Research on LAN Performance Evaluation Based on Fuzzy Comprehensive Evaluation Method

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Abstract: A LAN performance evaluation method is proposed based on fuzzy comprehensive evaluation method for the shortcomings of LAN in network performance evaluation on this paper. The basic principles, steps and advantages of the fuzzy comprehensive evaluation method are briefly analyzed. The key parameters such as the selection of technical parameters of the LAN, the determination of the evaluation weight coefficient, and the formulation of evaluation criteria are analyzed in-depth. The membership function is constructed. The simulation test was carried out by applying the fuzzy comprehensive evaluation method, and the correct rate was 98.3%. An objective and fair evaluation of the performance of the local area network is achieved. It provides a theoretical basis for accurately grasping the health status of the local area network.

1. Introduction
A local area network (LAN) is a bearer network that carries a large number of data transmission and exchange tasks such as data, voice, and live video. The performance status of the LAN is directly related to the quality of the network, which directly affects whether the tasks undertaken can be completed. Because the LAN is a new technology system and the use time is short, there is a lack of reasonable performance evaluation system, perfect evaluation standard and scientific evaluation method. Therefore, carry out research on key technologies of LAN performance evaluation, propose scientific, objective and practical evaluation index system and evaluation method, formulate local area network performance evaluation standards, realize objective and fair evaluation of LAN performance, and effectively improve the accuracy of network performance comprehensive evaluation results. It has important practical significance. The fuzzy comprehensive evaluation method is a widely used method in fuzzy mathematics [1]. In the evaluation of a certain transaction, there is often such a problem. Since the evaluation is determined by many factors, each factor is evaluated; on the basis of a separate comment for each factor, how to consider all the factors and make a comprehensive review is a comprehensive evaluation question. The boundaries of many things are not very obvious. It is difficult to attribute them to a certain category during evaluation. Therefore, individual factors are evaluated first, and then comprehensive fuzzy evaluation of all factors is carried out to prevent the loss of any statistical information and information. Help solve the problem of deviation from objective reality brought about by the deterministic evaluation of “yes” or “no”. Based on the above reasons, this paper proposes a local area network performance evaluation method based on fuzzy comprehensive evaluation method to realize objective and fair evaluation of local area network performance.
2. The basic principles, steps and advantages of fuzzy comprehensive evaluation

2.1. The basic principle of fuzzy comprehensive evaluation
Fuzzy comprehensive evaluation method is a comprehensive evaluation method based on fuzzy mathematics. The comprehensive evaluation method transforms the qualitative evaluation into quantitative evaluation according to the membership degree theory of fuzzy mathematics, that is, using fuzzy mathematics to make an overall evaluation of things or objects subject to various factors [1]. It has the characteristics of clear results and strong system, which can solve fuzzy and difficult to quantify problems, and is suitable for solving various non-deterministic problems.

2.2. Basic steps of fuzzy comprehensive evaluation
(1) Construction of fuzzy comprehensive evaluation index
The fuzzy comprehensive evaluation index system is the basis for comprehensive evaluation. Whether the selection of evaluation indicators is appropriate will directly affect the accuracy of comprehensive evaluation [2].
   (2) Construct a weight vector
   The weight vector is constructed by expert experience method or AHP analytic hierarchy process.
   (3) Building an evaluation matrix
   Establish a suitable membership function to construct an evaluation matrix.
   (4) Synthesis of evaluation matrix and weights
   It is synthesized using appropriate synthesis factors and the result vector is interpreted.

2.3. Advantages of network performance evaluation using fuzzy comprehensive evaluation method
(1) It is possible to avoid the subjectivity inherent in the objective selection by experience, and make the assessment classification more scientific and reasonable. Although fuzzy evaluation method adopts fuzzy mathematics, its method is simple and easy. It shows its application prospects on some problems that cannot be quantitatively analyzed from the traditional point of view, and it solves the ambiguity and uncertainty of judgment well[2].
(2) Apply the fuzzy comprehensive evaluation method, no training data and training steps are needed, as long as the threshold of each parameter in each network level state is set, the comprehensive evaluation of the network level can be performed. It is worthwhile that the accuracy of the algorithm does not require excessive dependency and training data.
(3) The fuzzy comprehensive evaluation algorithm is simple in operation and can meet the requirements of real-time and fast processing of the system.

