Security Evaluation of Computer Network Based on Hierarchy

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Abstract

Network security is an important issue that the development of computers faces. Based on hierarchy, the network security evaluation is researched by using the analytic hierarchy process in this study. The network security was the target hierarchy, and the environment, hardware, software and data security were used as the indicator hierarchy. The weights were calculated and sorted to understand the network security situation. An instance analysis was carried out by taking a campus network as an example. It was found that the campus network had some shortcomings in anti-virus software, vulnerability scanning and access control, and the security needed to be strengthened. Moreover the reliability of the method was proved. The network security evaluation method based on hierarchy designed in this study is feasible, which provides some theoretical bases for its further development in the field of network security.

Keywords: Data Security; Hierarchy; Network Security

1 Introduction

With the development of society, the popularity of computers has gradually increased, and the network has continuously penetrated into people's daily lives, occupying an indispensable important position [12]. However, with the rapid development of computer networks, more and more information sharing has made the network attack methods more diversified, and the network security problem has become more and more serious [2]. The network security problem mainly refers to ensuring the security of information and data in the network. The threat of network security not only affects people's private information, but also causes certain economic losses [7].

In order to establish a secure network environment, network security technologies are constantly being updated and developed. However, in the face of ever-changing network threats and attacks, traditional network security methods have become more and more inadequate [1]. Thus, pre-understanding of the network security situation becomes more and more important. The network security evaluation refers to understanding the problem of the network through the overall analysis of the network security situation, and timely adopting repair measures to improve network security and ensure the good operation of the network. Due to the significance of of the network security, research on its evaluation methods is also deepening.

Zhou *et al.* [14] proposed an evaluation method combined with fuzzy logic modeling and entropy weight method. The entropy was used to verify the objectivity of the model, and then quantitative analysis was carried out by fuzzy method. Sun *et al.* [10] combined the genetic algorithm and neural network to study the financial network security evaluation of the power industry. The weighted algorithm was used to calculate the comprehensive security score of the network, and corresponding suggestions were put forward. Jiang *et al.* [5] proposed a model based on body temperature safety evaluation, through the imbalance of immune system to carry out network risk assessment, and proved the validity of the model through simulation experiments. Based on the gray relational clustering analysis, Shi [9] analyzed and evaluated the influencing factors of network security to determine the level of network security. The effectiveness of the method was proved by the analysis of actual cases. Based on hierarchy, this study analyzed network security from environment, hardware and software security, and then used analytic hierarchy process to evaluate network security, so as to discover the inadequacies of the network and take timely measures to improve network security. The example analysis proved the effectiveness of the method and provided some theoretical support for network security evaluation.

2 Computer Network Security

The rapid development of computers has brought a series of network threats and risks which have a great impact

on network security. Network security means that hardware, data, etc. in a computer network are not damaged and leaked and can be safely and continuously operated. The following points should be achieved to realize network security:

Availability: Information in the network can be accessed and used to provide effective services.

Confidentiality: Information and data in the network are not illegally stolen by unauthorized users, and users can operate in an absolutely confidential environment. Integrity: the information and data in the network will not always be tampering, deleting, etc. during the transmission process.

Non-repudiation: The network ensures the authenticity of the identity of the recipients of the information, and the recipients of the information cannot deny the transmitted information.

The current network security problem comes from the network attack in the process of information transmission. On the one hand, it comes from the threat to network devices. These insecure factors may be caused by unintentional operations, or may be due to hackers and other lawless elements. In order to ensure network security, methods such as identity authentication, access control, digital signature, and digital encryption have emerged. Based on hierarchy, this study evaluated network security to have a better understanding of network security.

3 Hierarchical Evaluation Indicator System

In order to evaluate network security, it is first necessary to establish an evaluation indicator system. The following principles need to be followed in the selection of indicators:

Scientificity: The selected indicators should be able to scientifically reflect the cyber security situation.

Feasibility: If the selected indicators can collect the required data conveniently, the evaluation process is as simple as possible and easy to operate.

Stability: If the selected indicators are changed regularly, they are not affected by chance.

Comprehensiveness: The selected indicators should be able to comprehensively reflect the network security situation.

This study considered the security factors of environment, hardware, software and data. These four aspects were used as the first-hierarchy indicators of network security evaluation. Then, each first-hierarchy indicator was subdivided and the hierarchical evaluation indicator system is established, as shown in Figure 1.

