The objective of the lab was to simulate an extended LAN network created to serve a company with four different departments, each with different usage characteristics, and a central set of servers. There were two main simulation scenarios to investigate the behavior of the network under different loads. The simulations were done using OpNet ITGuru; they utilized the prepackaged application configurations and user profiles available in the OpNet modeler to configure the simulation.

The first section describes the configuration of the network and the simulation parameters for each scenario. The second section presents the actual simulation results and analyzes them. The third section describes additional scenarios that were simulated to explore the behavior of the network under different changes to the data center server and network configurations, including an analysis of the simulation results. The final section presents conclusions.

Configuration

The first simulation scenario, **SimleNetwork**, consisted of a campus-wide network consisting of four different groups of users: Engineering, Research, Sales, and E-Commerce. Each of these groups was organized into a separate subnet of the network; each subnet included 10 workstations on a *10BaseT_LAN*, connected to an *ethernet16_switch*. The scenario also included OpNet's default applications and user profiles. The application profile for the LAN on each of the subnets was set to correspond to the department (i.e. the *Engineer*, *Researcher*, *Sales Person*, and *E-Commerce Customer*). An additional subnet was added for the server center; it included three *ethernet_servers* attached to an *ethernet16_switch.* The servers were configured as follows: a Web Server, supporting the light and heavy web browsing, light email, and light telnet session services, a File server, supporting the light file transfer and light file printing services, and a database server, supporting the light database access service.

The switches in the four departmental subnets were connected to the switch in the server subnet using *100BaseT* links. Fig. 1 shows the top-level topology of the scenario, Fig. 2 shows the topology of an individual department's subnet and the topology of the server center subnet.

The second scenario, **BusyNetwork**, had the same network topology, but each of the links connecting a departmental subnet to the server subnet was changed to have background traffic utilizing 99% of the link.

Both scenarios were set to capture the HTTP page response time (in sec.) for the entire network.