3. Key points of the evaluation process

3.1. Selection and analysis of evaluation factors
The evaluation factor is the basis for the completion of the assessment and the object of the evaluation criteria. Whether the selection of the evaluation factors is reasonable is directly related to the accuracy of the assessment conclusions, whether the evaluation criteria are targeted, and the evaluation elements are systematic, operable, and effective. Sex, comparability and dynamics are the selection principles of evaluation factors [3]. In this paper, a total of 276 parameters can be extracted from the local area network, and there are 4 text data, including 42 network equipment performance management classes, 170 network traffic management classes, 64 network transmission performance management, network topology management and network failure. The management class has 4 text class data. According to the actual demand, the evaluation index parameters are: 15 equipment index parameters, 41 link index parameters, and 18 traffic index parameters, and a total of 74 network indicator parameters. The following is the analysis of the main parameters that will be used in the system evaluation of this paper. After analysis, these parameters fully meet the requirements of IP network quality assessment.
(1) Equipment class parameters
It mainly includes the NE device, the board, the subrack, and the optical module. The NE and the subrack are mainly CPU and memory usage. The parameters of the board are CPU, memory usage, voltage, and temperature. The parameters of the optical module are Receives luminous power, voltage, temperature, and bias current. The device class parameters mainly reflect the basic health of the device.

(2) Link transmission performance parameters
The main reaction link and the working state of the network.
Bandwidth utilization: Reflects the bandwidth utilization of the link. If the value is too high, it means that the link bandwidth is insufficient or overloaded.
One-way delay, two-way delay: mainly reflects the average time spent on data being forwarded through the device and transmitted in the link.
Maximum latency: primarily reflects the maximum time spent on data being forwarded through the device and transmitted over the link.
Delay jitter: mainly reflects the stability of data transmission services provided by devices and links, and has a great impact on video transmission services.
Packet loss rate: stability index of data transmission
Incoming (out) broadcast packets: Too many broadcast packets will consume a lot of network resources, causing normal services to fail. Too many broadcast packets indicate problems with network topology and connectivity.
Number of packets exceeding the queue limit: The matching of the link rate of the network is reflected. If the indicator is too high, the device or link should be replaced.
Number of collisions: Ethernet uses the carrier sense multiple access/collision detection mechanism. In the same collision domain, if two or more devices simultaneously send frames to the cable, conflicts will occur. If the number of conflicts is too high, the throughput of the network will be seriously affected, resulting in degraded network performance. The network segmentation collision domain must be upgraded. Usually the conflict should be less than one percent of the total traffic.
Number of error frames caused by collisions: When a collision occurs, it is highly likely that both frames will not be decipherable. If the number of error frames caused by the conflict is too high, the network performance in this subnet is reached, and the network performance is degraded. The network should be upgraded in time.
IP routing failure packet rate: mainly reflects the working status of the routing protocol. If the parameter is too high, the routing protocol has a problem or the routing protocol is working abnormally.
SNMP packet receiving error packet rate: SNMP packets are mainly used for network management. If this parameter is too high, the network management software cannot reflect the network status.

(3) Network traffic performance parameters
Monitor link bandwidth utilization and alert the network bandwidth bottleneck to links with bandwidth utilization exceeding 80%.
Focus on monitoring the export traffic, setting the upper and lower thresholds for each link traffic, and alerting the traffic that exceeds the threshold setting or the model setting.
Count the number of unicast, multicast, broadcast packets and packet speed in the link;
The traffic of different transport protocols is recorded and displayed in the source/destination IP and source/destination port numbers.

