Lab 1: Evaluating Internet Connection Choices for a Small Home PC Network

Requirement

This set of labs works in conjunction with Professor Ray Panko's textbook, Business Data Networks and Telecommunications. You can download the labs from http://panko.info.

Objective

This lab teaches the basics of using OPNET IT Guru. OPNET IT Guru's user-friendly interface with drag-and-drop features enable students to effectively model, manage, and troubleshoot real-world network infrastructures.

We investigate application performance and capacity planning, by changing the link speed between a home LAN and its ISP.

Overview

OPNET's IT Guru provides a Virtual Network Environment that models the behavior of networks, including its routers, switches, protocols, servers, and individual applications. The Virtual Network Environment allows IT managers, network and system planners, and operation's staff to more effectively diagnose difficult problems, validate changes before they are implemented, and plan for future scenarios such as traffic growth and network failures.

You can do "what if" analyses (called **scenarios** in IT Guru) on network designs, just as you can on spreadsheets with financial business models. However, instead of looking at "bottom line" financial numbers, you will be looking at how response times, latency (delays) and other network performance measures will change under different network design approaches.

To create a network simulation (called a **project** in IT Guru), you specify the nodes (computers, switches, routers, etc.) in your network, the links between nodes, and the applications that will be running on the nodes.

In this exercise, the initial simulation (project) has been built for you. It models a family's home PC network, which has three PCs connected to the Internet for game playing, web browsing, E-mail, audio streaming, and FTP (file transfer protocol).

Your objective will be to conduct a series of what-if simulations (scenarios) to see how performance differs if the family connects to the Internet using 1) a slow modem downloading at 20 kbps, 2) a fastwe modem downloading at 40 kbps, 3) a cable modem or DSL line downloading at 512 kbps, or 4) a T1 line (discussed in

Chapter 6) with download speed of 1.544 Mbps. (Although modems, cable modems, and DSL connections often are advertised as being faster, these numbers are realistic throughput rates that users typically obtain in practice. Modem connections cost about $25 per month, while cable modem and DSL connections cost about $50 per month, and a T1 line costs several hundred dollars per month.)

For each scenario, you will set the download speed in the simulation model, run a simulation, and view the results. You will be addressing the question of whether faster connections are worth higher prices for the home network.

Lab Instructions

Step 1: Open Lab 1

IT Guru consists of **projects** and **scenarios**. Each scenario represents the different **what-if** analysis performed by the users. Scenarios may contain different versions of the same network or models of different networks. A project consists of one or more network scenarios. In this lab, you will create 4 different scenarios comparing application performance with different connection speeds to the ISP.