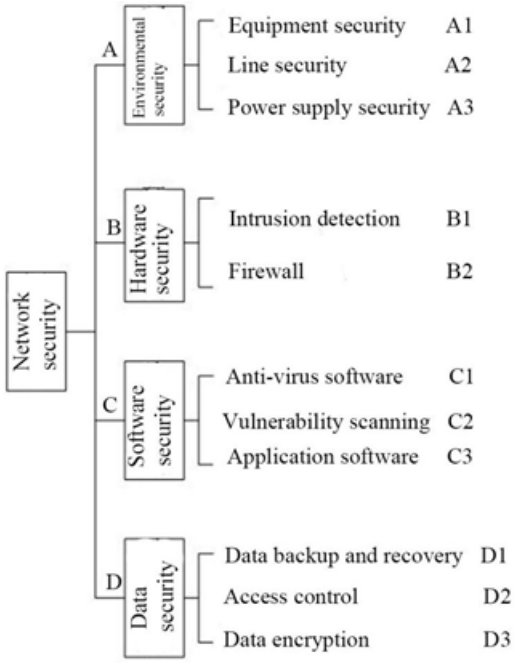

Figure 1: Hierarchical evaluation indicator system

In Figure 1, network security is the target hierarchy, A, B, C, and D represent the indicator hierarchy, and A1, B1, etc. represent the sub-indicator hierarchy, and the project hierarchy is the method that achieves the goal.

4 Hierarchical Analytical Method

4.1 Establishment of Judgment Matrix

According to the expert and the 1-9 proportional scale [4] (see Table 1), the significance of each index is analyzed by the method of pairwise comparison to form the judgment matrix A:

$$A = \begin{bmatrix} a_{11} & a_{12} & \cdots & a_{1n} \\ a_{21} & a_{22} & \cdots & a_{2n} \\ \cdots & \cdots & \cdots & \cdots \\ a_{n1} & a_{n2} & \cdots & a_{nn} \end{bmatrix}$$

which can also be written as $A = \lfloor a_{ij} \rfloor$, $i, j = 1, 2, \cdots, n$.

4.2 Single Hierarchical Arrangement

The largest root λ_{max} of matrix is solved, where λ is the eigenvalues of the matrix, and then the eigenvector W is formed, $W = (W_1, W-2, \cdots, W_n)^T$. The calculation formula of the largest root is $\lambda_{max} = \sum_{i=1}^{n} \frac{AW)_i}{nW_i}$, where $(AW)_i$ is the i-th element of AW.

4.3 Consistency Judgment

Consistency indicator is $CI = \frac{(\lambda_{max}-n)}{n-1}$ and consistency ratio is $CR = \frac{CI}{RI}$, where RI is average random indicator

Table 1: 1-9 proportional scale

Scale	Meaning
1	Indicator A = indicator B
3	Indicator A is a little bit more important than indicator B.
5	Indicator A > indicator B
7	Indicator A ≫ indicator B
9	Indicator A is extremely more important than indicator B.
2, 4, 6, 8	Intermediate values of the indicators mentioned above
Reciprocal	Indicator A and indicator B

(See Table 2). The order n can be judged according to matrix.

$CR = 0.10$ indicates that the matrix has consistency, otherwise the matrix needs to be adjusted.

4.4 Total order Sorting of Hierarchy

The ranking weighting of each plan to the target hierarchy was calculated. The total weight can be expressed as:

$$W_l = \sum_{i,j} W_i W_{ij} W_{ijl}$$

where W_l and W_i are respectively the weight of the plan and indicator to the target hierarchy, W_{ij} is the weight of the sub-indicator to the indicator, and W_{ijl} is the weight of the sub-indicator.

5 Network Security Assessment Based on Hierarchy

In order to verify the effectiveness of the proposed method, a campus network was taken as an example. Five network security experts were selected to evaluate the network, and then the comprehensive evaluation results of network security were obtained through the AHP method.

The evaluation results of network security are shown in Table 3.

The judgement matrix can be obtained according to Table 3:

$$O = \begin{bmatrix} 1 & 1 & 1 & 1/2 \\ 3 & 1/2 & 2 & 2 \\ 2 & 1/5 & 1 & 1 \\ 2 & 2 & 1/2 & 2 \end{bmatrix}$$

. The eigenvector is $W_1 = [0.21, 0.24, 0.26, 0.29]^T$. Then the consistency of the matrix is calculated to obtain

$$OW_1 = \begin{bmatrix} 0.62 \\ 2.01 \\ 1.84 \\ 0.31 \end{bmatrix}$$

According to $\lambda_{max} = \sum_{i=1}^{n} \frac{(AW)_i}{nW_i}$, $\lambda_{,ax} = 5.12$ can be obtained. $CI = 0.02$ and $CR = 0.026$ can be calculated to satisfy consistency. Thus, the weight is $W_1 = [0.21, 0.24, 0.26, 0.29]^T$. The evaluation results of environmental security are shown in Table 4.

The weight $W_2 = [0.42, 0.12, 0.46]^T$ can be obtained by the same way. The evaluation results of hardware security are shown in Table 5.

$W_3 = [0.50, 0.50]^T$ is obtained. The evaluation results of software security is shown in Table 6.

$W_4 = [0.62, 0.28, 0.10]^T$ is obtained. The evaluation results of data security are shown in Table 7.