3.2. Evaluation index weight determination
At present, there are many methods for determining the weight coefficient. According to the different sources of the original data when calculating the weight coefficient, these methods can be divided into three categories: subjective judgment method, objective judgment method and subjective and objective combination judgment method [3]. The subjective and objective combination judgment method is mainly to combine subjective and objective judgment methods, and to make full use of their respective
advantages while making up for the deficiencies. This method is more commonly used in the current comprehensive evaluation index system empowerment.

According to the actual situation studied in this paper, the collected evaluation information cannot constitute a large sample of data, so it is determined that the weight is determined by subjective judgment. The AHP method is the most commonly used subjective judgment method, but its research finds that there is only one judgment matrix constructed by this method. In practice, many experts need to be invited to score, so it needs to be improved to solve the group judgment matrix. Question [4]. The group AHP method can solve the group judgment matrix problem well, so this paper uses the group AHP method to determine the index weight.

By constructing the judgment matrix and selecting the judgment matrix, the importance ranking index, the construction judgment matrix, the transfer matrix of the construction judgment matrix, the optimal transfer matrix of the construction transfer matrix, the consistency of the correction judgment matrix, the eigenvector, and the relative weight of the expert are calculated. The weights of the various indicators are calculated by the steps of determining and judging the comprehensive weight [4].

3.3. Develop network performance evaluation criteria
The LAN performance evaluation standard is the code of conduct for standardizing LAN performance evaluation [5], which is an important basis for achieving objective and fair quality assessment of LAN performance. Whether the development of LAN performance evaluation criteria is scientific and reasonable is a key factor related to the accuracy of LAN performance evaluation conclusions. Therefore, it is especially important to formulate scientific and reasonable LAN performance evaluation standards with reference to relevant national standards and national military standards, combined with the actual needs of unit LAN performance [5]. According to the actual demand, the evaluation index parameters are: equipment type index parameters, 14 link type index parameters, and a total of 21 network indicator parameters. These metric parameters can be extended as needed during the evaluation implementation.

The 21 network indicator parameters and their rating criteria used in the paper are shown in Table 1 below.

| Parameter | Grade | Excellent | Qualified | Unqualified |
|-----------|-------|-----------|-----------|-------------|
| CPU usage | <40%  | [40%,70%] | >70%      |
| Memory usage | <60% | [60%,80%] | >80% |
| Optical module temperature | <65°C | [65°C, 80°C] | >80°C |
| Optical module voltage | <1% | [1%, 5%] | >5% |
| Optical module bias current | <0.5% | [0.5%, 1%] | >1% |
| Optical module receiving power | -4dBm | [-2,-5] dBm | >-5 dBm |
| Optical module transmit power | -2 dBm | [-1,-3] dBm | >-3 dBm |
| Number of incoming messages | <40% of bandwidth | Between 40% and 70% of bandwidth | >70% bandwidth |
| Incoming unicast packet rate | <40% of bandwidth | Between 40% and 70% of bandwidth | >70% bandwidth |
| Error protocol packet rate | 0.05% (64 bytes packet length) | Better than 0.1% | >0.1% |
| Outgoing unicast packet speed | <40% of bandwidth | Between 40% and 70% of bandwidth | >70% bandwidth |
| Received multicast | <40% of bandwidth | Between 40% and 70% of bandwidth | >70% bandwidth |
| Received broadcast | <40% of bandwidth | Between 40% and 70% of bandwidth | >70% bandwidth |
| Transmitted multicast | <40% of bandwidth | Between 40% and 70% of bandwidth | >70% bandwidth |
| Sent broadcast | <40% of bandwidth | Between 40% and 70% of bandwidth | >70% bandwidth |
| Bandwidth | <40% of bandwidth | Between 40% and 70% of bandwidth | >70% bandwidth |
| Incoming (out) error package | <0.05% (64 bytes packet length) | Better than 0.1% | >0.1% |
| Inflow (out) discard | <0.5 packs / 5 minutes | Better than 3 packs / 5 minutes | > 3 packs / 5 minutes |
| Delay | <10 ms | ≤100ms | >100ms |
| Packet loss rate | <0.05% (64 bytes packet length) | Better than 0.1% | >0.1% |
| Inflow (out) packet speed | <40% of bandwidth | Between 40% and 70% of bandwidth | > 70% bandwidth |
4. Constructing membership function
The 21 networks are collected in real time, and the membership functions are calculated according to their three levels. The membership function of each of the three levels of excellent, qualified, and unqualified parameters is as follows.