1. Start IT Guru.

2. Select **File** ⇒ **Open…** and make sure **Project** is selected from the pull-down menu at the top.

3. Scroll down to the project named **Home_LAN**, select it and click **OK**.
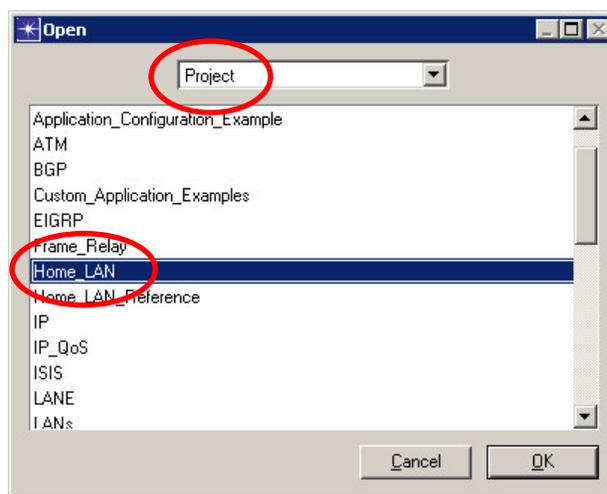
Note: If you do not see the project file, then make sure you have downloaded the lab files. Then unzip the file and add the unzipped lab files directory by going to **File** ⇒ **Model File** ⇒ **Add Model Directory** and selecting that directory. The project should now be added.
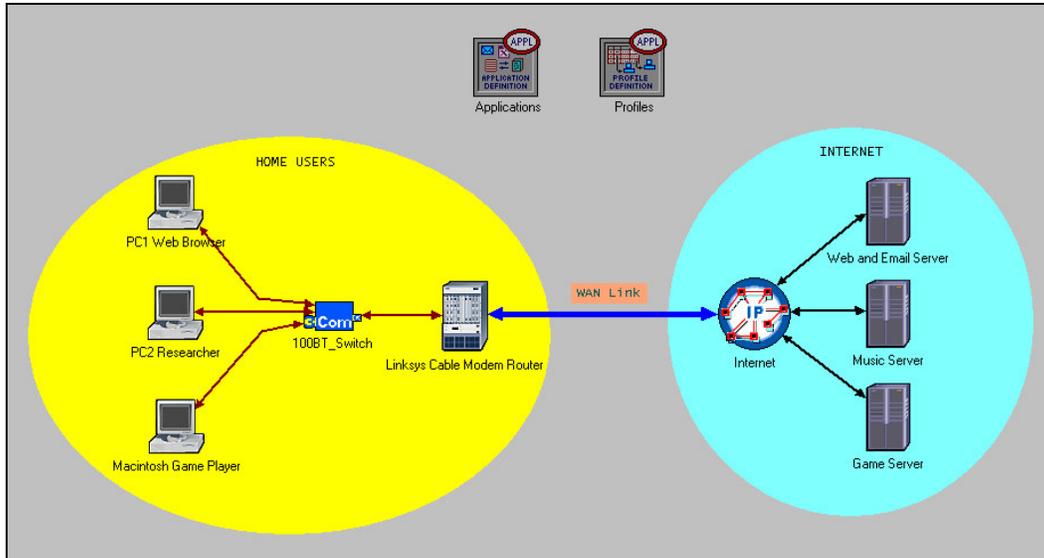
The figure above shows the simulated network. While the Pat Lee case in Chapter 1 (Refer to Business Data Networks and Telecommunications by Professor Ray Panko) has two PCs, there are three PCs doing different tasks in this network. Each PC connects to the family's 100 Mbps Ethernet switch via a UTP connection. The switch connects to the router, also via UTP. (In the Pat Lee case in Chapter 1, the switch and router are combined in a gateway. The two are shown as separate here to make the logic easier to see.) The cable modem is not shown; it is implicit in the WAN link connecting the home PC network to the Internet. Three Internet servers provide different services to the client PCs.

Near the top of the figure are two boxes that do not represent physical components: Applications and Profiles. The Applications node contains data about the applications used in the network, such as Web browsing. More specifically, traffic is associated with each application, so there is a difference between "light Web browsing" and "heavy Web browsing." Internal file service and print service traffic are not shown; these would be too light to make a difference in performance because the Internet WAN connection is the weak link in this network. In the Profiles icon, different applications are associated with different PCs.

The complete topology is laid out and the attributes for all the objects are pre-configured except the link data rate between the Router and the Internet cloud, this is our WAN link.

Step 2: Configure the Link to 20 Kbps

In your first scenario, you will configure the WAN link as a 20 kbps dial-up line.

