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Design and application of computer network system integration based on network topology

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Abstract. To explore the computer network system that covers more and more areas, including the management of network, system, operating environment and other aspects, reasonable layout and unified planning to the network are carried out in relatively complex computer network system engineering. What's more, the network center, the open network room, the network management running system and the network security system based on the topology are also designed. In addition, the algorithm implementation is carried out to the topology construction process. In the design, the internal network topology is determined according to the actual internal distribution of the buildings in campus, and the basic engineering design is divided into work areas, buildings, trunk and management, and the NFCT algorithm operation and realization is carried out in the process of the topology construction. The results showed that the reliability and accuracy of the network system is realized through the final verification and analysis of the results. In a word, the computer network system integration based on network topology has good performances and it can be applied in computer related fields.

Key words. Network topology, computer network, system integration.

1. Introduction

Computer network is the foundation and core of promoting informatization, digitalization and globalization, because computer network system is an open and digital integrated information system. All kinds of application system based on computer network, through the comprehensive collection, storage, transmission, processing and utilization of the digital information, linked all kinds of social factors closely. As a result, the computer network has become the most important infrastructure in information society [1]. With the development of economy and the implementation of the strategy of invigorating the country through science and education, the construction of computer network has gradually become the basic construction project of many fields, and has become an important symbol to measure the informatization

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and modernization.The computer network construction project is the basic condition to realize the overall quality education and the cultivation of creative talents. Through the implementation of the computer network project, it not only can the network platform, but more importantly, it will be beneficial for the sharing and cooperation of educational resources, and it is conducive to realize modern distance education. The construction of computer network is a fundamental way to realize the educational informatization. Rich and colorful, healthy and clean computer network culture will become the new way to cultivate way of thinking, moral quality, and creative ability [2]. In addition, it becomes a new platform for all students, to cultivate all-round developed high-quality personnel.

Computer networking construction is the foundation and core of promoting informatization, digitization and globalization. The design of computer network integration based on network topology collects, stores, transmits, processes and utilizes various types of information through network topology to closely link with the various components and interconnect various devices through transmission media. Computer network system covers the management of operation environment, equipment and other aspects, is a synthesis of variety technologies such as information, management science, computer and network technology, and is a relatively complex systems engineering.

With the development of the economy and the implementation of the national strategy of rejuvenating the country through science and education, the university network construction has gradually become the basic construction project of the school, and become an important symbol of measuring the informatization and modernization of education [3]. In this paper, the design and application of computer network system integration architecture is mainly from the network topology, and the interconnection design based on the topology technology is taken the university computer network as the object. The campus network has the characteristics of large number of computers, rich network application, complex topology and high bandwidth requirement. The rational distribution of topology design is carried out to the university computer network will help solve the network bottleneck and congestion, further strengthen the reliability and accuracy of the integrated system.

2. Summary of network topology and system integration development

The computer connective way is called the network topology. Network topology is the physical layout that uses transmission media to interconnect with various devices, especially the location of the computer distribution and how the cable through them. Classification of network topology: network topology can be divided into two categories according to the communication channel of the communication subnet, which are the topology of the broadcast communication channel subnet and the topology of the point-to-point communication subnet [4]. The basic topological structure of the broadcast communication channel subnet main has bus shape, tree shape, ring shape, wireless communication and satellite communication. The basic topological structure of point-to-point communication subnets are star shape, ring

shape, tree shape and mesh shape.

The topological structure of the network is divided into logical topological and physical topological structure. Bus topology is a topology based on multi-point connections, and all devices connect to a common transmission medium. Star topology puts a central computer in the center, each arm of the endpoint is placed one, all the data packages and messages through the central computer to communicate, and each has only one connection except the central machine. This structure requires a large number of the cable, and star topology can be seen as a layer of the tree structure that does not require multi-layer access contention. Star topology is more common in the network cabling [5]. Daisy-chain topology is similar to a ring topology, but with a pair of breakpoints in the middle. Several topologies can be mixed and star topology is more common in campus network planning.

With the rapidly development of the computer technology, the computer network system integration gradually developed. The development of computer network system integration technology is divided into three stages, namely, single integration technology, distributed integration technology and information integration technology. In order to ensure that the designed target of the network integration system is completed on time with high quality, the certain steps should be followed. The steps of the network system integration design mainly are network size, network topology structure, network protocols, equipment instruction, IP address planning, network security design and so on. In the actual operation, some procedures according to the actual situation, if necessary, can be omitted as appropriate. In real life, computer network integration technology has a lot of applications. Due to the rapidly development of computer network integration technology, many industries have the intersection with it, the computer network integration technology can effectively improve the security and reliability of the data.

