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The Computer Network Reliability Evaluation Research

Ning Yu

Weifang University of Science and Technology, Shouguang,Shandong, CHINA
7087370@qq.com

Computer network reliability receives much concern. People's life has been inseparable from computer network. In this paper, according to the determined selection principles of computer network reliability evaluation indexes, 5 first-level indexes and 19 second-level indexes are selected to structure the computer network reliability evaluation system. Using the analytic hierarchy process (AHP) to determine the weight of each index, computer network reliability can be divided into five levels, that is, very reliable, reliable, general, poor, and very poor. Through expert evaluation, fuzzy mathematical evaluation model is established and the simulation experiment was carried out. The fuzzy mathematical evaluation model of computer network reliability is professional, scientific, and reasonable, which provides theoretical basis for the development of computer network.

1. Introduction

With the development of society and the progress of science and technology, computers and mobile phones are widely popularized. Network has been applied in various fields. Network appears everywhere in current life(Adnen Sanaa, Samir Ben Abid, Abdennacer Boulila, Chokri Messaoud, Mohamed Boussaid, Najeh Ben Fadhel.2016). People are inseparable from the network now. As the users' dependence on the network grows, the requirement for computer network reliability people demand is higher and higher. If there appear problems on computer network, people's daily life, national economy, and even social stability will be affected a lot.

The reliability of network system is a computer discipline. Its task is to carry on the statistical analysis to the network system faults in certain time, under certain conditions and a certain function, to find out rules, by means of mathematical methods to synthesize, analyse and describe network system regularly, selecting the appropriate data to analyse computer network reliability(Chuan-sheng Xie, et.al. 2010).

Reliability is an important performance index of network evaluation. With the wide application of computers in various fields, the importance of computer network reliability becomes clear. A specialized network system reliability study is gradually formed. The necessary tools that be used are reliability mathematics which includes fuzzy mathematics, probability statistics, graph theory, optimization decision and topology, etc (Michal Przewozniczek.2016).

Since the 1990s, computer network system reliability becomes a new research hotspot gradually. Traffic network, logistics network, power network, and transport network are associated with computer network. And its evaluation problems are more and more paid attention to. In this paper, on the basis of previous research, the evaluation index system of computer network reliability is first determined and then fuzzy mathematical evaluation model of computer network reliability is established(Mohammad Sadeq Garshasbi.2016).

2. The establishment of computer network reliability evaluation index system

The computer network reliability evaluation is tedious work, which need to fully consider the influencing factors of computer network, not only the fixed indexes, but change indexes as well. In the process of selecting evaluation indexes, certain principles should be followed(Ahmad Jakalan, Jian Gong, Qi Su, Xiaoyan Hu, Abdeldime M.S. Abdelgder.2016). The detailed principles are as follows:

(1)The combination of overall consideration and an emphasis

In the process of selecting computer network reliability evaluation indexes, not only each main index that influences computer network should be fully considered, but also the outburst indexes that influence computer

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network in various links should be considered. That is, overall consideration should be combined with an emphasis.

(2)The combination of accuracy evaluation and fuzzy evaluation

In the process of selecting computer network reliability evaluation indexes, most indexes need accurate data, according to its data to evaluate computer network reliability. Some indexes haven't got accurate data. But we need to clear the evaluation direction or trend. Therefore, it is necessary to combine the accuracy evaluation with fuzzy evaluation.

(3)The combination of operability and systematization

In the process of selecting computer network reliability evaluation indexes, the final evaluation indexes that have been determined must be operable. Thus, the evaluation indexes are required to be simple, practical, and amortizable. At the same time, the integrity and systematization of computer network reliability evaluation system should be considered, combining the operability with the systematization.

According to the three principles determining computer network reliability evaluation indexes above, based on a large number of document data, the 5 first-level indexes and 19 second-level indexes of computer network reliability evaluation index system could be determined. The detailed indexes are shown in table 1.

Table 1: computer network reliability evaluation index system

	first-level indexes	second-level indexes
computer network reliability evaluation P	physical performance A	the standardization of interface A1 electrical operability A 2 communication exchange equipment A 3 communication link A 4
	link performance B	the efficiency of data transmission B1 link utilization ratio B2 link transmission ability B3 data transfer success ratio B4
	network performance C	network connectivity C 1 network vulnerability C 2 network transmitting coefficient C 3 network accessibility C4
	transmission performance D	total transmission D1 transmission delay D2 transmission pipeline D3 maximum transmission D4
	user performance E	user number E1 user usage time E2 network knowledge of users E3

3. The introduction of fuzzy mathematics level evaluation method(Li Tao.2015)

The fuzzy mathematics level evaluation method is a common method in fuzzy decision problems, which is a comprehensive evaluation method to the object affected by multiple evaluation indexes based on fuzzy mathematics. The aim is using fuzzy mathematics knowledge system to determine the factor set and evaluation set of all evaluation indexes, to structure level evaluation matrix and to determine the evaluation level of the object so as to make overall evaluation to evaluated object.

