = \begin{pmatrix}
1 & 0.4 & 0 \\
1 & 0.33 & 0 \\
1 & 1 & 0
\end{pmatrix}, \quad \text{entropy weight: } w_{c1} = (0.277, 0.298, 0.225).
\]
(3) Using \( w_i = \frac{w_i'}{\sum_{i=1}^{n} w_i'} \) on the three evaluation index for correction, get coupling weight vector \( \omega = (0.358, 0.246, 0.396) \). Similarly for the others each layer index of the coupling weight, the results such as shown in Table 2.

Table 2. A computer network security evaluation index weight and sort the coupling

<table>
<thead>
<tr>
<th>Primary indicators</th>
<th>Primary indicators weight</th>
<th>Secondary indicators</th>
<th>Secondary indicators weight</th>
<th>Combination weight</th>
<th>Weight sorting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Physical security B₁</td>
<td>0.120</td>
<td>C₁₁, C₁₂, C₁₃</td>
<td>0.358, 0.246, 0.396</td>
<td>0.043, 0.030, 0.048</td>
<td>10, 12, 8</td>
</tr>
<tr>
<td>Management security B₂</td>
<td>0.097</td>
<td>C₂₁, C₂₂, C₂₃</td>
<td>0.458, 0.413, 0.129</td>
<td>0.044, 0.040, 0.013</td>
<td>9, 11, 15</td>
</tr>
<tr>
<td>Software security B₃</td>
<td>0.217</td>
<td>C₃₁, C₃₂, C₃₃</td>
<td>0.422, 0.278, 0.300</td>
<td>0.092, 0.060, 0.065</td>
<td>3, 7, 6</td>
</tr>
<tr>
<td>Hardware security B₄</td>
<td>0.353</td>
<td>C₄₁, C₄₂</td>
<td>0.603, 0.397</td>
<td>0.213, 0.140</td>
<td>1, 2</td>
</tr>
<tr>
<td>Data security B₅</td>
<td>0.213</td>
<td>C₅₁, C₅₂, C₅₃, C₅₄</td>
<td>0.370, 0.362, 0.128, 0.140</td>
<td>0.079, 0.077, 0.065</td>
<td>4, 5, 14</td>
</tr>
</tbody>
</table>

The implementation of the comprehensive evaluation.

In order to evaluate the safety of the network, we organize the related experts on the secondary index according to the comments concentration of 5 levels to a vote, the normalized results such as shown in Table 3.

Table 3. Experts vote normalization results of a computer network security evaluation secondary indicators

<table>
<thead>
<tr>
<th>Secondary indicators</th>
<th>Very safe</th>
<th>Safe</th>
<th>Safer</th>
<th>Basically safe</th>
<th>Unsafe</th>
</tr>
</thead>
<tbody>
<tr>
<td>C₁₁</td>
<td>0.4</td>
<td>0.30</td>
<td>0.25</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>C₁₂</td>
<td>0.2</td>
<td>0.40</td>
<td>0.30</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>C₁₃</td>
<td>0.4</td>
<td>0.25</td>
<td>0.20</td>
<td>0.10</td>
<td>0.05</td>
</tr>
<tr>
<td>C₂₁</td>
<td>0.4</td>
<td>0.30</td>
<td>0.20</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>C₂₂</td>
<td>0.2</td>
<td>0.30</td>
<td>0.30</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>C₂₃</td>
<td>0.1</td>
<td>0.40</td>
<td>0.30</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>C₃₁</td>
<td>0.5</td>
<td>0.30</td>
<td>0.10</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>C₃₂</td>
<td>0.4</td>
<td>0.50</td>
<td>0.20</td>
<td>0.00</td>
<td>0.00</td>
</tr>
<tr>
<td>C₃₃</td>
<td>0.3</td>
<td>0.30</td>
<td>0.35</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>C₄₁</td>
<td>0.3</td>
<td>0.40</td>
<td>0.25</td>
<td>0.05</td>
<td>0.05</td>
</tr>
<tr>
<td>C₄₂</td>
<td>0.3</td>
<td>0.40</td>
<td>0.20</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>C₅₁</td>
<td>0.3</td>
<td>0.30</td>
<td>0.30</td>
<td>0.10</td>
<td>0.00</td>
</tr>
<tr>
<td>C₅₂</td>
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<td>0.30</td>
<td>0.30</td>
<td>0.10</td>
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</tr>
<tr>
<td>C₅₃</td>
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<td>0.40</td>
<td>0.30</td>
<td>0.10</td>
<td>0.10</td>
</tr>
<tr>
<td>C₅₄</td>
<td>0.3</td>
<td>0.30</td>
<td>0.20</td>
<td>0.10</td>
<td>0.10</td>
</tr>
</tbody>
</table>