1. Right-click on the WAN link select **Edit Attributes**.
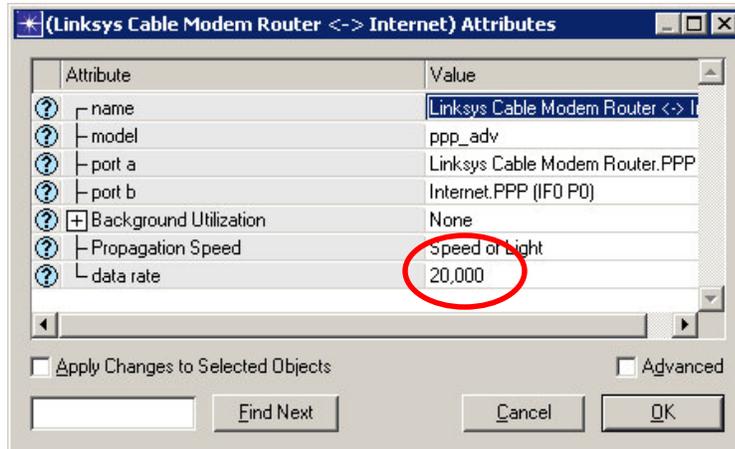
Here we can see the different link attributes. We will be changing the **data rate** attribute of this link.

2. Click in the Value field of the **data rate** attribute and select **Edit…**

3. Enter **20000**; press **Enter** and then click **OK**.

Step 3: Configure and Run the Simulation

To simulate this network, we will use high fidelity discrete event simulation. The model simulates client/server application packets, which represent real world network traffic.

1. Click on the **configure/run simulation** button.

2. Make sure the Simulation **Duration** is set to **8 hours** to represent a typical day.

3. Click **Run**, monitor the progress bar as the simulation proceeds.

4. When the simulation completes, Click **Close**.

Step 4: View Results

We can now view various statistics including the web application **Response Time** experienced by the Researcher and the WAN **link utilization**.

Follow the instructions below to view the statistics.

Performance for the WAN link

1. Right-click on the WAN link and select **View Results** to view the **utilization** results for this link.
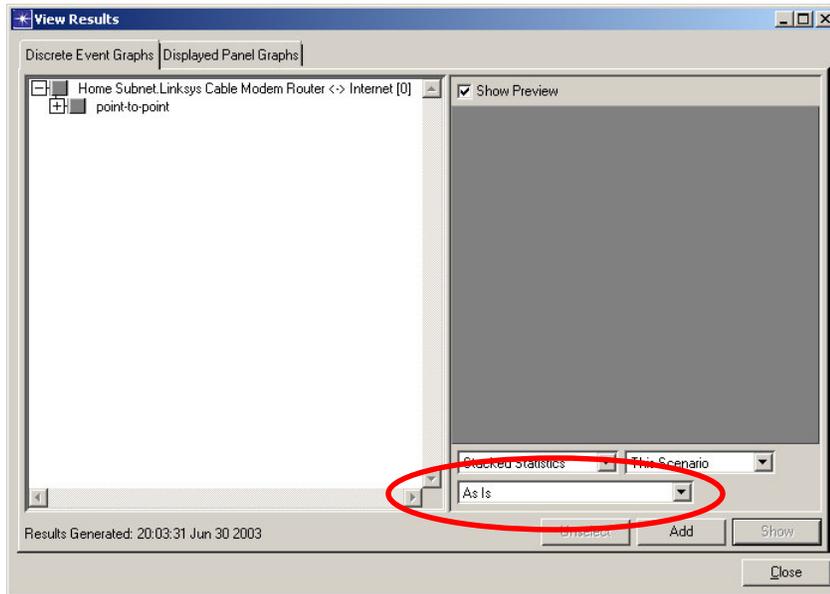