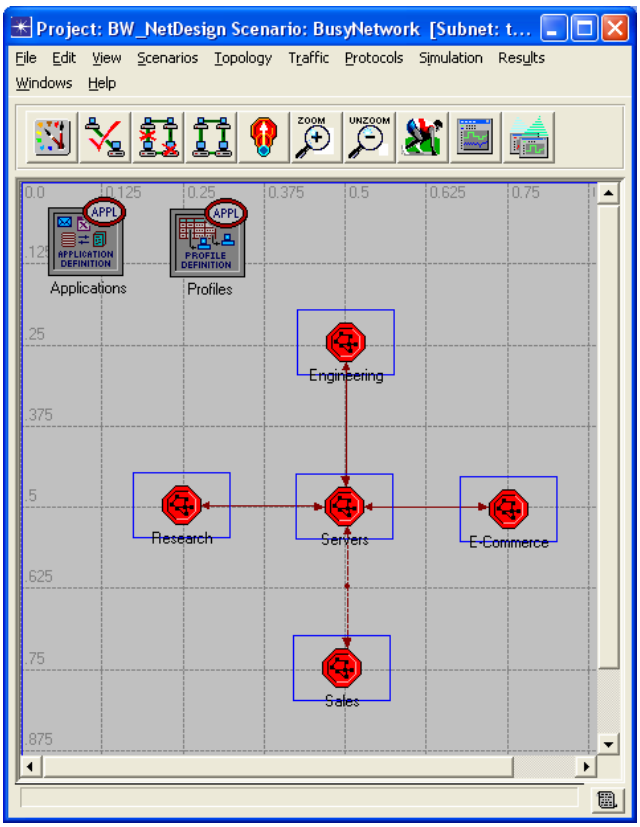

Figure 1 – Top Level Network Topology

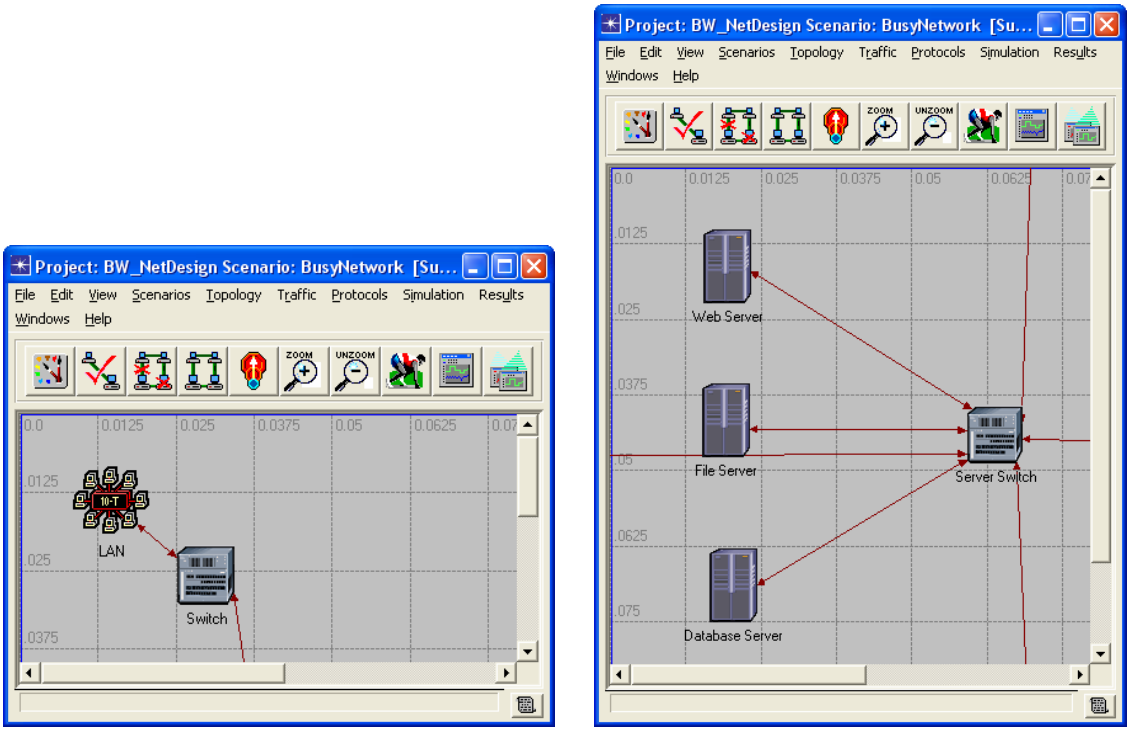

Figure 2 - Department Subnet and Server Subnet

Running the Simulation

The simulation was executed for thirty minutes for each scenario. After the simulation was completed, a graph was generated comparing the HTTP page response time for each scenario; Fig. 3 shows the graph that was generated (this is the time-average value over the simulation).

