# Research on Modeling and Evaluation of Topology Reliability of Smart Campus Network Based on Cloud Computing

Qiangjun Liu[1,2](✉) and Ningning Wang[3]

[1] Krirk University, Bangkok 10220, Thailand
liu13941@126.com
[2] Guangxi Vocational and Technical College, Nanaing 530226, China
[3] Aba Teachers University, Wenchuan 623002, China

**Abstract.** In order to further optimize the security and reliability of smart campus network, this paper designs a reliability modeling and evaluation method of smart campus network topology based on cloud computing. Implement the topological structure modeling of smart campus network through OPNET software. Based on cloud computing, node anomaly detection in the topology model of smart campus network is realized. Abnormal nodes include single node detection and associated node detection. Fuzzy comprehensive evaluation method is used to evaluate the reliability of intelligent campus network topology. The performance and effect of this method are tested. The test results show that the evaluation accuracy of this method is generally high, and the evaluation accuracy can reach 98.65%. The overall evaluation time of the method is less than 1000 s.

**Keywords:** Cloud Computing · Smart Campus · Network Topology · Node Anomaly Detection · Reliability Modeling Evaluation

## 1 Introduction

Educational informatization refers to the addition of informatization elements to the education system. Information technology is used in all stages of education, and education informationization is finally realized [1]. Education informatization is a long-term development process, which has its objective path and law, and has the characteristics of stages. UNESCO divides the process of applying information technology to education into four stages: starting, application, integration and innovation, which reveals the objective law of educational informatization development. In this context, "smart campus" has gradually replaced "digital campus" as the theme and trend of current information development [2].

In the construction of smart campuses, the reliability of its network topology has been a key research topic, so the reliability modeling evaluation of smart campus topology is studied.


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## 2 Reliability Modeling and Evaluation of Smart Campus Network Topology

### 2.1 Topology Modeling

Topology modeling of smart campus network is implemented by OPNET software. OPNET provides two kinds of simulation model libraries: standard model library and special model library. Typically, in OPNET's Modeler, standard model libraries are included to meet most customer needs. A special model library is a library of models tailored to the specific needs of a customer or the know-how of a manufacturer. The modeling process of Modeler can be divided into three levels, and the modeling can be completed in these three different levels: network level, node level and process level. The network level is to connect the modeling network devices to each other, the node level is to connect the network objects in the process level to specific devices, and the process level is to simulate the behavior of a single object.

OPNET uses a discrete event-driven simulation mechanism, which ensures that simulation events are triggered when the network state changes. If the network state does not change, no simulation will be performed. Compared with the time-driven mechanism, the discrete-time-driven mechanism can guarantee the efficiency of the computer running the simulation program. The core of simulation is a discrete time driven event scheduler, which will list and maintain the relevant programs of the events in different time periods. Event scheduler mainly maintains priority queues, which are used to sequence simulation work according to time sequence and execute in FIFO order. Communication between different modules is mainly based on packet transfer.

OPNET models the network system by reasonably scheduling events to execute reasonable processes, even if the scheduling mechanism is based on event list. The scheduling in the modeling process is realized by the simulation core and simulation tool modules.

In OPNET software, there are many distributed subsystems which communicate with each other. There are some communication resources such as command, query and general information exchange between subsystems. The communication methods include communication link mechanism, datagram communication mechanism, application interface control information and statistical line communication mechanism.

OPNET modeling can be divided into the following steps:

(1) Analyze a problem

The topology of smart campus network is analyzed.

(2) Build a model

According to the goal and the corresponding question, establishes the OPNET network technology, the protocol conceptual model, or is the mathematical model. According to the configuration model, determine the relevant business needed. Such as selecting the appropriate device network topology. If you want to define their own process model, you can combine VC + software modeling.

