

EVALUATING DEPLOYMENT OF CENTRALIZED COURSE SERVER AND MOBILE WEB CLIENTS

Junaid A Zubairi and Joel Greutman

Department of Mathematics and Computer Science

SUNY at Fredonia, Fredonia NY 14063

E-mail: zubairi@cs.fredonia.edu

Abstract

We are studying the effects of deploying a proposed centralized course server in the SUNY Fredonia campus network and introducing mobile web clients using OPNET. We have simulated web clients accessing the server that resides on a Gigabit link in the central network facilities. We also simulate the mobile web clients in classrooms and evaluate their performance. Initial results have indicated negligible packet loss and annoying additional delays but with server connected directly to the central switch, the increase in the delays is not noticeable. In case of mobile nodes, we are working on the generalized problems of determining the performance with web applications and error rates for various WLAN parameters.

Introduction

OPNET has been used to study and provide assistance in campus network modifications in SUNY Fredonia. SUNY Fredonia is a campus of SUNY with about 5000 students. Most resident students use the network frequently and overall usage is between moderate to heavy. Last year the OPNET simulation results exposed a potential congestion point in the campus network where 13 residence halls collapsed into a single Cisco 5500 [1]. The network manager corrected the problem before it could jeopardize the performance.

The campus network has been changed recently from the description given in [1]. Residence Hall core switch is upgraded from a WS-C5500 to a WS-C6509. With the Campus Core switch/router and the ResNet core equipment side by side, we are able to implement all sub-networks on both switches. Thus each router routes its primary subnets and is also acting as secondary for the other's routed subnets via HSRP (Cisco's Hot Standby Routing Protocol). In the event that either router fails, the other picks up automatically.

Many of the 100Mbps switches and fiber links to main buildings have been upgraded to Gigabit Ethernet. Besides improving the internal structure, campus has expanded the Internet bandwidth from a single T1 to 8 x T1 (12 Mbps) via three Cisco 3640 routers. A Cisco CE560 content switch was added recently. The content engine caches previously fetched web pages for all three routers. Since turning it on, it has been delivering about 40% of the web content on campus. When a user goes outside of fredonia.edu for a web page, the routers send a query to the content engine, if the page is cached it sends a "light query" to check the page version with the server.

If the content engine has the most recent update, it sends the page to the requester at wire speed. If not, the router passes the query out onto the Internet. Also, a campus wide firewall is in early deployment stage.

The AIT (Academic Information Technology) has recently proposed that all of the current campus web pages related to courses be moved to a single powerful Win-NT/2000 server. Presently, professors who maintain web pages have stored them mostly on their individual departmental servers. We have initiated a study based on OPNET simulation to evaluate the performance pros and cons of this proposed change.

Mobile computing will be an integral part of the targeted ubiquitous computing environment. Third generation wireless systems and the Internet are pushing the mobile telecommunications market [2]. Mobile users tend to move around and still maintain active communication links. There is a growing need to provide quality of service to the mobile users based on an increase in the number of time-sensitive applications. Significant amount of work has been done to deal with the issue of providing multimedia services in the mobile wireless network [3,4,5]. Our study takes into account the future Fredonia campus network scenario when mobile computers would be taken into the traditional classrooms and professors would be able to download and show multimedia presentations to their students. For this purpose, we have added an access point in one of the academic buildings and provided ten mobile clients. These mobile clients will also be feeding from the same central course server. We also look at the performance of mobile nodes while adjusting various WLAN parameters. Rest of the paper is divided into two sections. In the next section, we introduce the experimental setup and simulation results for the campus course server proposal. Later, we present results of simulation with the mobile clients in an academic building as well as an independent wireless LAN that connects to the fixed network.

Simulations With Centralized Course Server

The current layout of the campus network is such that all local web-related material for a department is based in that department's subnet and such traffic does not need to transmit at a higher level. The proposed plan by AIT would place a powerful Windows NT/2000 server in the central network facilities and all web queries and responses would be carried by the central network switches. The most obvious issue with such a change is the increase in traffic through the central

switches. Each server request and response transmission would have to pass through the central switch thus increasing the load on the switch. Once the new changes in the campus network were incorporated into our network model, we were able to study the performance by monitoring several different network links in academic buildings and the links that connect the server to the central switch and central switch to the other buildings.

The campus network as simulated is shown in Figure 1. Figure 2 shows the network of Maytum Hall where all servers and central campus switches and routers are located. The course server is connected via Gigabit NIC directly to the central campus switch CS6509, as proposed.