3. Materials and methods

3.1. Overall scheme design of universities network

Because the campus network have a higher stability requirement on the network, it is necessary to use dual-core in the topology design to do two unit standby and double exports. This not only avoids the possibility of failure in a certain extent, but also makes users shunt, achieving load balancing. Campus network set up the core switchboard to interconnection with the help of the link, and the Gigabit fiber-optic link is adopted between all convergence switches and core switches [6]. When the two core switches can work properly, they share all the communication data of the inter-changer to achieve the load balancing of network access. When one of the core equipment is failure, other core equipment quickly assumes all the tasks.

The export route is planed according to the actual management mode, you can select an export device, according to the site that the user clicks to determine the user uses the education network or telecommunications or Netcom, etc., so that achieving the unified management to the users, as well as the control to the networked computer [7–8]. It can greatly improve the network security for management personnel.

Link redundancy is mainly for the communication lines between the core switches and aggregation interchanger; so that each aggregation interchanger can connect with two core switches with fiber-optic to ensure the stability of the network.

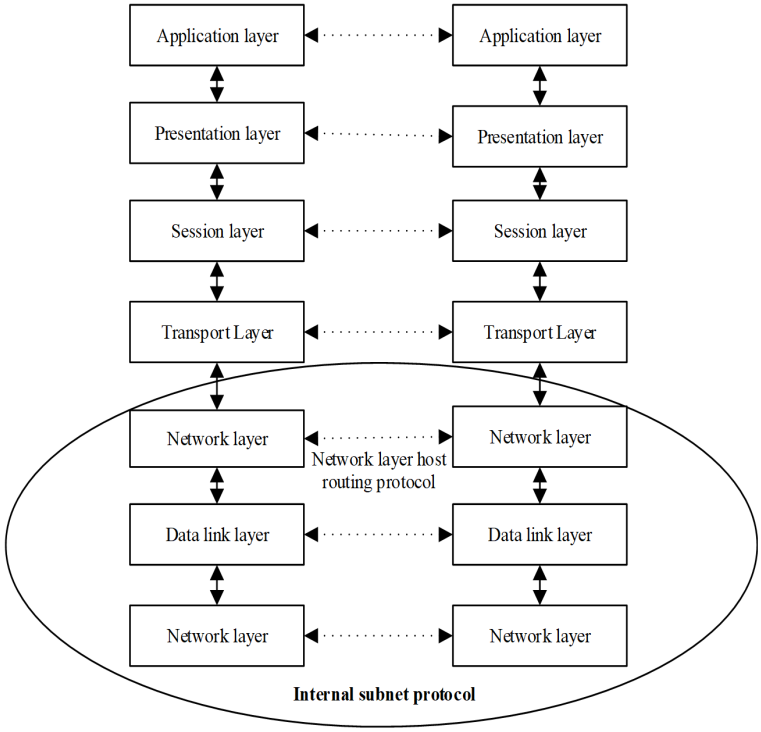

Fig. 1. System interconnection model

3.2. Development scheme design

The main functions of the university network include providing the basic network service function, providing the office automation of each management institution in the school, providing the interconnection with the other application system through the WAN interface. The design principle is set according to the specific environment. In the initial period of network construction, the access control is the key, and the system construction uses star topology to make the backbone of the network server to provide better maintenance and optimization of network service management with Gigabit Ethernet technology [9]. In the network system construction, the long-distance teaching and the multimedia application are supported, and the authentication charge management platform and the firewall are also supported. In the latter part of the network, the global security and the deep security are the focus, and the actual location of the building determine that the admissions room server and the client can not be directly connected with the core device. In doing isolation, it is enough to shield the others. The admissions room access is allowed to visit the

college internal resources. Export, trainees' general topology general firewall and core routing can ensure the reliability and stability of the network operation [10].