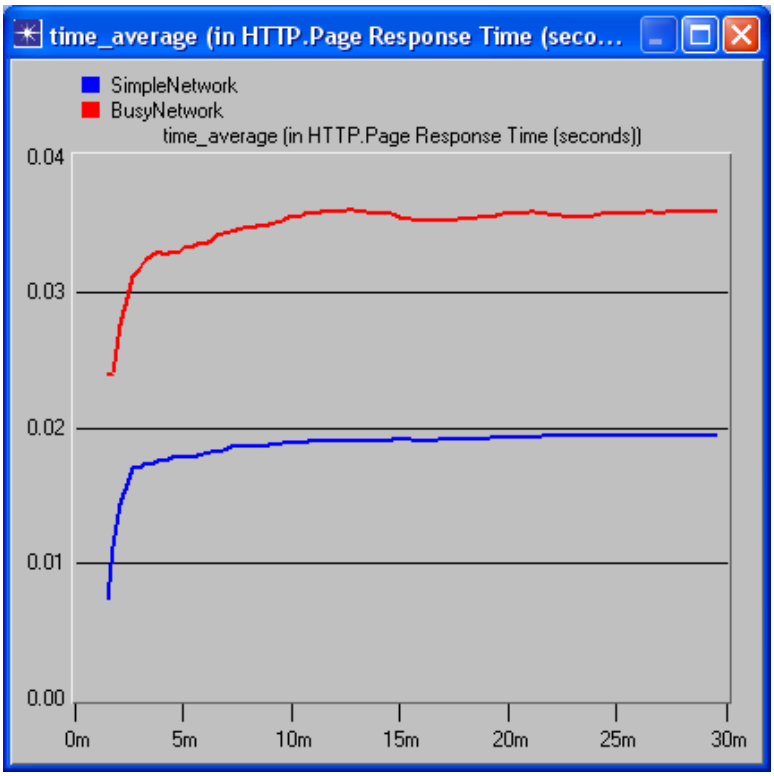

Figure 3 – Time-Average HTTP Page Response Time

As expected, the significantly higher rate of background traffic on the main 100BaseT links connecting the departmental switches to the server switch significantly degraded overall application performance; HTTP page response times were roughly 75% longer for the busy network.