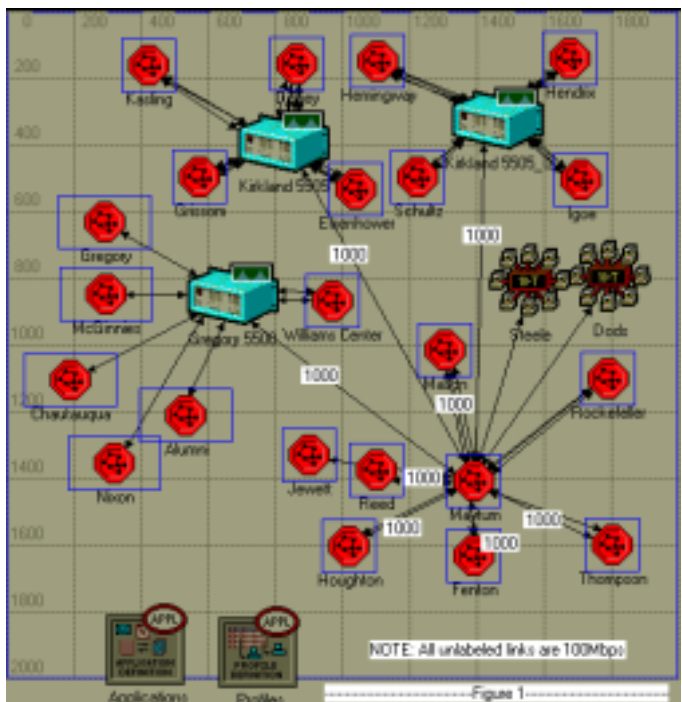


Figure 1: The campus network layout

We conducted simulations using seven scenarios.

- [I]. The first scenario is with light web traffic but without the central web server. Some nodes access the Fenton server and some connect with other servers in Maytum and other halls.
- [II]. Second scenario is scenario-I with heavy web related traffic.
- [III]. Third scenario directs web traffic to the central course server in Maytum Hall with light load.
- [IV]. Fourth scenario is scenario-III with heavy web related traffic.
- [V]. Fifth scenario is worse case by including other types of traffic as background traffic in scenario-II.

- [VI]. Sixth scenario is scenario-V with central course server.
- [VII]. Final scenario is scenario-IV with a WLAN included in Fenton Hall.

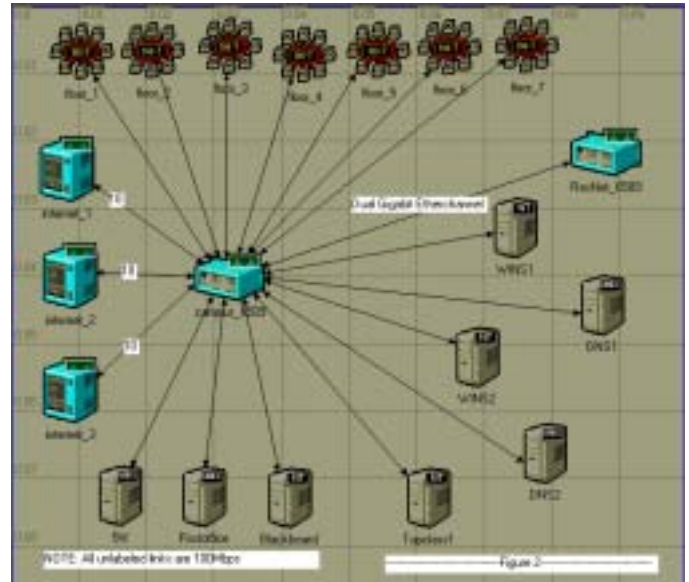


Figure 2: Maytum Hall network layout with centralized course server

We selected a Gigabit Ethernet link between Maytum Hall and Fenton Hall for monitoring the queuing delays. Some results are shown in the following diagrams. Figure 3 shows the results in scenario II and IV. Figure 4 shows the results in scenario V and VI. It is clear from these results that if the central course server is connected directly to the central CS6509 switch as proposed, the clients will not experience any significant additional delays and there is going to be no packet loss. With the Gigabit links now in place, traditional elastic applications (e.g. ftp, email and web traffic) will also enjoy a good quality of service within the campus network.