2. Expand **point-to-point** and select **utilization** in both directions.

3. Select **Overlaid Statistics** from the pull-down menu on the bottom right- hand corner to place the results in the same panel.
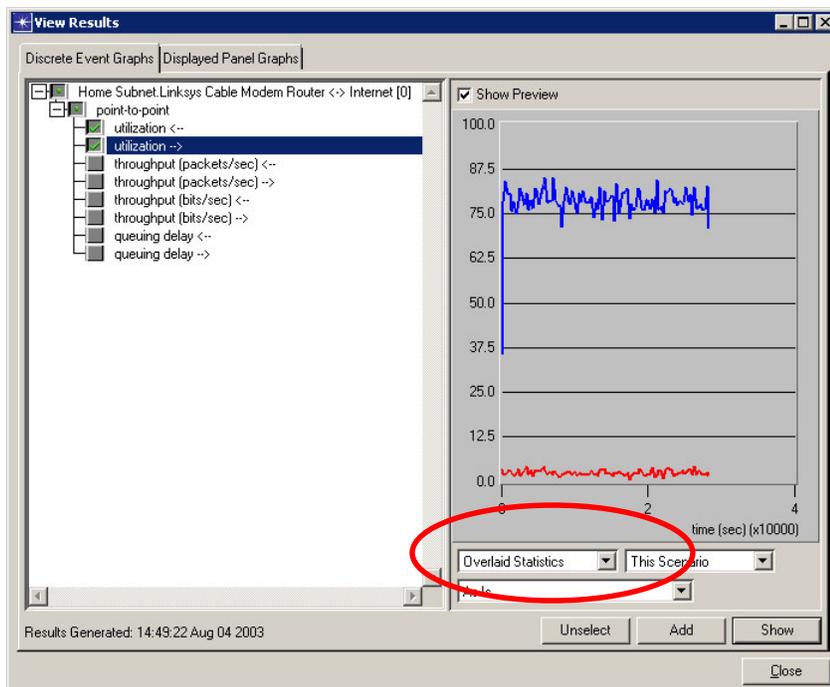
4. Select **Show** and then click **Close** in the **View Results** window.

Performance for PC2 (Researcher PC)

5. Right-click on the **PC2 Researcher** client and select **View Results** to view the web **Response Time** and **Traffic Received**.

6. Expand **Client Http** and select **Page Response Time (seconds).** Also make sure that the pull-down menu on the bottom right-hand corner is set to **As Is**.

7. Click **Close** in the **View Results** window.

8. You can use the **hide or show all graphs** button [icon] to hide/show the graphs.
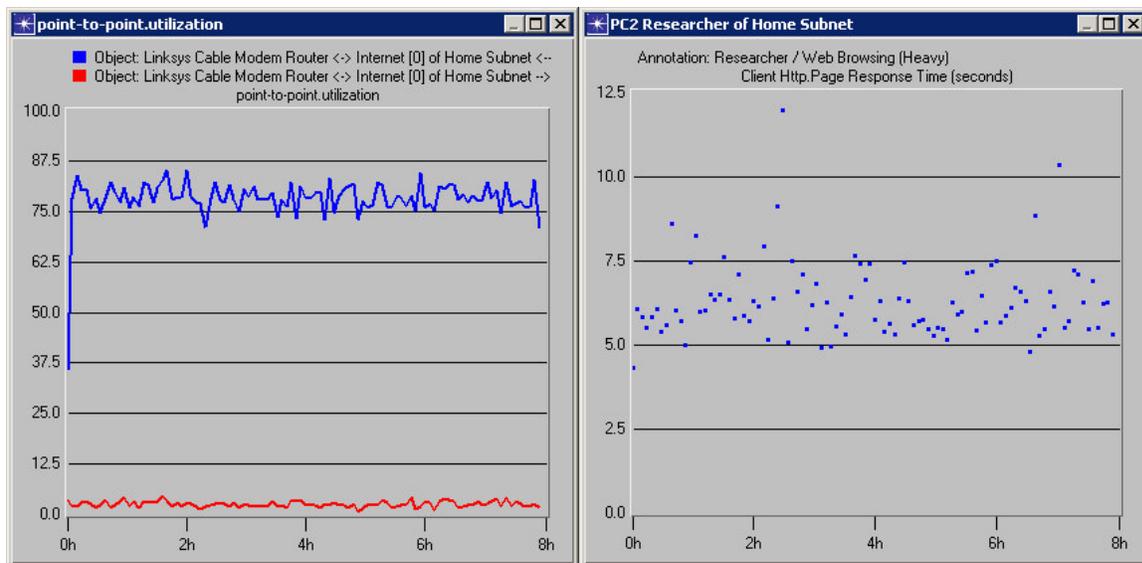
Your results should be similar to the graphs above. The **download link Utilization** averages about **80%** and the **upload link Utilization** about **2%**. With a download link utilization of 80%, this does not give much available bandwidth for potential new applications or users. The **Response Time** that the Researcher experiences is in the range of 5 to 7.5 seconds, which is painfully long. This slow WAN link is badly overloaded.