Four additional statistics were captured and compared between runs of the two scenarios: DB query response time, email download response time, the file printing bytes received/sec, and the remote login response time. All were time averages over the simulation. Fig. 4 shows the resulting graphs. As expected, each statistic exhibited similar behavior; the busy network had significantly poorer response times for any of the application services. File printing experienced the least degradation, because the response time of the print server was not being measured, but the load on the network did produce a noticeable decrease in the rate that at which clients were submitting files to be printed, which is indicative of a slower response time to individual print requests.

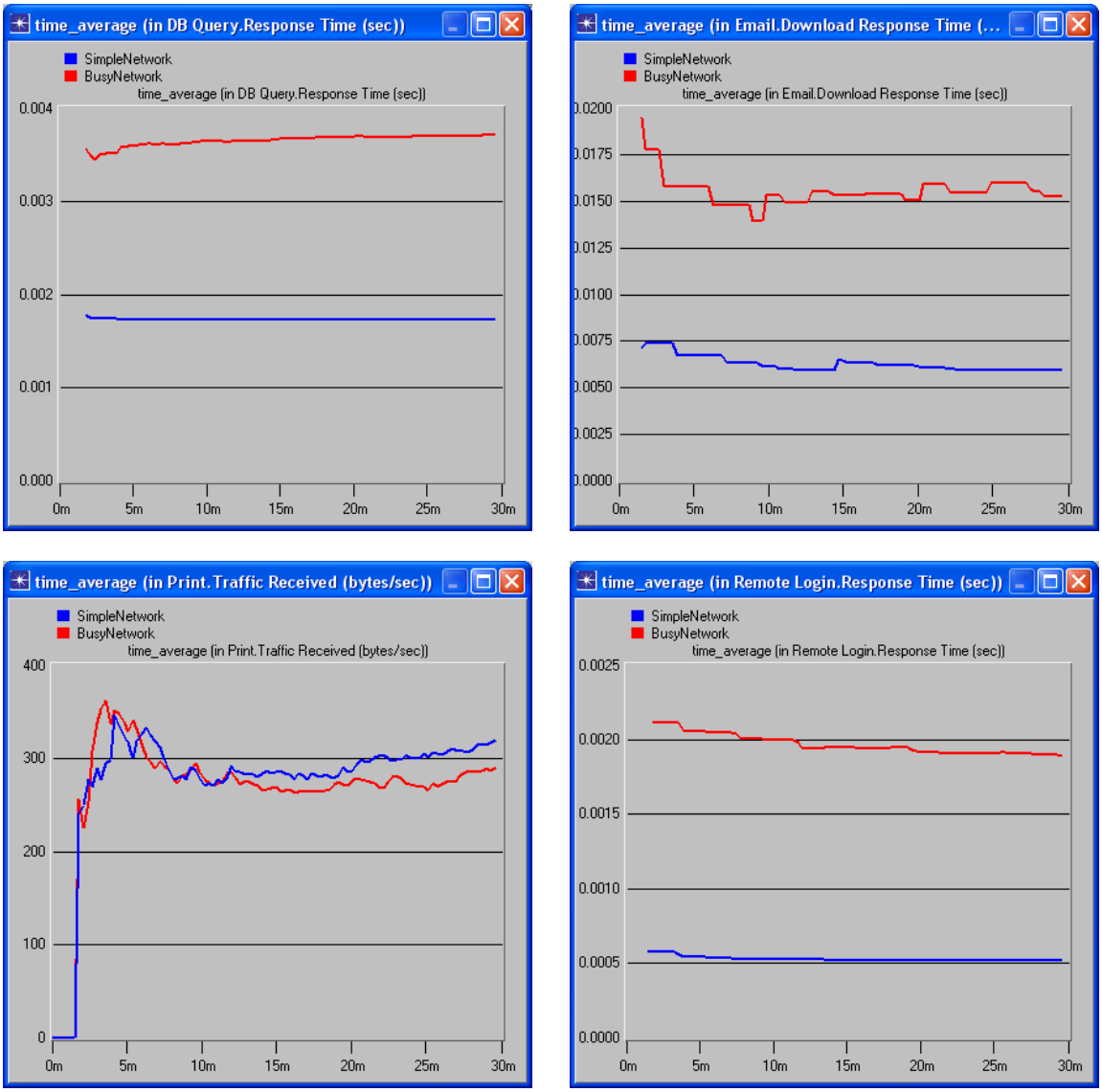

Figure 4 – Time-Average Statistics for Different Application Services

Additional Scenarios

Two additional simulation scenarios were created; each of them had the same network topology, but the first, *Q3_OneServer*, replaced the three servers from the *BusyNetwork* scenario with a single server. The second scenario, *Q4_FasterNetwork*, replaced the switch-to-switch links in the *BusyNetwork* scenario with with *10Gbps Ethernet* links and replaced all *10BaseT* links with *100BaseT* links.

For the *Q3_OneServer* scenario, CPU utilization was compared between the three servers in the *BusyNetworks* scenario and the new scenario. Fig. 5 shows the CPU utilization for each of the three servers in the original scenario, compared with the utilization for the single server in the new scenario. Obviously the load presented by the departments is not sufficient to require multiple servers; the HTTP page response time was compared between the two scenarios and was nearly identical, so providing all the application services via a single server is a practical alternative.