A review of the top results shows that the maximum delay of 0.252 ms was observed on a link that connects one of the servers to the campus 6509 switch in that direction. This queuing delay is negligible even for multimedia applications. The bottleneck link between central course server and campus 6509 switch shows an average utilization of 39.1% in worse case scenario (scenario-VI). The central course server carried a maximum load of 28.3 requests per second under this scenario. The top results also indicate that the busiest Gigabit links in the campus network involve one academic building (Fenton) and two residential buildings (Gregory and Kirkland). The academic building link handled maximum of about half a million packets per second in scenario-VI.

Simulations With Wireless Nodes

Laptop computers equipped with wireless NIC's are becoming widespread. Mobile nodes that connect from one AP (access point) to the other AP with little or no interruption in the

service provide the mobility to the users that wish to remain connected to the Internet while travelling. One possible use of the wireless nodes is in converting the traditional classrooms into smart classrooms. The Instructor can bring the laptop to the classroom and connect to the Internet via an access point installed in the academic building. We have simulated this scenario by installing an access point in one of the academic buildings on campus and providing 10 laptop computers with wireless NIC's. The objectives of this study are as follows:

- [1] To assess the performance of mobile web clients that connect to the central course server. The performance can be assessed by looking at the error rate, delays and packet loss statistics.
- [2] To determine the relationship between various configurable WLAN parameters and delays.

The next two diagrams show configurations for experiment 1 and 2 as listed.