(3) System Verilog is the modeling language used in the construction of smart campus network topology model

Based on System Verilog language, this model abstracts the whole function model into a class, in which the inner function blocks are realized by means of methods. The functional model is divided into two main channels: the sending channel and the receiving channel, represented in two ways: transmit and receive (). The sending channel is divided into the following methods: pcs_transmit(), scrambler (), ml_en (). The receiving channels are also divided accordingly into the following methods: ml_de (), descrambler(), carrier _ detect (), pcs_receive(). In addition, methods such as link_monitor(), crs _ col () are included.

Among them, the pcs _ transmit () method mainly realizes the coding function of 4-bit half-byte data to 5-bit code group, the scrambler () method mainly encapsulates the scrambling function, and the mlt _ en () method realizes the MLT-3 coding function of the scrambled data stream. The mlt _ de () method decodes the MLT-3 encoded data stream, descrambler () mainly performs the decoding function, and pcs _ receive () mainly converts the decoded 5-bit code group into 4-bit half-byte data. The link _ monitor () method enables link monitoring.

The 4B/5B coding function implemented by the pcs _ transmi () method is one of the core functions of the campus network topology. The so-called 4B/5B coding refers to the mapping of four-bit half-byte data from the MAC layer into five-bit code groups. The main functions of this feature are as follows: First, it has appropriate coding efficiency. Represents 4-bit half-byte data in 5-bit code groups, with encoding efficiency of 4/5 or 80%, providing sufficient code. Four-bit code produces 16 combinations of data, while 5-bit code has 32. Use 32 5B code group to represent 16 4B code group, redundant 16 5B code group can play the role of control.

The ps_transmit() method is the first method called in the transmit() method[3]. The entry method first detects that the link_status is 2’ b11, or OK, and that only if the variable value is OK, the subsequent code will continue to execute, or it will wait. This design uses a while loop to achieve this function, when the decision to use break out of the loop. This design uses a 5-bit dynamic array to store 5B code groups. The definition format is as follows: bit [4: 0] pload_5b; dynamic arrays allocate space during emulation so that the smallest amount of storage can be used during emulation, and the 5-bit width is defined because it fits the physical laminar data code group format. The Mac frame of the sending packet is defined as a 4-bit dynamic array, and the size () method is used to allocate space to the pload_5b array so that the size of the space allocated is exactly the same, complying with 4B/5B coding rules while also facilitating coding implementation and increasing code readability.

In 4B/5B coding, TX_EN and TX_ER in MAC layer are used to control the 4B/5B code. In this design, TX_EN and TX_ER are also defined as dynamic array when they are encapsulated as transactional data packets.

First, the traversal detects that TX_EN makes the array value a valid starting position where the 5-bit code preceding the position should store the output in the IDLE state, after which the output is encoded. First, the output stream starting delimiter/J/K/is encoded to a valid array position, and if the corresponding TX _ ER error indicates that the array is still valid after/J/K/output is finished, the output/H/state is identified using an error flag bit.

After the SSD has been processed, enter a loop to encode, and output the appropriate/T/R/code group if the 4B/5B code is sent to make it valid and error-free, if it does not satisfy it to determine if there is an error indication, if there is an error, output/H/code group if it is invalid, if it is the end of the data stream encoding, and output the corresponding/T/R/code group.

The scrambler () method mainly realizes the scrambling function. Scrambling is essential in 100 Base-TX PHY systems because the robustness of digital transmission systems often depends on the statistical characteristics of their source. When repetitive data patterns appear in the signal, the distribution of the power spectrum density of their signals will appear a peak value of energy, which will produce discontinuous spectrum components that will harm the electromagnetic compatibility of the surrounding equipment. Scrambling technology expands these patterns (signal data are random) to suppress discontinuous spectrum components and thus uniform distribution of data signal power to improve equipment EMC.

The ml_en() method is primarily implemented for MLT-3 (Multi-Level Transmit) encoding of data streams passing through scrambled codes. The so-called MLT-3 coding, also often known as third-order baseband coding, the number 3 in its name means that this coding method can have "positive", "zero", "negative" three state potential.