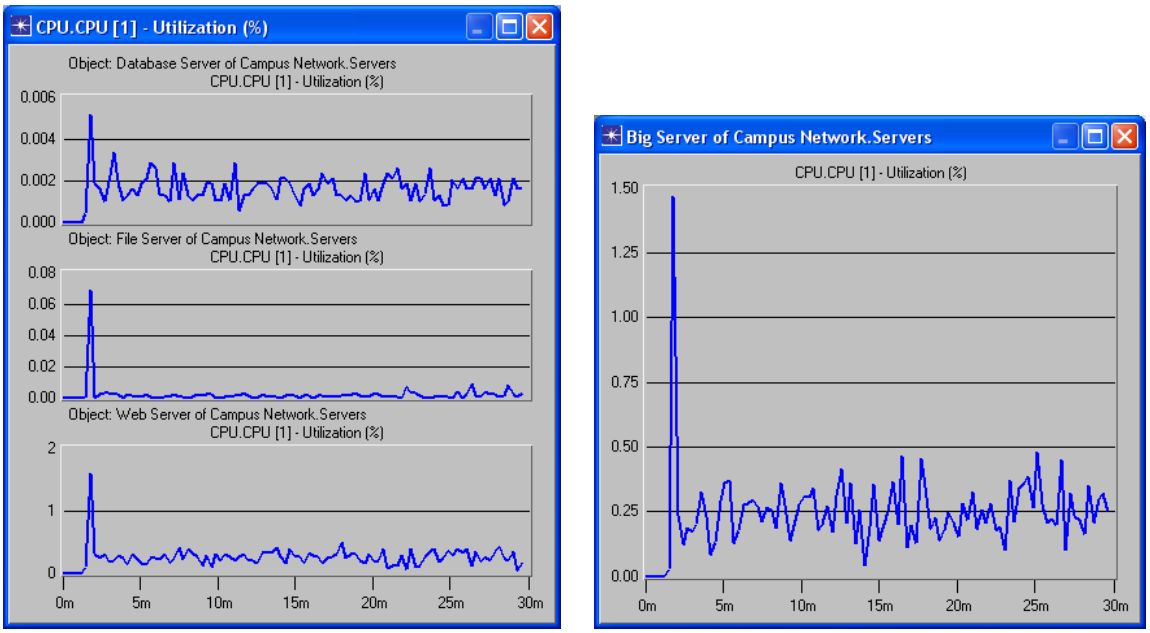

Figure 5 - CPU Utilization Comparison

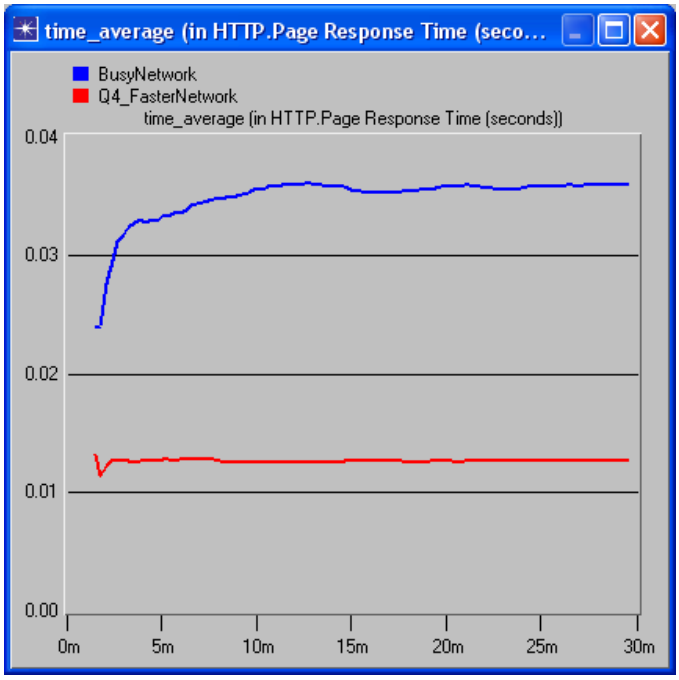

Figure 6 - Page Response Time Comparison for 10Gbps Ethernet Switch Links

Finally, the HTTP page response time was compared between the *BusyNetwork* and *Q4_FasterNetwork* scenarios. Fig. 6 shows the comparison of time-average values. The increase throughput of the network bandwidth resulted in the network introducing essentially no wait time at all to the HTTP responses. This much network bandwidth is probably a little overkill; an additional run of the simulation with the *10Gbps_Ethernet* links replaced with *1000BaseX* links showed nearly identical results, as shown in Fig. 7.

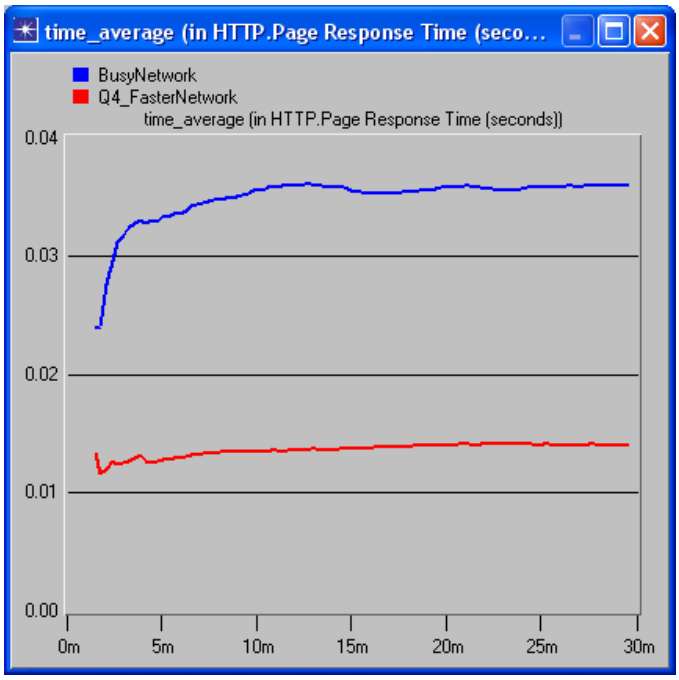

Figure 7 - Page Response Time Comparison for 1000BaseX Switch Links

Conclusions

The simulation scenarios helped to demonstrate the tradeoffs that are involved in designing a network; it is easy to over-engineer the network and provide excess capacity (with corresponding extra expense). By the same token, it is important to include all appropriate factors in the simulation – if decisions were made based on the initial *SimpleNetwork* scenario, without taking into account the background traffic that might be present on links, incorrect decisions could easily be made.