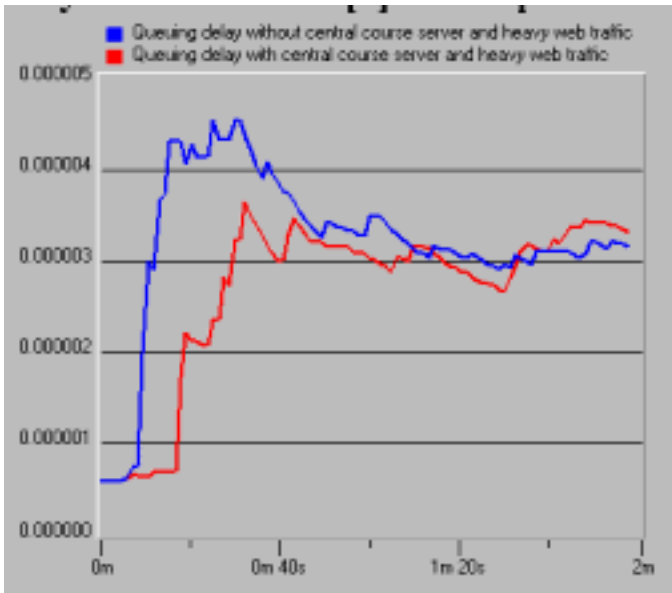


Figure 3: Results of the simulated scenarios II and IV

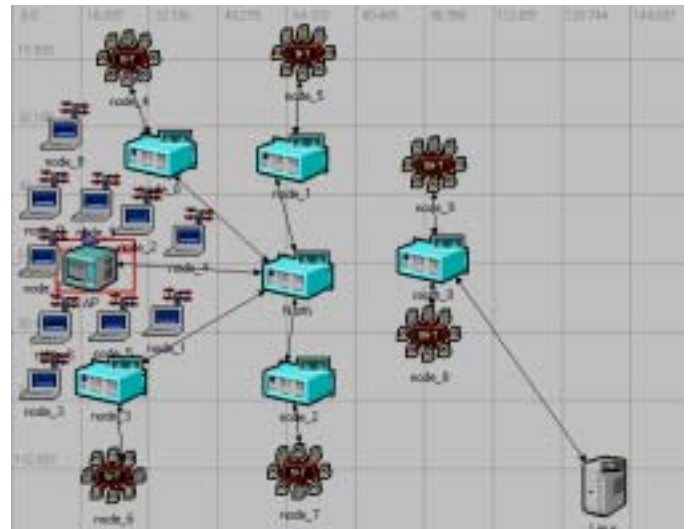


Figure 5: Wireless nodes in Fenton Hall

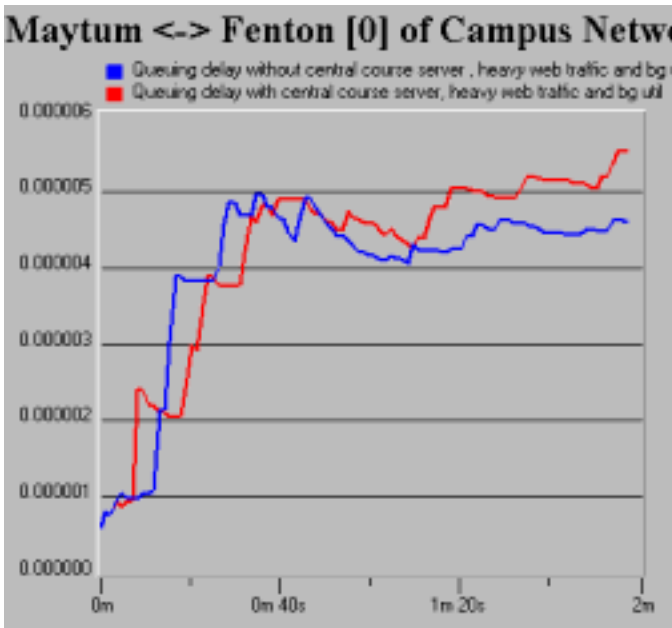


Figure 4: Results of the simulated scenarios V and VI

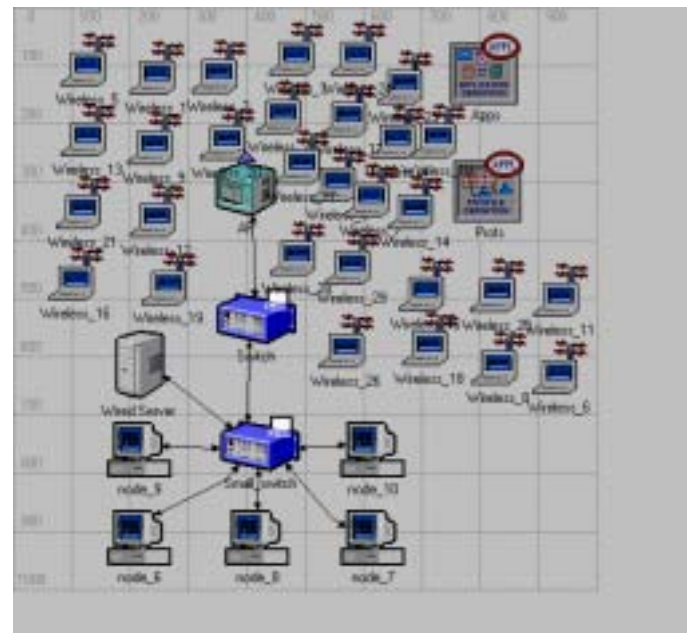


Figure 6: Wireless nodes in an BSSI

As described in [6], OPNET v7 does not support multiple link layer technologies in wireless LAN. OPNET's wireless LAN model allows DCF (Distributed Coordination Function) based MAC performance estimation where DCF is contention based access scheme. A BSS (Basic Service Set) is formed when multiple wireless workstations are defined. If there are only mobile stations in the subnet, it is considered an independent BSS also known as "ad-hoc" network, otherwise an access point (AP) is provided to establish communication with the wired facility and such a setup is known as Infrastructure BSS. An Ethernet-wireless router can be used as the access point.

In our experiments with mobile clients, we define two types of networks:

- [1] The first network consists of an access point within the Fenton Hall of the SUNY Fredonia campus network. Through this access point, mobile clients are able to communicate with the central campus course server. Statistics of interest to us are the error rates, delays and packet loss for mobile clients.
- [2] The second network consists of an infrastructure BSS with an access point that connects mobile clients to a wired switch. This switch lets the clients communicate with an Ethernet server. Buffer size is varied for obtaining delay statistics of the wireless clients.