The MLT_EN() method mainly realizes the MLT-3 decoding function, which is the inverse process of the MLT-3 encoding function, namely, converting the MLT-3 encoding data stream into a scrambled data stream. The encoding rule is output 1 if input changes, output 0 if input remains constant.

The descrambler() method mainly realizes the decoding function, which is the key point and difficulty in the design of this model. Its main function is to unscramble the disturbed data stream and restore it to the original data stream. The effect achieved by the decoding is the inverse process of the scrambled code described above. Although the decoding of scrambled codes and scrambled codes can be regarded as a reciprocal process, the decoding of scrambled codes is much more complicated than scrambled codes.

The carrier_detect() method primarily implements the carrier detection function, the main task of which is to provide the repeater client with two indications: first, an indication that a carrier event has been detected, and then an indication that the carrier has considered it incorrect.

The pcs_receive() method mainly realizes the decoding function of 4B/5B, the process of which is the inverse process of the previous 4B/5B coding, which is coded into a five-bit code group according to the four-bit half-byte data value, enable information and error information, while the decoding process restores the four-bit half-byte data, enable information and error information according to the five-bit code group.

The link_monitor() method primarily implements link monitoring, which is responsible for determining whether the lower receiving channel provides reliable data. The ability to monitor links is important because errors in the lower channel cause the upper client to pause normal action.

The crs_col() method mainly realizes the two functions of carrier interception and conflict detection. In a communication network, channel resources are limited, so it is often shared by multiple users to use the same channel. Therefore, if multiple users transmit the data simultaneously, conflicts and contradictions will occur. The MAC (media access control) layer protocol of Ethernet system can solve this control problem. The PHY layer is used for carrier detection and collision detection, and provides the relevant control signals to the MAC layer circuit.

(4) Collect statistics

Collect relevant data to be used in the model. To collect server-related statistics, select Load for the Ethenet in NodeSatistis. The statistics for network latency can choose global statistics, i.e. Ethernet delay in Global Saistis, or statistics related to network traffic and load.

(5) Operational simulation

Build a good model and collect statistics, choose simulation run, set the running time and number of seeds.

(6) View and analyze the results

Simulation results can be analyzed by comparison or by using mathematical data.

(7) Debugging and resimulation

If the data obtained is not ideal, to identify the problem, re-follow steps (2) to (6) to reset the network topology, loop operation, and finally get the desired simulation results.

### 2.2 Anomaly Node Detection in Topology

In the node running data processing, mainly carried out the following processing: data at different intervals into a fixed interval of time data, fill missing samples, formatted values, etc. [4]. For example, the missing value of the data is populated by the average of two adjacent data, and the data is uniformly formatted.

After preprocessing, in order to analyze the data collected from different nodes, it is necessary to convert the data into a unified format and construct a unified data matrix. In data conversion, $p$ is the number of nodes, $q$ is the number of data metrics, and $u$ is the number of samples for each data metric. Let $Y_{u\times q\times p}$ be the data matrix collected from $p$ nodes. Each node collects $q$ data metrics, each data metrics collects $u$ samples, and $Y^k$ represents the data matrix of the $k$ node. In each data matrix $Y^k$, the element $y_{wr}^k$ represents the value of data metric $r$ collected at sample $w$, where:

$$\begin{cases} 1 \leq w \leq u \\ 1 \leq r \leq q \\ 1 \leq k \leq p \end{cases} \tag{1}$$

Each matrix $Y^k$ is reorganized into a column vector:

$$Y^k = \left[y_1^k, y_2^k, \cdots, y_r^k\right]^t \tag{2}$$

where, element $y_r^k$ represents the $r$-th sample collected on the $k$-th node, and $t$ refers to the column vector threshold.

Finally, the data matrix is constructed as:

$$Y_{u\times q\times p}=\left[Y^1, Y^2, \cdots, Y^p\right] \tag{3}$$

The goal of data preprocessing and transformation is to build a data matrix for data analysis. In addition, the collected data may have different proportions and dimensions, which is not convenient for data indicators to be directly compared with each other. Therefore, it is necessary to convert the collected original data into a unified proportion. The commonly used data processing methods include normalization, normalization and zero mean. The normalization method can change the dimensionless expression into the dimensionless expression, map the data to the range of 0 to 1, and facilitate the comparison and weighting of indicators of different units or magnitudes. Therefore, the normalization method is used to scale the collected data indicators to [0,1] [5].

