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Simulation for Upgrade Scheme Optimization of Campus Network

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Abstract

As a new network planning and design technique, the network simulation provides the objective and reliable reference for the network design, the network expansion, upgrade and optimization, thus the science of decision-making in network building is promoted. In this paper, we simulated campus users' online behavior and actual network equipment operation by using OPNET, and carried on the simulation to the different scale and the different structure network, which obtained a group of simulation results. According to link utilization and end-to-end delay and other simulation results, we have analyzed the issue of influence campus network performance for designing the best network configuration, which has the important reference value for the planning and construction of the campus network.

Keywords*: campus network, network optimization, network simulation, user behavior analysis*

1. Introduction

In China, many colleges and universities had established the campus network. With the continuous development of the campus, the number of students grows and the demand of network services also increases. Therefore, the previous network planning had not met the current needs. The development of the campus network is facing the following problem, first how to expand the original network, second how to optimize this network. However, nowadays the new network technologies unceasingly appear and the network architecture is more and more complex, to achieve the optimal expansion and upgrade scheme is quite difficult. Therefore using the network simulation to test the expansion and upgrade scheme is extremely essential [1]. The network simulation is a very useful network research tool, it's based on the system theory, the formalized theory, the stochastic process and statistics theory and optimization principle [2]. In the design stage, the simulation method provides a virtual model to forecast and compare the performance in a variety of programs. Through the analysis and comparison of different environments and workloads, the network engineers can optimize the system performance. In certain situations, the simulation is the only feasible method and the technology [3]. The simulation method abstraction degree is lower than the mathematical analysis method, the simulation consumption time is less than the measurement techniques, and it has the characteristics of low cost and effectiveness [4].

OPNET is one kind of outstanding network simulation and the modelling tool, it supports the object-oriented modelling way and provides a graphical editing interface more user-friendly [5]. It has a powerful feature that can simulate almost any network device, and supports a variety of network technologies.

The OPNET simulation follows the following workflow:

Analysis objective: Make the question and the network architecture which the network simulation needs to study clear, determine the performance parameters of network simulation.

Establishment simulation model: According to the analysis result, establishes the network, the advancement or the agreement model (including network topology, agreement type, package form and so on), disposes the relevant service [6].

Data collection: Collect relevant statistical data for the simulation model and validation

Run simulation: experiment the simulation and get the data.

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Analysis debugging and run again: Analyzing the simulation data to find out bottleneck of performance in the network; and then, modify topology, upgrade equipment, and adjust business distribution, revision protocol and other methods to get a new simulation scenario, run the simulation again.

In this paper, by comparing OPNET simulation results of the original network with the extended network, we found that the expansion brought some deficiencies, and then put forward the corresponding optimization plan.

2. The Campus Topological Model

The original campus backbone network was 1000Mbps Ethernet. In this network, we used Catalyst 4500 switches as the central layer, and used Catalyst 3560 switches as the convergence layer. Server group was connected to the aggregation layer switches with the 100Mbps links. In the model, we had set 1000 terminals; they simulate a variety of computers in the whole campus. As in part of the region users have the same behaviour, therefore we had adopted the form of a set of nodes. The specific topology is shown in Figure 1.