So, the first indicators physical security weight vector is:

\[
W_{B₁} = W_{C₁} \cdot R = \begin{pmatrix} 0.4 & 0.3 & 0.25 & 0.05 & 0.05 \\ 0.2 & 0.4 & 0.3 & 0.1 & 0 \end{pmatrix} \begin{pmatrix} 0.358 & 0.246 & 0.396 \\ 0.2 & 0.4 & 0.3 & 0.1 & 0 \end{pmatrix} = \begin{pmatrix} 0.396 & 0.3 & 0.25 & 0.1 & 0.05 \end{pmatrix}
\]

Through normalization: \( \bar{W}_{B₁} = (0.36,0.27,0.23,0.09,0.05) \). Similarly,

\( \bar{W}_{B₂} = (0.33,0.25,0.25,0.08,0.08) \), \( \bar{W}_{B₃} = (0.36,0.27,0.27,0.09,0) \),

\( \bar{W}_{B₄} = (0.27,0.36,0.23,0.09,0.05) \), \( \bar{W}_{B₅} = (0.27,0.27,0.27,0.1,0.08) \).
So as to get the computer network security evaluation results of A weight vector:

\[ W_A = W_B \ast R_B = W_B \ast (\overline{W}_{B_1}, \overline{W}_{B_2}, \overline{W}_{B_3}, \overline{W}_{B_4}, \overline{W}_{B_5})^T = (0.27, 0.353, 0.23, 0.1, 0.08) \]

Through normalization: 

\[ \overline{W}_A = (0.261, 0.342, 0.223, 0.097, 0.077) \]

Because of 

\[ Z = W_A \ast W^T \]

the network security status for the comprehensive evaluation score is \( Z = 81.1 \).

**Analysis of the results.**

Through the calculation above, using the fuzzy comprehensive evaluation method is concluded that the network security evaluation results show that 26.1% very safe, 34.2% for security, 22.3% for a safer, 9.7% for the basic safety, 7.7% for safety. According to the principle of maximum membership, the network security rating for the "safe" level, the comprehensive score of 81.1, security is good, the results basically in accord with actual situation.

Table 2 calculation results can be seen: among the influence network security primary factor, hardware safe impact, accounting for 35.3%; In the secondary factor in primary factor influence, environmental safety, organization system, operating system security, firewall and data backup to the corresponding level factor influences, respectively is 62.5%, 45.8%, 42.2%, 60.3% and 37.0%; In the secondary factor in computer network security in the overall effect, firewall and intrusion detection system for network security influence row in 15 index the first position, the second, specific gravity are 21.3% and 14.0% respectively, therefore, in the network security, it shall pay special attention to hardware security on the influence of computer network security.

**Conclusions**

Influence factors of computer network security has multi-level and multi-attribute characteristic, for this reason, this paper puts forward a kind of based on improved AHP and information entropy coupling empowerment computer network security evaluation model. The numerical example shows that, this model can for the network system security strategy and security solutions offer establish the basis, so as to guide the network information system security system and the construction of the management system. Due to the different assessment method to analyze the problem from different angles, and the result also unavoidably exists deficiencies, so to all kinds of evaluation method in combination, innovation, the comparison is the next research direction.

**References**