Normalize each column of the data matrix $Y^k$ using formula (4) to obtain the normalized matrix $M_{u\times q}$.

$$M_{u\times q}(s\times g) = \frac{Y^{s\times g} - \min_k}{\max_k - \min_k} \tag{4}$$

In formula (4), $M_{u\times q}(s\times g)$ refers to the elements in the $s$-th row and the $g$-th column of the normalized matrix $M_{u\times q}$; $Y^{s\times g}$ refers to the $s$-th row and $g$-th column elements of the data matrix $Y^k$; $\min_k$ refers to the minimum value of all data indicators in the $g$-th column of the data matrix $Y^k$; $\max_k$ refers to the maximum value of all data indicators in column $g$ of the data matrix $Y^k$.

Secondly, use the converted data to train the anomaly detection model, calculate the index weight array and train the anomaly detection model.

The calculation formula of index weight is as follows:

$$F(h) = \frac{\alpha_h}{\sum_{h=1}^{s}\alpha_h} \times 100\% \tag{5}$$

In formula (5), $\alpha_h$ refers to the eigenvalue of the $h$-th data; $s$ refers to the number of data indicators.

Finally, the sliding time window method is used. In order to judge the status of a single node, this section puts the node's operation data into the time window, and first judges the data status using the method based on the time point; If there is an exception, calculate the ratio of the abnormal data and the normal data in the time window. If the ratio is greater than the threshold of the degree of data abnormality, the node state is abnormal, otherwise it is normal [6, 7].

And update the node anomaly detection model with the marked data: by sliding the time window, the anomaly detection model and the index weight array are constantly updated, and the latest running data of the node is preserved, so that the detection algorithm can accurately detect anomalies when the node load changes.

An anomaly detection method for associated nodes in the cloud computing environment is designed. When a single node is abnormal, the method detects the anomaly of other nodes associated with it. In the process of abnormal detection of associated nodes, it is necessary to fully understand the relationship between nodes and the current state of nodes, so a node monitoring model is established. Through this model, we can grasp the status of each node in real time, and can detect the abnormality of related nodes.

The relationship between nodes is divided into direct association and indirect association. The same method may not be applicable to both direct association and indirect association. In order to detect abnormalities of associated nodes, it is necessary to distinguish different association relationships and design different detection algorithms. Therefore, the anomaly detection methods of associated nodes in the cloud computing environment are divided into the anomaly detection methods of directly associated nodes and indirectly associated nodes. The abnormality detection of the directly related node is performed first, and then the abnormality detection of the indirectly related node is performed.

Information is transmitted between directly related nodes through shared communication lines. There is often a close relationship between directly related nodes. There are often data communication, resource sharing and other behaviors between nodes. A large amount of use of resources by one node will inevitably cause fluctuations in other nodes, which indicates that the data between nodes is relevant. Therefore, when designing an anomaly detection method for directly related nodes, we must fully consider the correlation between node data.

In order to find the directly related nodes affected by the abnormal nodes, it is first necessary to understand the correlation between the abnormal nodes and the data of other related nodes, and then find the nodes affected by the abnormality through these correlations. Mutual information refers to the amount of information shared by two variables. Through this feature, the correlation of data between nodes can be measured.

Assuming that $A_1, A_2, \cdots, A_m$ and $B_1, B_2, \cdots, B_m$ represent discrete random variables of different operation data in node A and node B, the mutual information of the operation data of the two nodes is as follows:

$$C\left(A_j;B_j\right)=\sum_{A_j}^{m}\sum_{B_j}^{m} g\left(A_j;B_j\right)\lg\frac{g\left(A_j;B_j\right)}{g\left(A_j\right)\left(B_j\right)} \tag{6}$$

In formula (6), $g\left(A_j;B_j\right)$ represents the shared information of the operation data of the two nodes; $g\left(A_j\right)\left(B_j\right)$ indicates the non shared information of the operation data of the two nodes.