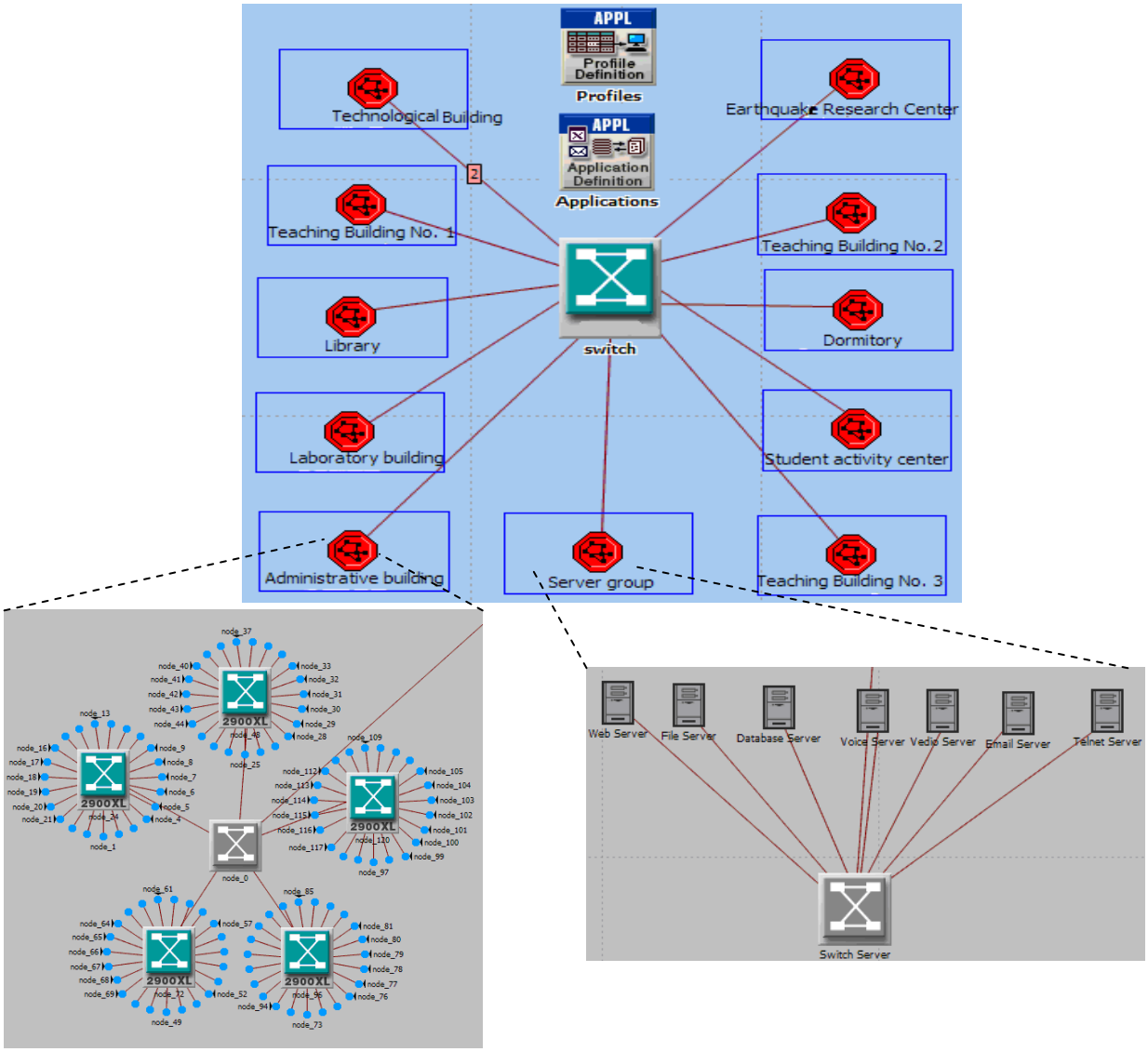

Figure 1. The Original Campus Network Topology

The expansion of campus network covers the new campus buildings, such as a graduate dormitory, study center, laboratory building, office building, and teaching buildings. A new 4500 switch was used as the core of the extended network, and this switch was connected by 1000Mbps link to the old one, they formed a dual-core structure. The main server group and campus network exports were still the old campus network. After the expansion, the new campus network was increased 650 terminals and connected to the main campus network by a single link. We used this model as the initial plan to carry on the simulation. The specific topology is shown in Figure 2.