$W_5 = [0.21, 0.37, 0.42]^T$ is obtained. According to the weight calculation result, the result of total order sorting of hierarchy is shown in Table 8.

From Table 8, it could be found that the main security issues of the campus network are anti-virus software, vulnerability scanning and access control. With the development of computers, the viruses and attacks faced by the network are becoming more and more diversified. Thus, anti-virus software and vulnerability scanning cannot fully intercept these attacks, which bring hidden dangers to network security. In addition, in terms of data security, due to the difficulty in identity authentication, etc., the access control of the network also has vulnerabilities. In summary, according to the evaluation results of hierarchical network security, the campus network should strengthen the three aspects of anti-virus software, vulnerability scanning and access control and be better to use a more secure method to manage and ensure network security.

6 Discussion and Conclusion

The Internet is a vital part of people's daily life [13]. It is a powerful information exchange platform that brings great convenience to people in terms of study, work and entertainment [3], and has been widely used in various fields. However, the expansion of network demand has brought about a reduction in the network security factor. Personal information and data stored in the network are increasingly threatened by cyber attacks. Thus, network security issues are becoming more prominent [8,11]. It has affected people's network experience and greatly threatened the progress of the network. Therefore, network security has become an increasingly important issue [6]. Research on network security is of great significance to the development of the network. Through network security evaluation, people can well grasp the network security situation and take targeted measures to repair the network before being attacked, thereby improving network security and ensuring the safe operation of the system. Based on hierarchy, this study evaluated network security through analytic hierarchy process from four aspects: environmental security, hardware security, software security and data security. A campus network was analyzed as an example, which proved the effectiveness of the method in

Table 2: Average random indicator

Order	1	2	3	4	5	6	7	8	9
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41	1.45

Table 3: The evaluation results of network security

Network security	Environmental security	Hardware security	Software security	Data security
Environmental security	1	1	1	1/2
Hardware security	3	1/2	2	2
Software security	2	1/5	1	1
Data security	2	2	1/2	2

Table 4: The evaluation results of environmental security

Environmental security	Equipment security	Line security	Power supply security
Equipment security	1	2	2
Line security	1/2	1	1
Power supply security	1/4	1	2

Table 5: The evaluation results of hardware security

Hardware security	Intrusion detection	Firewall
Intrusion detection	1	1
Firewall	1	1

Table 6: The evaluation results of software security

Software security	Anti-virus software	Vulnerability scanning	Application software
Anti-virus software	1/3	4	2
Vulnerability scanning	2	2	2
Application software	1	1	1

Table 7: The evaluation results of data security

Data security	Data backup and recovery	Access control	Data encryption
Data backup and recovery	1	2	1/3
Access control	2	1	1
Data encryption	1/2	1/4	1

Table 8: The result of total order sorting of hierarchy

Target Hierarchy	Indicator Hierarchy	Sub-indicator Hierarchy	Weight	Total Order Sorting of Hierarchy
Network security	Environmental security 0.21	Equipment security	0.42	0.052
		Line security	0.12	0.016
		Power supply security	0.46	0.027
	Hardware security 0.24	Intrusion detection	0.50	0.046
		Firewall	0.50	0.046
	Software security 0.26	Anti-virus software	0.62	0.124
		Vulnerability scanning	0.28	0.136
		Application software	0.10	0.064
	Data security 0.29	Data backup and recovery	0.21	0.052
		Access control	0.37	0.134
		Data encryption	0.42	0.018

network security evaluation. In the face of an increasingly complex network environment, the following is critical to the enhancement of network security:

Network security awareness should be strengthened. With the popularity of computer networks, some users have insufficient understanding of the network and non-proficient network operations, which is easy to bring an opportunity to the attacker and cause security risks. The hierarchical protection system can enhance network security awareness of users and scientifically and effectively manage the network. After the user's security awareness is improved, it can promote the further improvement of the protection system, thereby achieving efficient network security protection and establishing a good network environment for users.

Hardware facilities should be improved. The security of network equipment will have a great impact on network security. When users use the network, they need to maintain and monitor the internal and external structure of the network. They also need to perform regular inspection and maintenance on existing equipment to provide reliable guarantee for network security.

Access control should be strengthened. User access is a key part of network security protection. In the process of using the protection system, it is necessary to strengthen the control of user access, monitor user identity, user password, authentication information, etc. and timely control access rights in case of problems to stop illegal behaviors and improve network security.

In summary, the hierarchical network security evaluation method designed in this study can analyze the network security situation well and find out the weak points. Therefore, the vulnerability of network can be repaired in time to improve the capabilities of network face attack and promote network security, which is beneficial to the further development of computer networks.

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Biography

Linbin Wen, born in 1980, male, from Hengdong, Hunan, China, has gained the master's degree. He is now working in Hunan Mass Media Vocational Technical College. He is an associate professor and senior engineer. He is interested in computer network technology, information security technology and cloud computing technology.