Since $C\left(A_j;B_j\right)$ has no upper bound, it is difficult to distinguish the degree of correlation between the two data. In order to compare $C\left(A_j;B_j\right)$ more easily, we need a standardized version of $C\left(A_j;B_j\right)$ from 0 to 1, represented by $C\left(A_j;B_j\right)'$. Standard mutual information is defined as follows:

$$C\left(A_j;B_j\right)'=\frac{C\left(A_j;B_j\right)}{\sqrt{F\left(A_j\right)F\left(B_j\right)}} \tag{7}$$

In formula (7), $F\left(A_j\right)$ refers to the information entropy of $A_j$; $F\left(B_j\right)$ refers to the information entropy of $\left(B_j\right)$.

When an exception occurs to a single node, the $C\left(A_j;B_j\right)'$ value between the abnormal node and its directly associated node can detect whether the directly associated node is affected by the abnormal node and detect the status of the directly associated node. The abnormal node has strong correlation with other nodes affected by the abnormal node, and the abnormal node has weak correlation with other nodes not affected by the abnormal node.

The abnormal node has strong correlation with other nodes affected by the abnormal node, and the abnormal node has weak correlation with other nodes not affected by the abnormal node.

In order to measure whether the two variables are strongly or weakly correlated, an appropriate threshold $T$ is also needed to distinguish the strong correlation and weak correlation of data. If the following formula holds:

$$C\left(A_j; B_j\right)' > T \tag{8}$$

It indicates that the associated node is affected by the abnormal node and an exception occurs.

The calculation formula of the threshold $T$ is as follows:

$$T = \min_{\varpi^2 A_j B_j > s_{\varpi^2}} C\left(A_j; B_j\right)' \tag{9}$$

In formula (9), $\varpi^2$ refers to the determination coefficient; $s_{\varpi^2}$ refers to the decision threshold.

The threshold $T$ can distinguish whether there is a strong correlation between the abnormal node and its directly associated node. If there is a strong correlation between them, it means that the directly related nodes are affected by the abnormal nodes, and the directly related nodes are also abnormal.

Then, the detection of indirectly related nodes is implemented, and the research object is the indirectly related node with a distance of 2 from the abnormal node. If there is an abnormality in a single node, the direct detection is not only time-consuming, but also consumes a lot of resources because of the large number of indirectly associated nodes and complex topology. In order to improve the detection efficiency, it is necessary to further select the indirect association nodes to be detected. A large number of research results show that the importance of nodes represents the degree of impact on node performance in the event of node failure. In the cloud computing environment, if only important nodes are detected, some invalid nodes can be filtered and the detection speed can be accelerated. Therefore, indirectly related nodes with high importance can be quickly found through node importance.

Through the node importance evaluation index, the importance of each node can be counted, and the associated nodes can be traversed in order according to the node importance. However, in the cloud computing environment, the number of nodes is huge. If a node has an exception, it will traverse all indirectly related nodes, which will increase the load of magent and reduce the efficiency of the algorithm. In order to improve the efficiency of the node anomaly detection algorithm, it is not necessary to traverse all the indirectly related nodes. The indirectly related node algorithm only needs to remove the nodes with low importance, and then traverse the indirectly related nodes in order according to the importance of the nodes.

In order to detect the status of indirectly associated nodes, it is not only necessary to calculate the importance of nodes, but also to obtain other relevant information. Data flow refers to the traffic rate of communication between this node and other nodes in a specific time period. Because there are often close connections between nodes, the data flow values between nodes are similar and the change trend is similar. If the data flow suddenly changes too much, it may mean that the node has abnormal behavior.