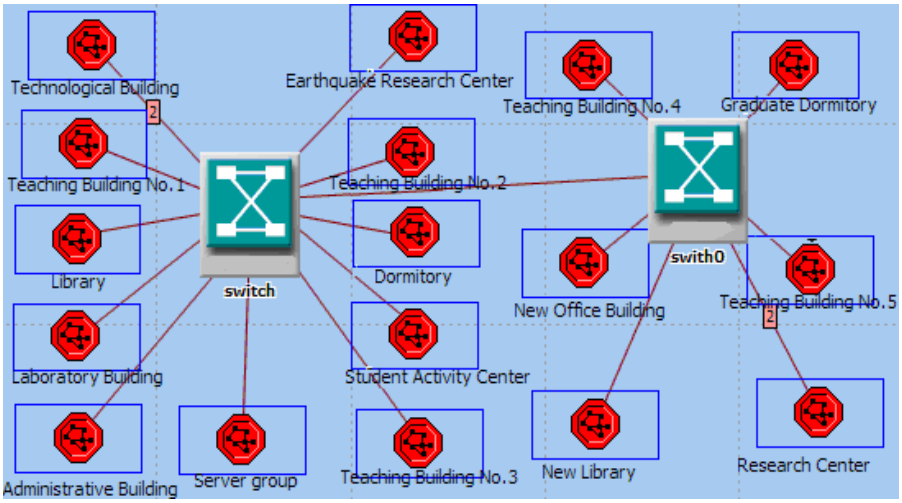

Figure 2. The Extended Campus Network Topology

3. Simulation of Campus Network Services

According to the actual situation of the campus network, the parameters of servers, switches and other hardware in the simulation were set in accordance with the actual parameters of equipments. The simulation parameter setting of the user's behaviour was based on the content of university servers and the user characteristic. The OPNET simulation modelling is separately realized at application layer, network layer and data link layer. Regarding the application layer parameter configuration, some applications were defined, service attributes were disposed, and then the applications of servers were deployed, client requests were configured [7].

3.1. Application Definition

Application definition is the description of various attributes, for example regarding the HTTP application, the web page content, size and access time gap were defined; Regarding the database, the proportion of inquiry operation, the size and data exchange of inquiry and the frequency of data exchange were defined. When the network simulation simulates the behavior, many probability distribution functions must be used in the application definition. These functions generate the random value is decided by the input parameter [8]. We adopted the exponential distributed function to indicate interarrival time of independent random events; the uniformly distributed function indicated various contents in the web page; the Poisson's distribution function indicated the number of events that occur in unit time.

Consideration of campus network service types, server group comprised Web, FTP, Email, Database, Voice, Video and Telnet servers. For each server, the configuration parameters were set as follows. For example, in the Application Definition, the HTTP Server: Web Browsing parameters were customized. The author defined two kinds of behaviour, which were "busy" and "idle". The busy behaviour of the parameters was set as follows: Page Interarrival Time (seconds), exponential (60); Page Properties (bytes), exponential (250000); Image object size (bytes), uniform_int (20000, 100000); Number of objects (objects per page), uniform_int (3,10). The amount of data on the idle behaviour was definitely more than the busy

behaviour, and the time interval was defined much longer. In addition, we also defined the parameters of Database Access, email, File Transfer, Telnet, Video, Voice and other services.

3.2. Profile Configuration

The Profile Configuration describes the application which a kind of user is involved, and contents of these applications and used frequency have very big difference. In accordance with the characteristics of campus users, the corresponding applications were set in the Profile Configuration. For example, the “Student Play” application corresponded with Web Browsing heavy, Video, Voice, File Transfer; the “Research” corresponded with Web Browsing heavy, Email, Telnet; the “Teacher Office” corresponded with Web Browsing light, Database Access, Email, File Transfer. According to the actual distribution of users, The Application: Supported Profiles were set as follows: in the dormitory, 70% terminals were set to the Student Play; in the Office building, 80% terminals were set to the Teacher Office; in the Laboratory and other scientific research buildings, 70% terminals were set to the Research.