(1) CPU usage

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 0.3 \\ 0: \text{Qualified} & 0 \leq x < 0.55 \\ 2: \text{Unqualified} & x \geq 0.55 \end{cases} \]

(2) Memory usage

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 0.5 \\ 0: \text{Qualified} & 0 \leq x < 0.7 \\ 2: \text{Unqualified} & x \geq 0.7 \end{cases} \]

(3) Optical module temperature

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 55 \\ 0: \text{Qualified} & 55 < x \leq 70 \\ 2: \text{Unqualified} & x \geq 70 \end{cases} \]

(4) Optical module voltage

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 55 \\ 0: \text{Qualified} & 55 < x \leq 70 \\ 2: \text{Unqualified} & x \geq 70 \end{cases} \]

(5) Optical module bias current

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 55 \\ 0: \text{Qualified} & 55 < x \leq 70 \\ 2: \text{Unqualified} & x \geq 70 \end{cases} \]

(6) Optical module receiving power

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 55 \\ 0: \text{Qualified} & 55 < x \leq 70 \\ 2: \text{Unqualified} & x \geq 70 \end{cases} \]

(7) Optical module transmit power

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 55 \\ 0: \text{Qualified} & 55 < x \leq 70 \\ 2: \text{Unqualified} & x \geq 70 \end{cases} \]

(8) Number of incoming messages

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 0.3 \\ 0: \text{Qualified} & 0 \leq x < 0.55 \\ 2: \text{Unqualified} & x \geq 0.55 \end{cases} \]

(9) Incoming unicast packet rate

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 0.3 \\ 0: \text{Qualified} & 0 \leq x < 0.55 \\ 2: \text{Unqualified} & x \geq 0.55 \end{cases} \]

(10) Error protocol packet rate

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 0.3 \\ 0: \text{Qualified} & 0 \leq x < 0.55 \\ 2: \text{Unqualified} & x \geq 0.55 \end{cases} \]

(11) Outgoing unicast packet speed

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 0.3 \\ 0: \text{Qualified} & 0 \leq x < 0.55 \\ 2: \text{Unqualified} & x \geq 0.55 \end{cases} \]

(12) Received multicast

\[ y_1 = \begin{cases} 1: \text{Excellent} & x \leq 0.3 \\ 0: \text{Qualified} & 0 \leq x < 0.55 \\ 2: \text{Unqualified} & x \geq 0.55 \end{cases} \]
(13) Received broadcast
Excellent: \( y_1 = \begin{cases} 1; x \leq 0.3 \\ -4r + 2.203 < x < 0.55 \\ 0; x \geq 0.55 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 0.3, r \geq 0.8 \\ 4r - 1.203 \leq x \leq 0.55 \\ -4r + 3.2055 < x < 0.8 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 0.55 \\ 4x - 2.2055 < x < 0.8 \\ 0; x \geq 0.8 \end{cases} \)

(14) Transmitted multicast
Excellent: \( y_1 = \begin{cases} 1; x \leq 0.3 \\ -4r + 2.203 < x < 0.55 \\ 0; x \geq 0.55 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 0.3, r \geq 0.8 \\ 4r - 1.203 \leq x \leq 0.55 \\ -4r + 3.2055 < x < 0.8 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 0.55 \\ 4x - 2.2055 < x < 0.8 \\ 0; x \geq 0.8 \end{cases} \)