A density based method is used to establish a detection model for normal data streams. This method belongs to the unsupervised method and can tolerate a small number of anomalies in the training data. The degree, aggregation coefficient and data flow are selected as the criteria for anomaly detection, and are defined as the attributes of nodes. The attribute of a node can represent the state of the node, calculate the importance of the node using the degree and aggregation coefficient, and detect the indirectly related nodes that may have abnormalities using the data flow.

### 2.3 Reliability Assessment

The fuzzy comprehensive evaluation method is used to evaluate the reliability of smart campus network topology.

Fuzzy comprehensive evaluation is a comprehensive evaluation method based on fuzzy mathematics. This method takes the membership degree theory of fuzzy mathematics as the basis, converts the qualitative evaluation of the evaluation object into quantitative evaluation, that is, makes an overall evaluation of the object restricted by many factors with the fuzzy mathematics theory. The characteristics of fuzzy comprehensive evaluation method are that the results are clear and systematic, which can solve the fuzzy and difficult to quantify non deterministic evaluation problems. The method of fuzzy comprehensive evaluation is a great application of fuzzy mathematics in practice and has a wide prospect. In reality, in the evaluation of some programs, achievements and technical levels, only some fuzzy language can be used to express the evaluation results. For example, the evaluator makes "high, medium and low" decisions on complex decision-making problems based on various factors considered and relevant data and conditions; "Excellent, good, medium and poor"; "Large, medium and small"; At this time, this kind of evaluation problem can be calculated by the method provided by the fuzzy comprehensive evaluation method, and finally the quantitative comprehensive evaluation result can be obtained. The fuzzy comprehensive evaluation method can comprehensively summarize the advantages and disadvantages of each evaluation index, and accurately reflect the comprehensive evaluation results of the evaluated object. Using fuzzy comprehensive evaluation to evaluate the reliability of smart campus network topology can comprehensively summarize various reliability indicators of smart campus network topology and comprehensively reflect the level of network transmission reliability. The specific process includes: determining a fuzzy set (called factor set U) composed of a variety of indicators that can reflect the reliability level of the topology of the smart campus network, setting the evaluation levels of these network reliability indicators, forming a fuzzy set (called comment set V) for reliability indicator evaluation, and obtaining the attribution degree of each reliability indicator to each evaluation level (called fuzzy membership matrix R) through experiments, Then, according to the weight distribution of each reliability index in the evaluation of the topology of the smart campus network, the quantitative expression result of the evaluation is obtained through the synthesis of the fuzzy matrix determined by the evaluation model.

The traditional fuzzy comprehensive evaluation method can be divided into the following five steps:

The evaluation factor set U is determined.

The indicators for evaluating the objects to be evaluated should reasonably and accurately reflect the performance of the objects.

The evaluation comment set V is determined.

Generally speaking, the results of the evaluation are divided into several grades, thereby establishing a comment set.

The fuzzy membership matrix R is established.

Each element in the fuzzy membership matrix R represents the degree of membership of the evaluation grade to which the specified index belongs.

Determine the index weight W.

In fuzzy comprehensive evaluation, the index weight can be determined by AHP.

The fuzzy comprehensive evaluation set S is calculated.

After determining the index weight W and the fuzzy membership matrix R, the fuzzy comprehensive evaluation set S can be calculated.

In the traditional fuzzy comprehensive evaluation method.

Add a step, namely step (6): calculate the efficiency index $E_I$.

The calculation formula is as follows:

$$E_I = \sum_{f=1}^{v} \beta_f \cdot \chi_f \tag{10}$$

In formula (10), $\beta_f$ refers to the specific gravity indicating that the performance parameter belongs to each grade; $\chi_f$ refers to the quantitative value corresponding to each level of data collection performance; $v$ refers to the number of indicators.

There are still some defects in using the principle of maximum membership to determine the final evaluation result. In order to solve this problem, the efficiency index $E_I$ is calculated by using the comprehensive index method. Using the efficiency index $E_I$ to evaluate the data collection performance of the smart campus network topology, not only comprehensively considers the evaluation coefficient of each index, but also can distinguish which of the two objects belonging to the same level has the better data collection performance.