3.3. The Simulation Results

Many results were calculated by simulation of the original network. Such as, the network delay time was 16ms; the Http page response time was 100ms. Therefore the original network status met the needs of actual communication. After the network scope expansion the number of users increased, which led to the whole network delay grew, as shown in Figure 3. The expanded network average delay was 0.5 seconds; it's shown that the larger load of extended network impact network performance. The page response time of HTTP is shown in Figure 4. It can be seen that the page response time of original network was less than a second, but in the extended network the time was 6.5 seconds. Such response time had already surpassed the scope that the user could tolerate.

In addition to the above data, we also obtained the FTP downloading and uploading reaction time, before the expansion they were 3 ms and 3.1 ms, but after the expansion the times became 2.2 second and 1.4 seconds. Obviously the FTP downloading and the uploading reaction times also increased so much. At the server group’s switch, the traffic forwarded packets per second were increased about 1.5 times. Between the core switchboard and server group, the link utilization was obvious increase, from beforehand 44% to 60%. The traffic and the utilization are shown in Figure 5 and 6.The utilization of the link between new campus and old campus was also very high, which reached around 55%.

In summary, along with the network went wide and the load went heavy, the network performance significantly got worse, and the user couldn’t get better service. Therefore, the extended campus network topology and equipments must be done some optimization.

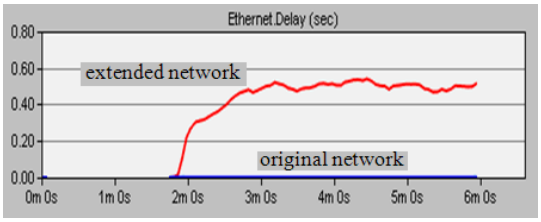

Figure 3. The Average Ethernet Delay

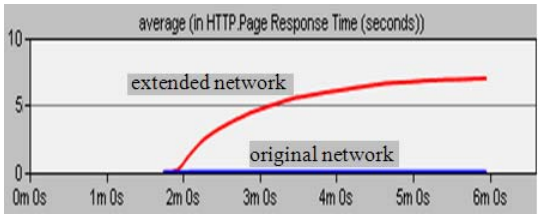

Figure 4. HTTP Page Response Time

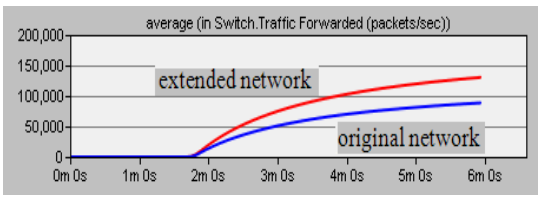

Figure 5. The Traffic Forwarded Packets Per Second

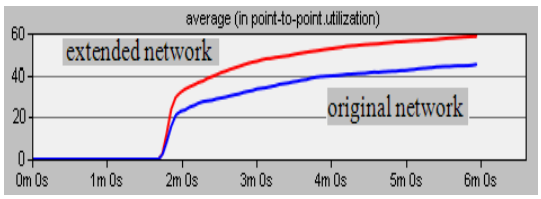

Figure 6. The Link Utilization

4. Optimization Scheme of Campus Network

We tested many optimization schemes, changed parameters of the switch (corresponding switches in different level), and changed topology, upgraded the connection lines, and then conducted several simulations to obtain the optimization measures as follows:

By changing the server's location, the servers would be directly connected to the central switch. This avoided the data forward through the aggregation switches again to reduce the forwarding times. Through addition of a WEB server; it could reduce the HTTP response time. This server was still placed in the server group, in order to manage and maintain easily.

The original core switch was upgraded to the 6500 series; the new core switch was still 4500. The 1000Mbps link was upgraded to four aggregated links, in order to increase the communication bandwidth between the two central switches. The optimization scheme is shown in Figure 7.

