Lab 1: Improving performance by LAN Hardware Upgrade

Objective
In this lab, OPNET's IT Guru Academic Edition advanced modeling software will be used to study performance improvements in LAN obtained by upgrading switch hardware. We will also look at a wireless LAN topology and characterize it by looking at Media Access Delay values.

You will learn the benefits of upgrading switch hardware in a congested LAN environment.

Lab Project
Friendly Care Hospital is one of the biggest hospitals in DC. It owns a 5-story building, and houses many departments that span multiple floors. Its Radiology department is spread across the first and second floor connected by a dedicated LAN. The department has recently deployed a new "Radiology Images" application as part of their initiative to digitize patient records. However, the department staff sometimes faces long application delays during busy hours. You, as their network engineer, are tasked with the job find the cause and recommend a solution. Also, Friendly Care is looking to design a wireless hospital for the future and wishes to study a proposed network design, using a completely different topology and traffic profile.

Overview
In this lab, there are 3 scenarios. The first two scenarios study the "Radiology Images" application performance on a 100 Mbps switched Ethernet network, and a 1 Gbps switched Ethernet network after a switch hardware upgrade. The third scenario focuses on evaluating a Wireless LAN, including low-level Media Access Delay (MAC) statistics, and high-level performance statistics like application response times.
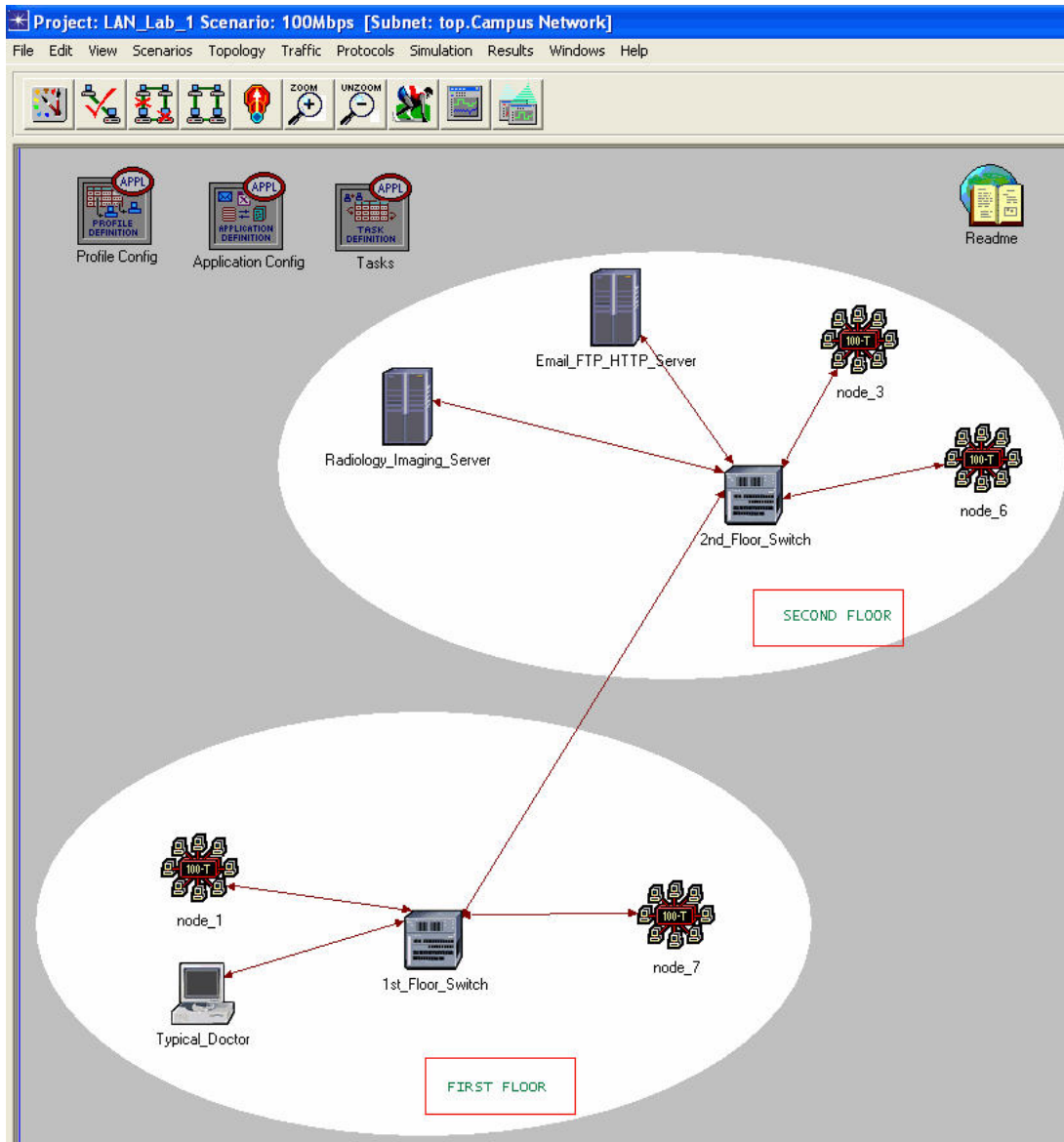
Lab Instructions
Note: Bold marked words indicate menu/clickable options.