Step 5: 40 kbps Scenario

Implement a fast modem connection downloading at 40 Kbps. This is realistic throughput for a modem whose download speed is rated at 56 Kbps.

1. Select **Scenarios** ⇒ **Duplicate Scenario…** and name the scenario as **40K_dialup_connection**.

2. Click **OK**. This creates a copy of the existing scenario.

Step 6: Configure the Link to 40 Kbps
- Right-click on the **WAN link** and change the **data rate** attribute to **40000**.

Step 7: Run the 40 Kbps Simulation
- Rerun the simulation. You can refer to the steps given previously for setting the duration and running the simulation.

Step 8: View Results for 40Kbps Scenario
- Follow the same steps mentioned before to view the link **utilization**, and **Response Time** by the researcher PC.
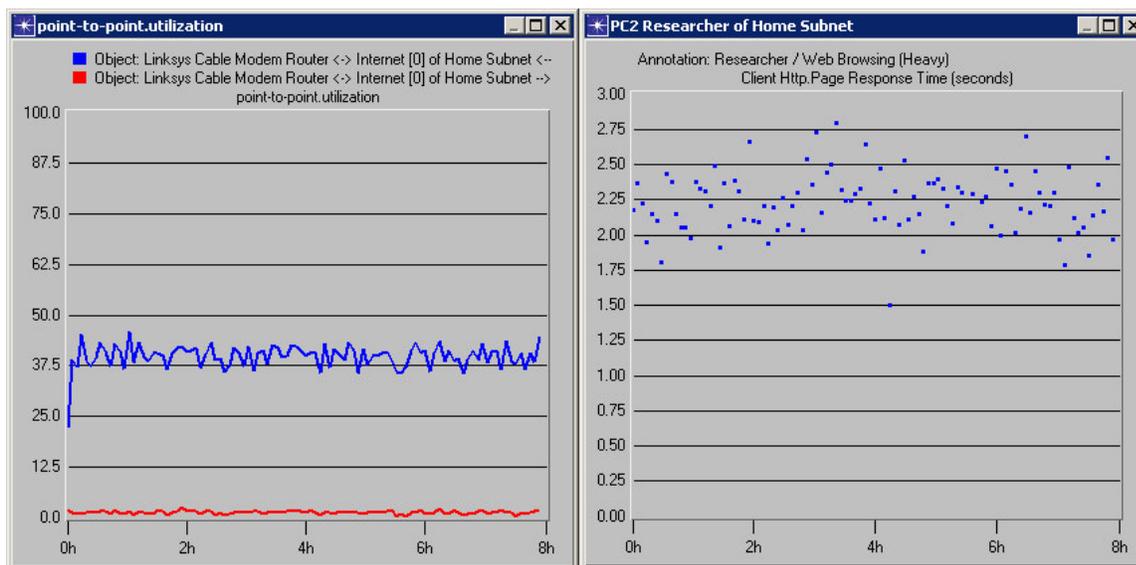

- Notice, that the link **Utilization** is reduced by half.
- The web application **Response Time** also went down from about 6 seconds to around 2.25 seconds. This is a significant improvement, both, in Utilization and Response Time.