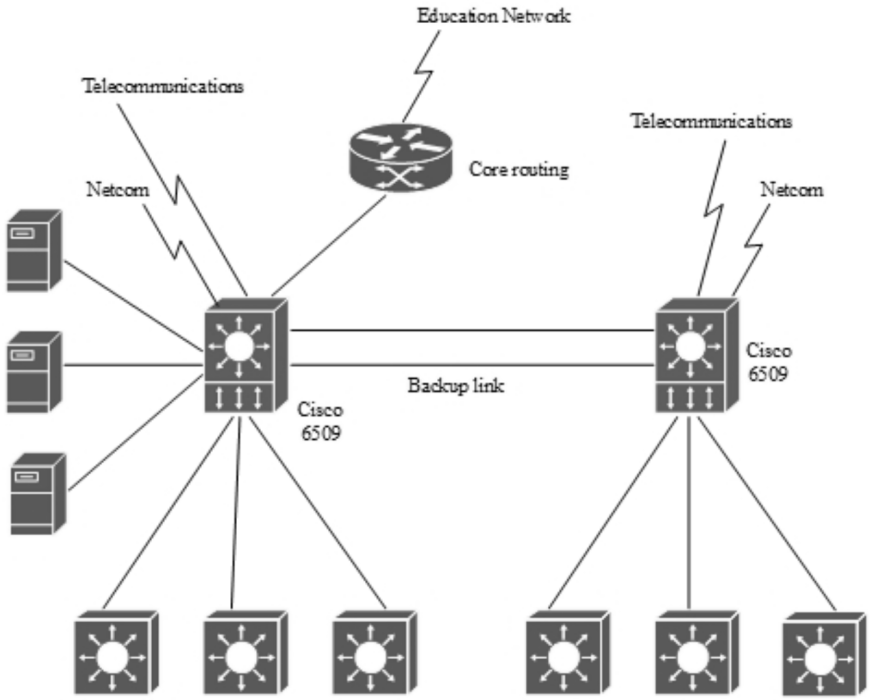

Fig. 2. General topology structure

3.3. Algorithm design

In the life cycle of the topology network, it can be divided into three phase according to the fault-tolerant clustering topology control algorithm (NFCT): cluster topology construction, fault detection and topology maintenance. In the phase of cluster topology construction, clustering and cluster head election mechanism are used to establish the cluster topology structure [11]. The topology fault detection phase is completed by the cluster construction in the network, and starts to execute the task and collects the information, also known as the running phase. At this phase, the fault detection mechanism is used to determine whether the cluster is faulty or not. If a fault occurs, the topology maintenance process is triggered. In the maintenance phase, it processes the faulty nodes or judges whether the cluster heads are still suitable as cluster heads or not. Once they are not suitable for cluster heads, the backup cluster heads are transformed into cluster heads to avoid affecting the operation of the cluster or even the stability of the entire network. In order to better describe the algorithm, the relevant definitions are introduced:

Cluster information: Chf. This is the association information that the node selects cluster head, which includes the cluster head ID, the cluster parameter cp of

the cluster head, and the residual energy resE of the cluster head [12].

The list of neighbors in the cluster: CnList. It is a list of neighbor nodes within the same cluster except the cluster head. Each entry in the list includes the neighbor's ID, clustering parameters, and residual energy.

Members of the cluster list: CmList. It is list of all members of the cluster head. Each entry in the list includes the member ID, clustering parameters, and residual energy.

The NFCT algorithm uses a local maintenance mechanism that combines the energy triggering with the fault triggering. The NFCT triggers the topology maintenance process when a network fault occurs. Then, the difference between the residual energy of the cluster head and the average energy in the cluster is calculated, when the energy difference is less than zero, the topology maintenance process is triggered.

The cluster head neighbor graph is composed of the cluster head u and its cluster members $v_i,\ i = 1, 2, \cdots, k$, expressed as

$$V_{\mathrm{c}} \in \{v_i \in CM_{\mathrm{u}} \cup u\},\ v_i \in N_{\mathrm{u}},\ E_{\mathrm{c}} = \{(v_i, u)|\ v_i \in CM\mathrm{List}_u\}\,. \tag{1}$$

Here, CM_{u} is the head of cluster message, N_{u} is the collection of node's neighbors. Symbol E_{c} denotes the energy cost, and $CM\mathrm{List}_u$ is the head of cluster member list.

The sum of the residual energy, including the cluster-head u and all its member nodes $v_i,\ i = 1, 2, \cdots, k$ in the neighborhood graph $G_{\mathrm{c}}(V_{\mathrm{c}}, E_{\mathrm{c}})$ of the cluster head u is called the total residual energy of the cluster head u neighbor graph

$$\mathrm{Sum}_{\mathrm{c}}(u) = \sum_{i=1}^{k} E_{\mathrm{res}}(v_i) + E_{\mathrm{res}}(u)\,. \tag{2}$$

Here, $E_{\mathrm{res}}(v_i)$ represents the residual energy of the cluster members nodes v_i and $E_{\mathrm{res}}(u)$ represents the residual energy of the cluster head u, k being the number of member nodes in the cluster [13].