According to above optimization measures, we adjusted the simulation parameters of equipment and links. In this simulation result, the Ethernet latency (60ms) and HTTP response time (0.95s) were reduced significantly. The results are shown in Figure 8 and Figure 9. The results basically met the needs of campus network communication; therefore the solution of this optimization was correct and effective. Therefore we promoted the practical network by the optimization scheme, and increased the number of links from the core switch to each subnet. Up to now, this promotion has made a very good effect.

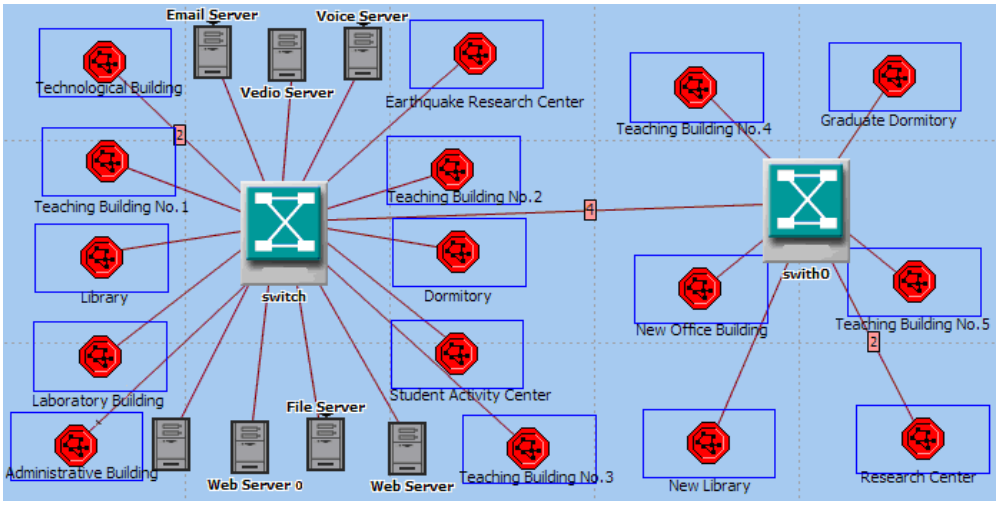

Figure. 7 The Optimization of Campus Network Topology

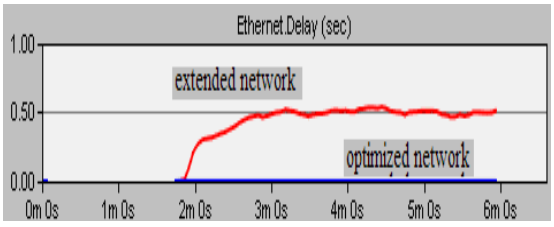

Figure 8. The Average Ethernet Delay

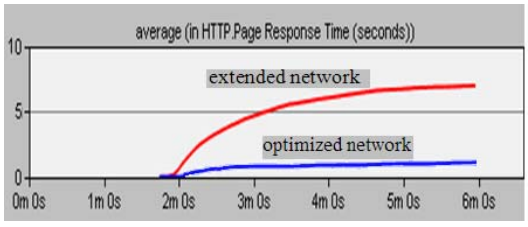

Figure 9. HTTP Page Response Time

5. Conclusion

This article discusses a variety of factors which affect the campus network performance. Especially when the network is expanded, the net latency increase, therefore a variety of user needs will not be met. By simulating this transformation of network, it provides some objective bases for network upgrades, and it ensures that the network upgrade project is reliability. Thus it can be seen, the network simulation technology is a new method of network planning and

design, this technology with its unique technology becomes a powerful network design tool. In this simulation, because the network size is huge, and structure is complex, therefore we have only defined specific service-based the network user, and have carried on the simplification to the network topology and equipment, these are certain disparity with the actual network. Therefore the network simulation recombines with actual test, which can achieve the best effect.

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