Step 9:Set the link to 512 Kbps and run the simulation

In the third scenario, you will simulate a 512 kbps download speed. This is a realistic downloading throughput for a cable modem or DSL line. This WAN connection

- Duplicate the scenario as before and name it **512K_Cable_Modem_connection**.
- Set the **data rate** for the **WAN link** to **512000**.
- Rerun the simulation.
- View the results for **link utilization**, **Response Time** and **Traffic Received** by the Researcher PC.
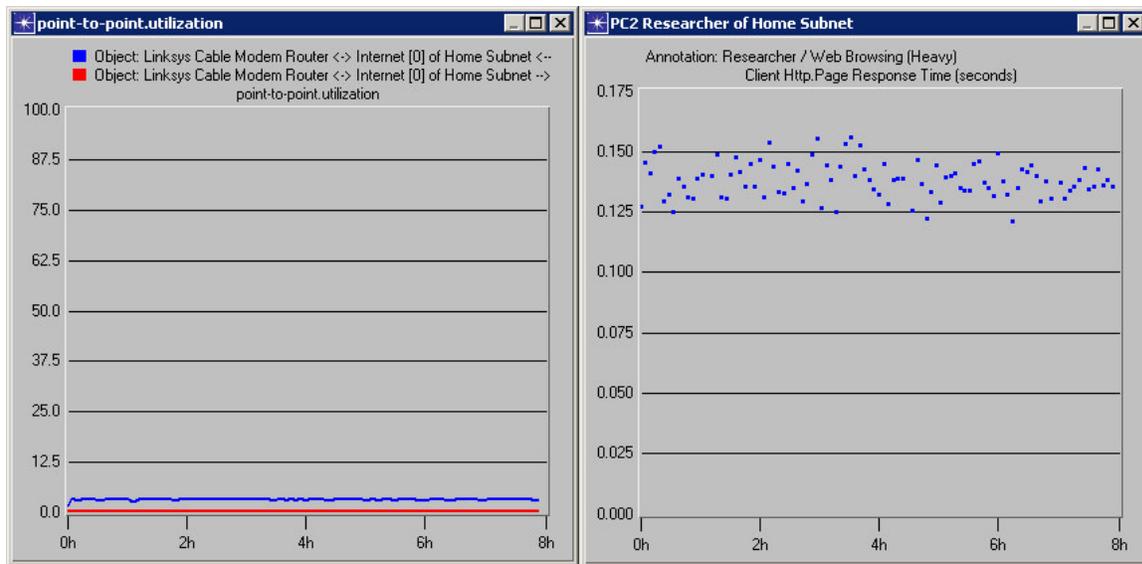
- The **Utilization** went down to **4%** and the **Response Time** for the Researcher went down to **0.15 seconds**. The cable modem improves our download times greatly. Response time is very good.

## Step 10: Configure the link to T1 line and run the simulation

The ISP also provides residential T1 connection. T1 lines, discussed in Chapter 6 (Refer to Business Data Networks and Telecommunications by Professor Ray Panko), offer a rated speed of 1.544 Mbps in both directions. This is also its actual throughput. The only problem is that a T1 line costs several hundred dollars a month. The telephone company needs to run a two pairs of special data-grade wires to the home and needs to manage the T1 line carefully because the rated speed is guaranteed and because there also are guarantees for availability. The fourth scenario will consider the benefits of using a T1 WAN link to the ISP.

- Duplicate the scenario again and name it **T1_connection**.
- Change the **data rate** of the **WAN link** to **T1** from the pull-down menu.
- Rerun the simulation.