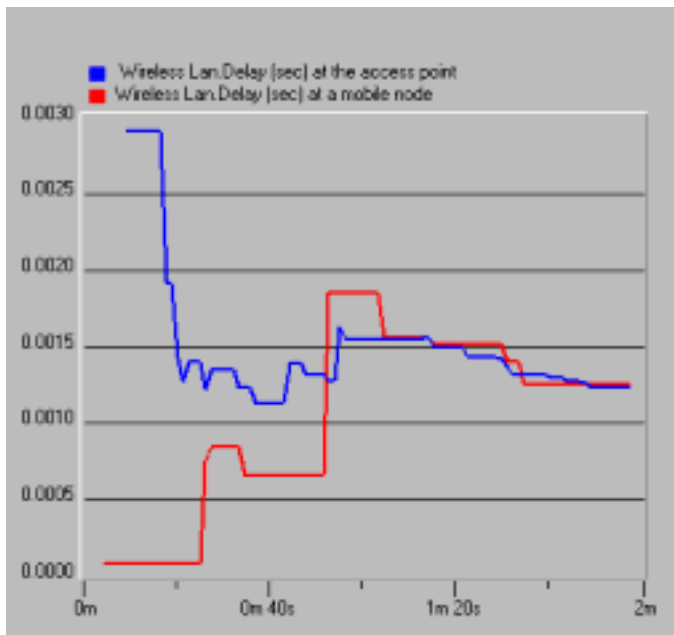


Figure 7: Wireless LAN Delay Statistics

The statistics for delay are plotted in Figure 7 for part (I) of the wireless simulation. It was noted that the packet loss and error rate are negligible and the delays stabilize around 0.0012 seconds.

In the simulation runs for part (II), the buffer size was changed for both 1Mbps and 11Mbps WLANs from 16,000 bits to one million bits. Delay and error rate were monitored for all various buffer sizes. For 1Mbps, the error rate is on a general decreasing trend as buffer size increases. For 11Mbps, things are much simpler; there are no errors, but the media access delay is clearly on an upward trend as buffer size increases with a sharp increase near the end.

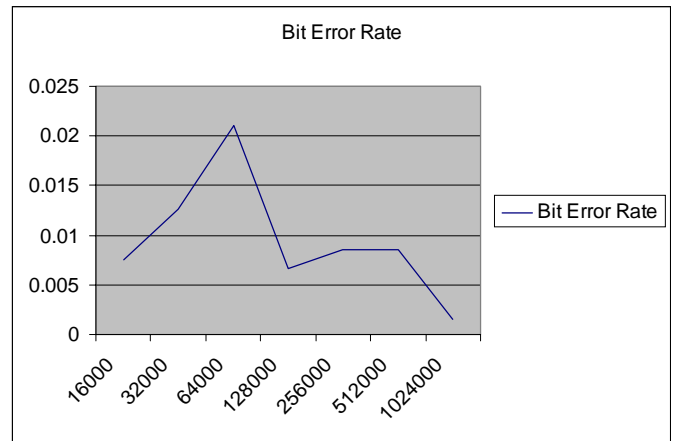


Figure 8: Bit errors for 1Mbps WLAN

These results indicate that as mobile client buffer size is increased in a low speed WLAN beyond 64,000 bits, bit error rate decreases. In an 11Mbps WLAN, a small buffer is the obvious choice, because as the buffer size increases, the media access delay also increases, which may result in non-smooth running of video applications

Conclusion

We have used OPNET to simulate the campus network in SUNY Fredonia and to answer some of the performance concerns about a centralized course server that may be deployed soon. The results indicate minimal packet loss however some clients may experience negligible increase in delays in service. We have also simulated mobile web clients in traditional classrooms. We have conducted another study related to infrastructure BSS WLAN by varying the client buffer size and monitoring delays and errors. The results show decrease in errors for low speed WLAN and increase in delays for 11Mbps WLAN if the buffer size is increased. We express our thanks to Jon Sheldon, senior student and Bruce Wilger, Network Manager for their help and support during this project.

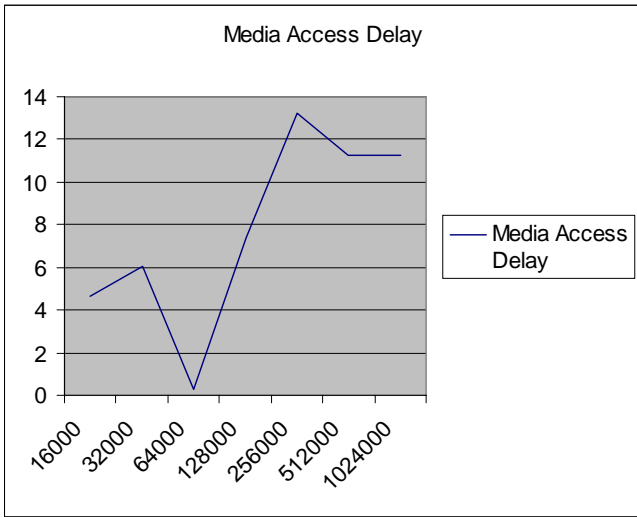


Figure 9: Delays for 11Mbps WLAN

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