(15) Sent broadcast
Excellent: \( y_1 = \begin{cases} 1; x \leq 0.3 \\ -4r + 2.203 < x < 0.55 \\ 0; x \geq 0.55 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 0.3, r \geq 0.8 \\ 4r - 1.203 \leq x \leq 0.55 \\ -4r + 3.2055 < x < 0.8 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 0.55 \\ 4x - 2.2055 < x < 0.8 \\ 0; x \geq 0.8 \end{cases} \)

(16) Bandwidth
Excellent: \( y_1 = \begin{cases} 1; x \leq 0.3 \\ -4r + 2.203 < x < 0.55 \\ 0; x \geq 0.55 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 0.3, r \geq 0.8 \\ 4r - 1.203 \leq x \leq 0.55 \\ -4r + 3.2055 < x < 0.8 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 0.55 \\ 4x - 2.2055 < x < 0.8 \\ 0; x \geq 0.8 \end{cases} \)

(17) Incoming (out) error package
Excellent: \( y_1 = \begin{cases} 1; x \leq 0.5 \\ -2x + 4 \times 0.5 \leq x < 0 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 0.5, r \geq 4 \\ 2/3 - x \leq 0 \leq 3 \\ -x + 2 \leq x < 4 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 2 \\ 12 - 2 < x < 4 \\ 1 \leq x \geq 4 \end{cases} \)

(18) Inflow (out) discard
Excellent: \( y_1 = \begin{cases} 1; x \leq 0.5 \\ -2x + 4 \times 0.5 \leq x < 0 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 0.5, r \geq 4 \\ 2/3 - x \leq 0 \leq 3 \\ -x + 2 \leq x < 4 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 2 \\ 12 - 2 < x < 4 \\ 1 \leq x \geq 4 \end{cases} \)

(19) Delay
Excellent: \( y_1 = \begin{cases} 1; x \leq 10 \\ -1/20 \times 10 \leq x < 0 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 10, r \geq 120 \\ 1/20 - x \leq 0 \leq 20 \\ 1/20 + 21 \leq x < 120 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 55 \\ 120 - 55 < x < 120 \\ 1 \leq x \geq 120 \end{cases} \)

(20) Packet loss rate
Excellent: \( y_1 = \begin{cases} 1; x \leq 0.03 \\ -4r + 2.203 < x < 0 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 0.03, r \geq 0.8 \\ 4x - 1.203 \leq x \leq 0.55 \\ -4x + 3.2055 < x < 0.8 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 0.08 \\ 25x - 0.08 < x < 0.12 \\ 0; x \geq 0.12 \end{cases} \)

(21) Inflow (out) packet speed
Excellent: \( y_1 = \begin{cases} 1; x \leq 0.3 \\ -4x + 2.203 < x < 0 \end{cases} \)
Qualified: \( y_2 = \begin{cases} 0; x \leq 0.3, r \geq 0.8 \\ 4x - 1.203 \leq x \leq 0.55 \\ -4x + 3.2055 < x < 0.8 \end{cases} \)
Unqualified: \( y_3 = \begin{cases} 0; x \leq 0.55 \\ 4x - 2.2055 < x < 0.8 \\ 0; x \geq 0.8 \end{cases} \)

5. Simulation of network performance evaluation using fuzzy comprehensive evaluation method
A 6×5 fuzzy relation matrix can be constructed from the corresponding membership function. According to the actual running condition of the local area network, the weight coefficient is given, and the weighted coefficient fuzzy subset A and the fuzzy relation matrix R are subjected to fuzzy composite operation to obtain the performance evaluation result of the network state.

6. Conclusion
In this paper, a network performance evaluation method based on fuzzy comprehensive evaluation method is proposed. 7 equipment index parameters and 14 link index parameters are selected. A total
of 21 network index parameters are used. The test data is used and the fuzzy comprehensive evaluation method is applied to simulation. Test simulation results show that the correct rate is 98.3%. The method is simple and easy to operate, and realizes real-time network performance evaluation of the local area network, which can meet the evaluation requirements of real-time and fast processing of the local area network.

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