Step 11: Compare Results

Rather than viewing the results for the T1 link alone, let us **compare** the results of **Utilization** and **Response Times** for **all** the **4 scenarios**. This will give us a broader picture of the effect of changing the data rate.
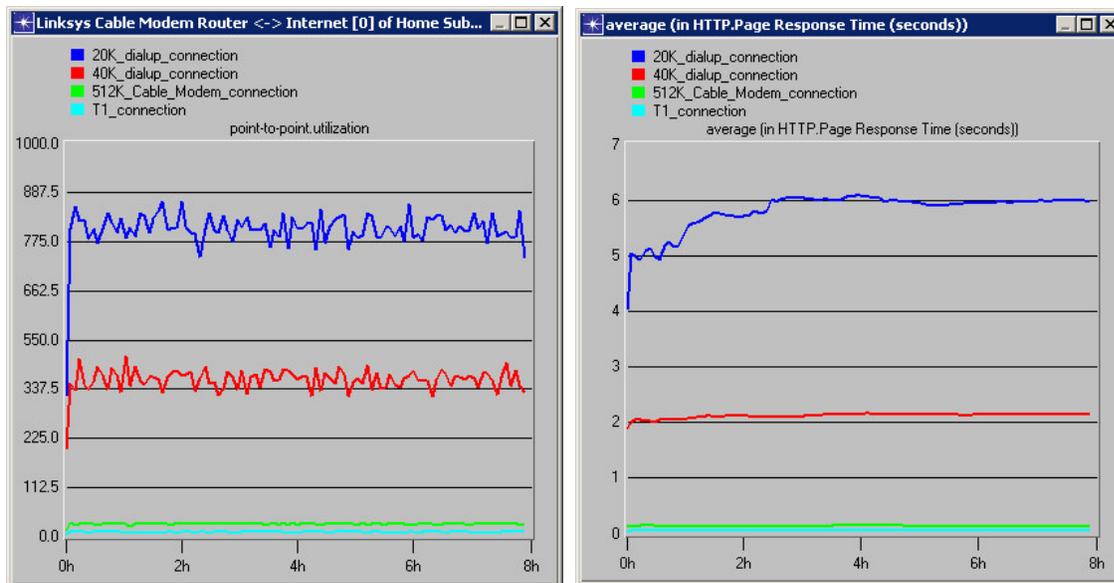
1. Select **Results ⟹ Compare Results…**

2. To compare the **utilization** statistics, choose the following statistics:

3. Make sure that **All Scenarios** is select.
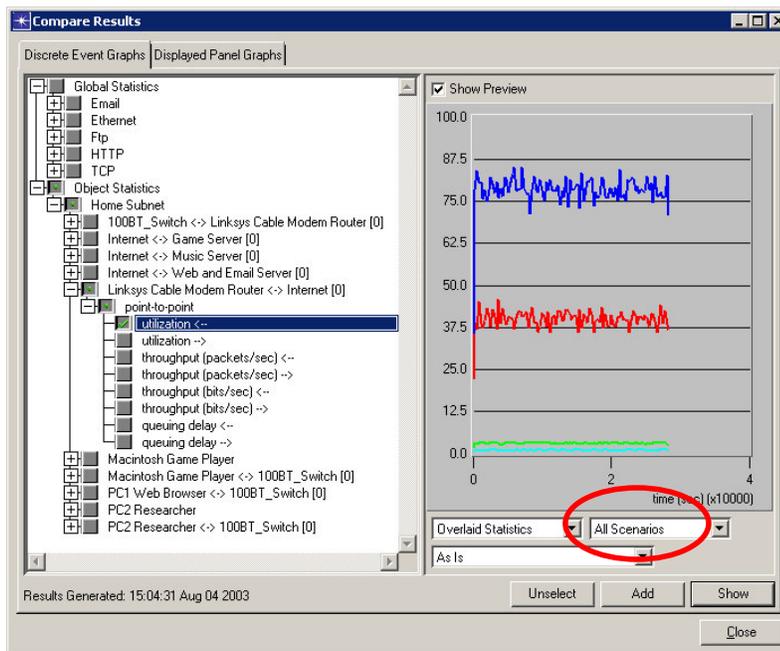
4. Click **Show**. To compare the **Response Time**, unselect the previous statistics, change the filter on the right-hand bottom corner from **As Is** to **average** and then choose the following statistics:
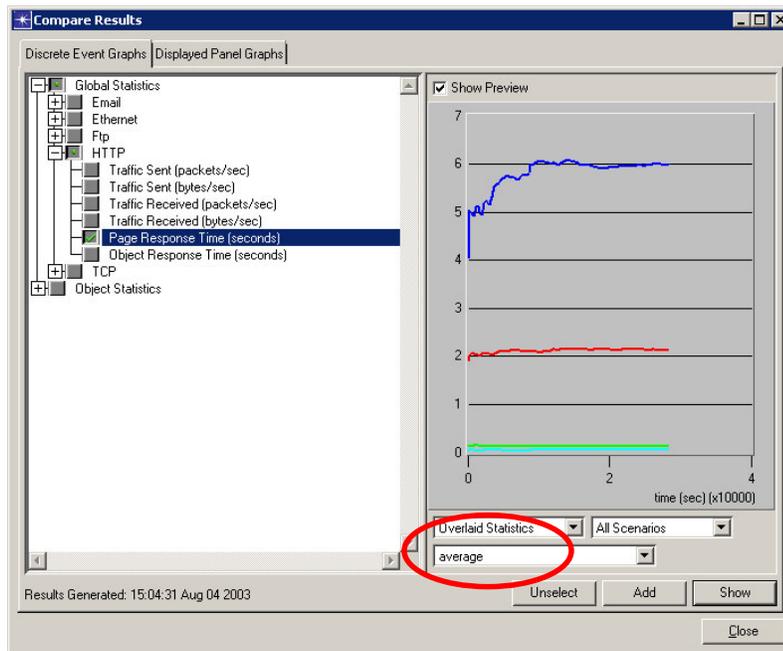
Here are the results