(1)Determine evaluation index factor set $P=\{p_1,p_2,\cdots,p_n\}$, and there are n kinds of evaluated objects.

(2)Determine level evaluation set $V=\{v_1,v_2,\cdots,v_m\}$, and m is the level number of evaluation.

(3)Determine fuzzy evaluation matrix $R=(r_{ij})_{n\times m}$, and the basic steps are as follows:

First, make a level evaluation $f(p)$ (and $i=1,2,\cdots,n$) to all index factors p, we could get a fuzzy mapping f from P to V, namely:

$$f:P\to F(P), p_i\to f(p_i)=(r_{i1},r_{i2},\cdots,r_{im})\in F(V)$$

Second, from the fuzzy mapping f, we could induce the fuzzy relation $R_f\in F(P\times V)$, namely:

$R_f(p_i,v_i)=f(p_i)(v_i)=r_{ij}$, and $i=1,2,\cdots,n$; $j=1,2,\cdots,m$,

Therefore, fuzzy evaluation matrix $R=(r_{ij})_{n\times m}$ could be determined.

(4)The analytic hierarchy process (AHP) is used to determine the weights of evaluation indexes at all levels.

(5)According to the weights of each evaluation index and evaluation matrix, use the matrix multiplication to get the comprehensive evaluation vector $w=\gamma^T R$.

4. The fuzzy mathematics model of computer network reliability evaluation(Han Zhonggeng.2005)

(1)According to table 1, the evaluation index factor set of computer network reliability evaluation $P=\{p_1, p_2,\cdots, p_{19}\}$ could be determined. And there are 19 evaluation indexes of the evaluated object. Meanwhile, draw the hierarchical structure diagram of computer network reliability evaluation. The specific details are shown in diagram 1.

Table 2: the second-level evaluation index classification of computer network reliability

second-level index	level				
the standardization of interface A1	very standard	standard	general	less standard	nonstandard
electrical operabilityA2	well-operated	operated	general	difficult to operate	very difficult to operate
communication exchange equipment A3	very good	good	general	poor	very poor
communication link A4	well integrated	integrate d	general	not integrated	damaged
the efficiency of data transmission B1	very high	high	general	low	very low
link utilization ratio B2	very high	high	general	low	very low
link transmission ability B3	very big	big	general	small	very small
data transfer success ratio B4	very high	high	general	low	very low
network connectivity C1	very good	good	general	poor	very poor
network vulnerability C2	very strong	strong	general	vulnerable	very vulnerable
network transmitting coefficient C3	very big	big	general	small	very small
network accessibility C4	very good	good	general	poor	very poor
total transmission D1	very big	big	general	small	very small
transmission delay D2	very good	good	general	poor	very poor
transmission pipeline D3	very good	good	general	poor	very poor
maximum transmission D4	very big	big	general	small	very small
user number E1	few	a few	general	many	a lot
user usage time E2	little	a little	general	much	a lot
network knowledge of users E3	very good	good	general	poor	very poor

(2)Determine the level evaluation set of computer network reliability evaluation $V=\{v_1,v_2,\cdots,v_5\}$,the computer network reliability is divided into 5 levels, that is, very reliable, reliable, general, poor, and very poor(Li Tao.2015). The specific levels are shown in table 2.

(3)Determine fuzzy evaluation matrix of computer network reliability evaluation $R=(r_{ij})_{n\times m}$.

Using the expert evaluation method, the level evaluation to the second-level indexes of computer network reliability evaluation is carried on. Here we choose the expert group composed of10 experts, and we could get:

$$R_A=\begin{bmatrix} r_{11}^{(A)} & r_{12}^{(A)} & \cdots & r_{15}^{(A)} \\ \cdots & & \cdots & \cdots \\ r_{41}^{(A)} & r_{42}^{(A)} & \cdots & r_{45}^{(A)} \end{bmatrix}, r_{ij}=\frac{\text{The expert number of j level}}{10}.$$

Similarly to the following conclusions: R_B , R_C , R_D , R_E .