# 3 Experimental Test

## 3.1 Establishment of Experimental Environment

For the reliability modeling and evaluation method of smart campus network topology based on cloud computing, its performance is tested through experiments. The campus of the experimental school covers an area of 500 m long and 400 m wide, with an area of about 200000 m$^2$, about 300 faculty members and 8000 students. The planning of the school's functional area is reasonable and clear, and the teaching, administration and accommodation areas are relatively independent. The school is divided into administrative office building, teaching building, library, conference room, stadium, canteen, teachers' dormitory and students' dormitory according to the area. There are two office buildings, of which - office building has 5 floors, 10 rooms on each floor, and each has 4 office positions; The other building has 12 floors, 5 rooms on each floor, and 8 office positions in each room. The data center is located on the third floor of the 12 storey administrative office building, with an area of about 250 $m^2$. There are 7 teaching buildings with 5 floors and 5 rooms on each floor. There is one laboratory building with 5 floors and 10 rooms on each floor. There are 5 conference rooms, including 3 small conference rooms, 1 large conference room and 1 multimedia studio. The library has five floors, including a borrowing room, a periodical reading room and an electronic reading room. Sports venues, including indoor courts, outdoor courts, basketball courts and volleyball courts. Teachers' dormitory, 30 rooms in one building, single room or double room. There are 7 student dormitories, each with 5 floors, 30 rooms on each floor, and 6–8 people in each dormitory. There is one canteen.

The existing campus network has been built synchronously with the campus construction period for ten years. The structure is a three-layer network structure of core switch + convergence switch + access switch. The core switch is located in the data center machine room, the convergence switch is located in the weak current well on the first floor of the building, and the access switch is located in the weak current well on each floor. The convergence switch connects the core switch through the optical fiber uplink interface, The access switch accesses the aggregation switch through the uplink port. Therefore, build the smart campus network of the University. It is composed of infrastructure layer, support platform layer, application platform layer, application terminal, information system security system.

Using the design method, the reliability of the topology of the experimental smart campus network is modeled and evaluated, and the performance of the design method is tested.

In the test, the three methods introduced will be used as comparison methods, which are represented by method 1, method 2 and method 3 respectively for comparison test.

### 3.2 Performance Testing

First, test the evaluation accuracy of the design method and the three comparison methods. The test results are shown in Table 1.

According to the data in Table 1, the evaluation accuracy of the design method can reach 98.65%, and the evaluation accuracy of methods 1, 2 and 3 can reach 96.52%, 97.10% and 94.63%. The evaluation accuracy of the design method is the highest as a whole.

Based on the above test results, the evaluation times of the four methods are compared, and the test results are shown in Fig. 1.

According to the data in Fig. 1, the evaluation time of the design method is less than 1000s as a whole, and the evaluation time of methods 1, 2 and 3 is higher than that of the design method, which indicates that the evaluation time of the design method is the shortest.

Finally, the modeling performance of the four methods is tested respectively, and the modeling time of the four methods is compared to verify the modeling efficiency of different methods. The test results are shown in Fig. 2.

**Table 1.** The accuracy comparison of different methods to assessing the reliability of campus network topology structure

| Serial number | Test times | Average assessment accuracy/% | | | |
|---|---|---|---|---|---|
| | | Design method | Method 1 | Method 2 | Method 3 |
| 1 | 50 | 98.25 | 95.30 | 94.63 | 94.20 |
| 2 | 100 | 98.62 | 94.63 | 93.24 | 92.30 |
| 3 | 150 | 98.41 | 94.68 | 94.32 | 92.04 |
| 4 | 200 | 98.65 | 94.75 | 92.54 | 90.21 |
| 5 | 250 | 98.63 | 95.20 | 97.10 | 94.63 |
| 6 | 300 | 98.52 | 96.30 | 96.01 | 93.14 |
| 7 | 350 | 98.48 | 96.52 | 93.54 | 94.30 |