- We can see from these results that as the data rate increases from 20K to 40K to 512K, the **Utilization** becomes better. Also the **Web Application response time** becomes better.

- However, the **Response Time** and **Utilization** do not get affected much by changing the data rate from 512K to T1 line. For the current number of users, the T1 connection does not offer much benefit. This shows that upgrading to a T1 link will not be economically feasible with the performance improvement that it gives.

Step 12: Recommendations

Now put on your consultant's hat. What would you recommend to the family? Use numbers to justify your recommendation, but don't simply restate the results. You are paid to make good recommendations.

Advanced Scenarios

So far, every scenario had step-by-step instructions. Now, here are some advanced scenarios for you to run.

- **Advanced Scenario 1.** Many statistics are being collected like the throughput and the queuing delay on the WAN link. View these 2 results for the four scenarios and prepare a brief report of your observation.

- **Advanced Scenario 2**. Create a duplicate scenario. Change the data rate of the WAN link between the Router and the ISP to get an average response time of 1 sec. (**Hint:** From the results, we can see that the data rate might fall between 40 Kbps and 512 Kbps.) What WAN speed did your find to give this response time?

- **Advanced Scenario 3.** There is continuous streaming between the music server and PC1 defined by a traffic demand object. You can view this object by selecting **View** ⇒ **Demand Objects** ⇒ **Show All** in the menu. Try changing the Traffic volume for this demand. (**Hint:** Edit the Traffic (packets/sec) and Traffic (bits/sec) attributes of the Demand Object.) Observe its effect on the web response time for the researcher. Briefly describe the data values you changed and the impact on the researcher.

- **Advanced Scenario 4**. What would happen if there were two more PCs? Select and Copy the Researcher PC. Then paste the PC. Copy one more PC in the similar manner. Connect these two PCs to the switch by copying and pasting the links connecting the first researcher PC and the switch. Run the simulation and see view the web Response Times of each of these PCs for all the data rates. What did you find?

- **Advanced Scenario 5**. Here is a harder task. Add more applications to the researcher PC and check the response time that it gets. (**Hint:** To add applications to a client, you need to edit the attributes of the Profile object and edit the **Profile Configuration**.)