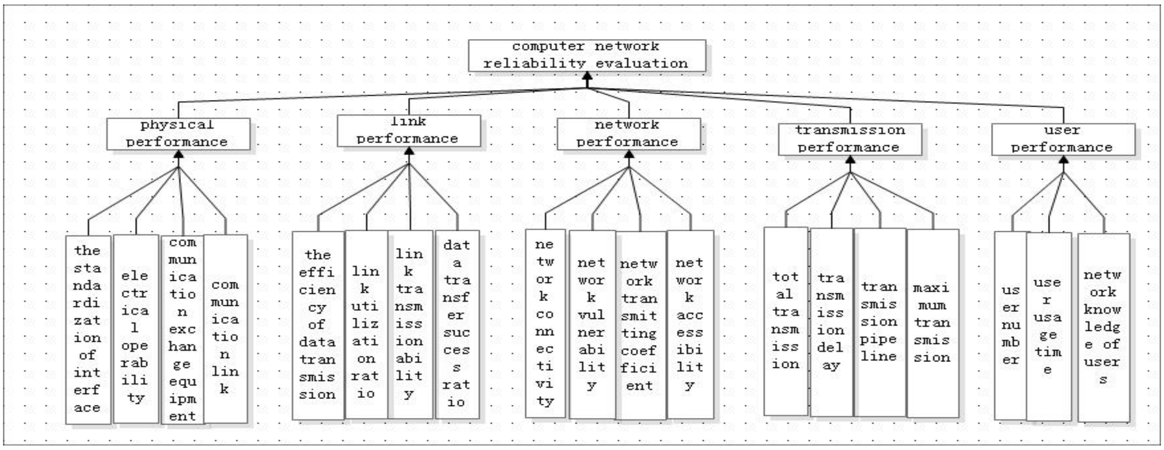

Diagram 1: the hierarchical structure diagram of computer network reliability evaluation

Table 3: each index weights of computer network reliability evaluation

	first-level indexes	weight	second-level indexes	weight
computer network reliability evaluation P	physical performance A	0.0506	the standardization of interface A1	0.1154
			electrical operabilityA2	0.5455
			communication exchange equipment A3	0.1940
			communication link A4	0.1451
	link performance B	0.2339	the efficiency of data transmission B1	0.0931
			link utilization ratio B2;	0.2452
			link transmission ability B3	0.5050
			data transfer success ratio B4	0.1567
	network performance C	0.1285	network connectivity C1	0.6489
			network vulnerability C2	0.0881
			network transmitting coefficient C3	0.2178
			network accessibility C4	0.0452
	transmission performance D	0.0931	total transmission D1	0.1445
			transmission delay D2	0.3705
			transmission pipeline D3	0.4406
			maximum transmission D4	0.0444
	user performance E	0.4939	user number E1	0.6250
			user usage time E2	0.1365
			network knowledge of users E3	0.2385

(4)Determine each index weights of computer network reliability evaluation at all levels.

The analytic hierarchy process (AHP) is used to calculate each index weights of computer network reliability evaluation at all levels. At the same time, consistency check is carried on. And the final weight results are shown in table 3.

(5)According to each second-level index corresponding weights of computer network reliability evaluation, the 5 fuzzy evaluation matrixes of first-level indexes could be obtained as follows:

$$R_P = (\gamma_A^T R_A \quad \gamma_B^T R_B \quad \gamma_C^T R_C \quad \gamma_D^T R_D \quad \gamma_E^T R_E)^T ,$$

According to the weights of first-level indexes, level evaluation vector of computer network reliability evaluation could be got as follows:

$$w = \gamma_P^T R_P \,,$$

Based on the maximum principle, the biggest component of w is the level of computer network reliability evaluation.

5. An empirical analysis of computer network reliability evaluation

10 experts evaluate the computer network reliability of Weifang University of Science and Technology. 19 second-level evaluation indexes are carried on the fuzzy level evaluation (SiShouKui Sun Zhaoliang.2015). The detailed results are shown in table 4.