The ratio of the sum of the residual energy of the cluster head u and all its member nodes $v_i,\ i = 1, 2, \cdots, k$ and the residual energy of the cluster head u in the neighbor graph $G_{\mathrm{c}}(V_{\mathrm{c}}, E_{\mathrm{c}})$ of the cluster head u and the sum of these nodes is the average residual energy of the cluster-u neighbor graph, expressed as

$$\mathrm{Aver}_{\mathrm{c}}(u) = \frac{1}{k+1}\left(\sum_{i=1}^{k} E_{\mathrm{res}}(v_i) + E_{\mathrm{res}}(u)\right)\,. \tag{3}$$

The topology maintenance process is carried out in the neighborhood of any cluster head u in the network, only needs the local information of the cluster node, not the network's global information and location information. The local information can be obtained through the normal communication "incidentally", reducing the communication overhead [14]. In the maintenance phase of the algorithm, a trigger mechanism combining fault and energy is used to trigger the local topology maintenance in the neighbor graph of the cluster head when the network node fails or the

residual energy of the cluster head is lower than the average energy in the cluster, so the algorithm is applicable to topology control of energy-sensitive large-scale wireless sensor networks.

4. Results

In order to verify the validity of the NFCT algorithm, the NFCT algorithm is compared with the typical backup mechanism algorithm P-CDS, FTCB and k-connected algorithm CBCC ($k = 2$). The simulation testing is carried out in the three methods from the cluster head size, cluster head node reliability, energy consumption, communication traffic, and network life cycle. In order to make the simulation results closer to the real wireless environment, and compare with other algorithms in the same environment, in addition to assumptions, the environmental simulation parameters items is set out which is shown in Table 1 to standardize the experimental environment, including network conditions, nodes attribute conditions, packet size and energy consumption and other related settings.

Table 1. Simulation parameters table

Parameter	Value
Network size	$500\times500\,\mathrm{m}^2$
Number of nodes	50–400
Aggregation node position	(0, 0)
Primary energy	1 J
E_{elec} (Electric energy consumption in info processing)	$50\,\mathrm{nJ/bit}$
ξ_{fs} (Energy loss on forward)	$10\,\mathrm{pJ/bit/m}^2$
ξ_{mp} (Energy loss on cluster switch)	$0.0013\,\mathrm{pJ/bit/m}^2$
E_{DA} (Energy loss on delay)	$5\,\mathrm{nJ/bit}$
Transmission range R	100 m

The size of the backbone nodes not only affects the energy consumption of the network but also the communication efficiency of the network. Therefore, the backbone node is measured by the ratio of the backbone node to the total number of nodes in the network. In addition, the NFCT algorithm and P-CDS, FTCB algorithm through the backup mechanism to tolerate the network fault, so the nodes number of the two algorithms in network is also tested. The results are shown in Figs. 3 and 4.

It can be seen from Fig. 3 that the connected CBCC algorithm has more backbone nodes than the NFCT and P-CDS algorithm, because each backbone node is equipped with redundant nodes to construct the backbone network, which results in more nodes carrying backbone tasks. In addition, it can be seen from the figure, NFCT algorithm has smaller backbone nodes and backup nodes than FTCB and P-CDS, so it can improve the network's energy utilization efficiency.