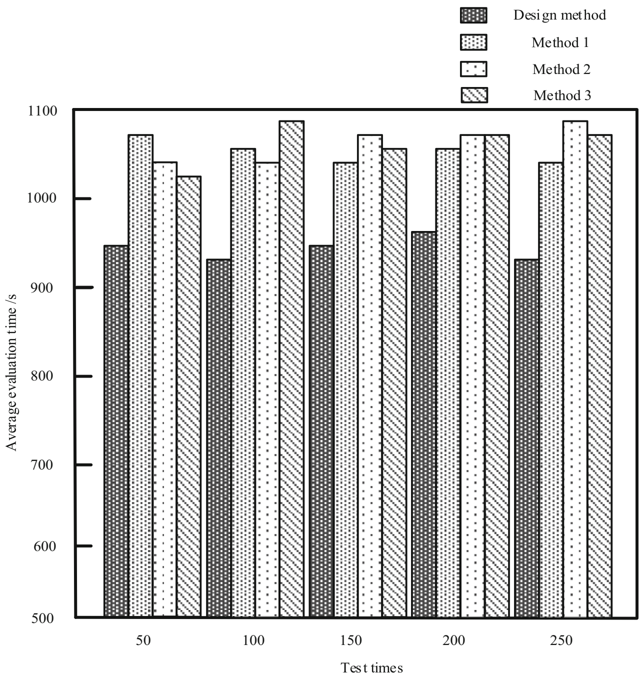


**Fig. 1.** Time comparison test results of different methods to evaluate the reliability of smart campus network topology structure

According to the modeling time-consuming test results in Fig. 2, the design method has the lowest modeling time-consuming, and the other three methods have higher modeling time-consuming, which indicates that the design method has the highest modeling efficiency.

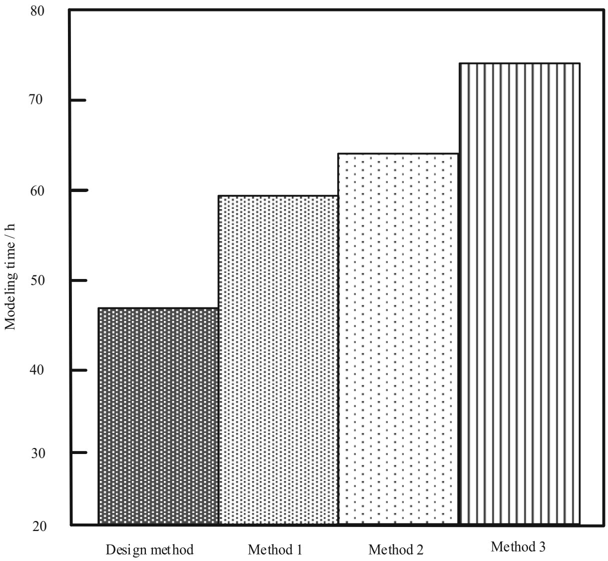


**Fig. 2.** Time-consuming comparison of smart campus network topology modeling under different methods

To sum up, because the method in this paper checks the abnormal status of single nodes and associated nodes by using cloud computing method, the interference nodes are excluded for the evaluation results, thereby improving the accuracy. Combined with the fuzzy comprehensive evaluation method, the reliability of the intelligent campus network topology is evaluated, which shortens the time of evaluation and modeling.

## 4 Conclusion

In order to improve the security of smart campus network, this paper studies a cloud computing-based reliability modeling and evaluation method of smart campus network topology. The topological structure of the campus network is constructed by using OPNET software. Based on the topology, the abnormal nodes of the topology model are detected through cloud computing. And the fuzzy comprehensive evaluation method is used to evaluate the topology reliability. The test results can show that the evaluation time and modeling time of the method in this paper are shorter, and the evaluation accuracy is higher. With the growth of campus network data, it is easy to cause the explosion of network storage space. In order to alleviate network space, we will further streamline the topology in the future to improve campus network reliability.

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