Table 4: the second-level index level evaluation results of computer network reliability of Weifang University of Science and Technology

second-level indexes	level				
the standardization of interface A1	0	2	6	2	0
electrical operabilityA2	1	2	4	2	1
communication exchange equipment A 3	1	3	3	2	1
communication link A4	0	2	4	3	1
the efficiency of data transmission B1	0	2	5	2	1
link utilization ratio B2	0	1	7	1	1
link transmission ability B3	2	4	4	0	0
data transfer success ratio B4	5	3	2	0	0
network connectivity C1	3	5	1	1	0
network vulnerability C2	1	3	5	1	0
network transmitting coefficient C3	4	3	3	0	0
network accessibility C4	1	2	4	3	0
total transmission D1	0	2	6	1	1
transmission delay D2	4	5	1	0	0
transmission pipeline D3	2	4	3	1	0
maximum transmission D4	1	3	5	1	0
user number E1	2	3	4	1	0
user usage time E2	1	3	6	0	0

After doing the data processing to the expert evaluation results.

Using the program MATLB (The specific details are shown in the attachment.), the evaluation vector of computer network reliability evaluation of Weifang University of Science and Technology is shown as follows:

$$w = \begin{pmatrix} 0.2098 & 0.3081 & 0.3877 & 0.0807 & 0.0137 \end{pmatrix},$$

Based on the maximum principle we could get that the evaluation level of computer network reliability of Weifang University of Science and Technology is general.

The results accord with the actual situation of computer network reliability of Weifang University of Science and Technology. Weifang University of Science and Technology is developing rapidly, but its computer network development is relatively slow, and its reliability and security should be further improved.

6. Conclusion

It is feasible to use fuzzy mathematics knowledge to evaluate computer network reliability. From the application of this model, we could get that the 5 first-level indexes of computer network reliability of Weifang University of Science and Technology doesn't coordinate well, especially the network performance is not good enough. In this paper, I suggest that this University should strengthen its management coordination through administration, market and technical means, change its computer network structure, and enhance its computer network reliability.

Attachment

Program MATLB
```
a=load ('jsjwlkkxpg.txt');
w= [0.0506 0.2339 0.1285 0.0931 0.4939];
w1= [0.1154, 0.5455, 0.1940, 0.1451];
w2= [0.0931, 0.2452, 0.5050, 0.1567];
w3= [0.6489, 0.0881, 0.2178, 0.0452];
w4= [0.1445, 0.3705, 0.4406, 0.0444];
w5= [0.6250, 0.1365, 0.2385];
b(1,:)=w1*a([1:4],:);
b(2,:)=w2*a([5:8],:);
b (3,:)=w3*a([9:12],:);
b (4,:)=w4*a([13:16],:);
b (5,:)=w5*a([17:end],:);
c=w*b
c =0.2098    0.3081    0.3877    0.0807    0.0137
```

Reference

Garshasbi M.S., 2016, Fault localization based on combines active and passive measurements in computer networks by ant colony optimization. Reliability Engineering and System Safety, DOI: 10.1016/j.ress.2016.03.017

Han Z.G., 2005, Mathematical modeling method and its application [M]. Beijing: higher education press.

Jakalan A., Gong J., Su Q., Hu X.Y., Abdelgder A.M.S., 2016, Social Relationship Discovery of IP Addresses in The Managed IP Networks by Observing Traffic at Network Boundary, Computer Networks, DOI: 10.1016/j.comnet.2016.02.012b

Li T., 2015, Application of fuzzy mathematics in the supermarket customer degree of satisfaction evaluation [J]. Journal of capital normal university, (3): 15-18.

Li T., 2015, Based on the network security risk fuzzy mathematical evaluation [J]. Journal of huaiyin normal university, (2): 60-64.

Li T., 2015, The environment impact evaluation -based on urban land planning project [J].International Journal of Earth Sciences and Engineering, (2).

Li Z.Z., Ge W.L., Deng P., Wang X.P., 2008, Analytic hierarchy process for reliability of computer networks [J]. Engineering Journal of Wuhan University, 12 (6): 113-117.

Przewozniczek M., 2016, Active Multi Population Pattern Searching Algorithm for Flow Optimization in Computer Networks – the novel coevolution schema combined with linkage learning. Information Sciences, DOI: 10.1016/j.ins.2016.02.048

Sanaa A., Abid S.B., Boulila A., Messaoud C., Boussaid M., Fadhel N.B., 2016, Ecological systems as computer networks: long distance sea dispersal as a communication medium between island plant populations, BioSystems, DOI：10.1016/j.biosystems.2016.04.006

Si S.K., Sun Z.L., 2015, mathematical modeling algorithm and its application [M]. Beijing: national defence industry press.

Xie C.S., Xu X., Hou W.T., Xu F.R., 2010, Path analysis and synthetic evaluation of city low carbon economy development [J], technical economy, (8): 29-32.