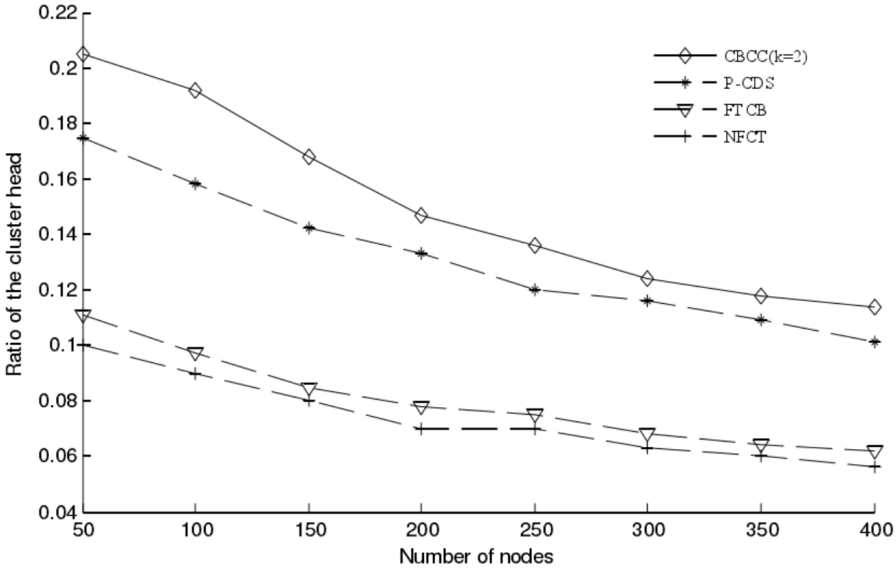

Fig. 3. Comparison of backbone nodes in network

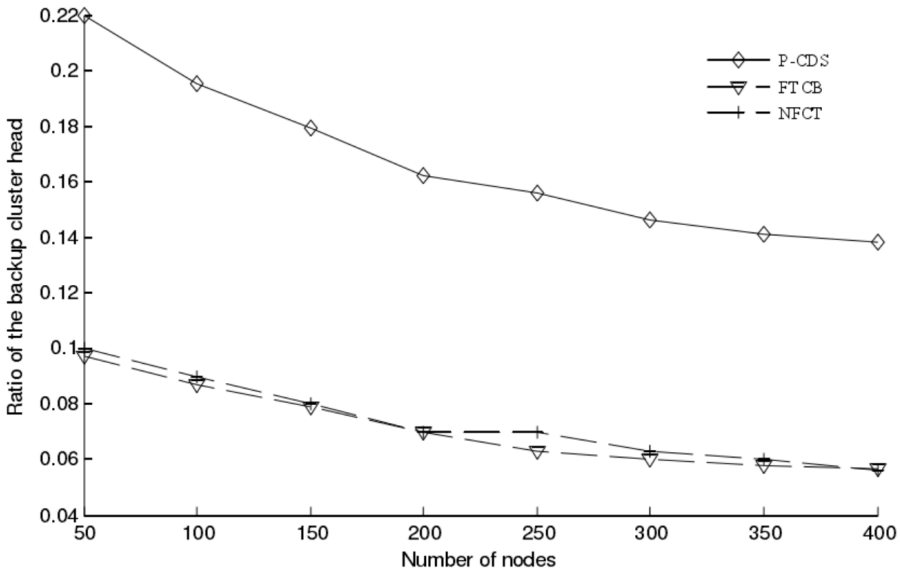

Fig. 4. Comparison of the backbone node and the backup node in the network

The simulation results of the typical algorithms k-connected FC-CBCC algorithm ($k = 2$) and the P-CDS and FCTB algorithms based on the backup mechanism in the fault-tolerant topology control algorithm show that the NFCT algorithm has much smaller backbone nodes, higher communication traffic and higher backbone node

reliability than the other three algorithms, and it can be applied to the traditional, which can effectively extend the life cycle of the university computer network to ensure the stability and accuracy of the network topology structure and integration system [6].

In the design and application of system integration based on the network topology, the rational distribution and unified planning are carried out in the network, and the fault-tolerant design is considered at each stage of the NFCT algorithm. Firstly, in the cluster phase, the cluster head backup mechanism is used to enhance the fault-tolerant ability of clusters and improve the stability of cluster operation. Secondly, in the process of network operation, a lightweight fault detection mechanism is adopted to detect the failure of the cluster heads and members in the network in real time. Once the faults are detected, the failure nodes are processed to further improve the network fault tolerance. Finally, a topology maintenance mechanism is used to monitor the residual energy of the cluster head node in real time. When the residual energy is lower than the average residual energy value in the cluster, the backup cluster head becomes cluster head to maintain the stable operation of the network and improve the network fault tolerance.

5. Conclusion

The computer network system integration based on the network topology can carry out the rational distribution and unified planning to the network in relative complex computer network system engineering. Taking the university computer network as an example, we design and apply the university network integration system of the backbone network, the network center, the open network room, the network management running system and the network security system based on the topology. In the design, the internal network topology is determined according to the actual internal distribution of the buildings in campus, and the basic engineering design is divided into work areas, buildings, trunk and management, and the NFCT algorithm operation and realization is carried out in the process of the topology construction. The reliability and accuracy of the network system is realized through the final verification and analysis of the results.

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