Part 1: Understand the model and modeling environment

1. Start IT Guru Academic Edition 9.1 (free download available at http://opnet.com/services/university/itguru_academic_edition.html)

2. Select **File** -> **Open…**

3. Scroll to the project named **LAN_Lab_1**, select it and click **OK**. If you do not see this project in the list, it means you have not downloaded and installed the labs properly. For complete instructions, follow the steps on this page: http://opnet.com/services/university/Install_Lab.html.

4. The first scenario is named "100Mbps". You can verify the project and scenario by observing the title bar (see screenshot below).

In this scenario, groups of users belonging to Radiology Department are connected on a dedicated LAN containing two switches, one on each floor. A switched is indicated by the icon: [icon]. The switches are named

1st_Floor_Switch and 2nd_Floor_Switch. Groups of users [icon] hit a variety of

servers running file, database, HTTP, and Email services. The Radiology Images application is hosted on a server called Radiology_Imaging_Server. This lab simulates users running these various applications between their workstations and the servers.

Note: OPNET allows for abstracting background application demands into traffic flows, which are defined by specifying a source, a destination and a bits/sec rate between them. This feature helps in faster simulation without sacrificing accuracy, as we can use analytical techniques to calculate the statistics instead of performing intensive per-packet based calculation. Thus various background demands that user places on the network have been encompassed into IP Flows here. We have hidden these demands for clarity purposes. For the curiously inclined, you may view these flows by clicking **View -> Demand Objects -> Show All**. To hide them, click **View -> Demand Objects -> Hide All**.

For input in this study, the groups of users are configured to run Email, HTTP, FTP and Radiology Image applications.

For output, OPNET software provides many types of output performance statistics; low level statistics such as link bit error rate, switch queuing delays, and switch throughput, and high-level statistics like end-user application response times. We will focus on application response time and switch queuing delays on the links.

5. Read the "Read Me" file by double-clicking the icon. Then, click the icon in the toolbar to return to the topology in the project workspace,

Continue navigating to explore and understand OPNET's GUI and environment. OPNET's models are made up of objects, which have attributes. An object's attributes may be examined and changed by right-clicking it and selecting **Edit Attributes**. Any **+** sign indicates a compound attribute and may be expanded by clicking the **+** sign. "(…)" indicates a table underneath this attribute and double clicking it will show the table.

Explore the attributes values of the following objects: Application Config , Profile Config , Tasks , and Workstation . These attributes define the traffic that will get generated for the network (they are numerous and detailed and are beyond the scope of this lab).

OPNET's objects may be moved by drag-n-drop action, and can also be operated on by cut/copy/paste. The attribute values configure an object's

behavior and act as input to the simulation engine. Click **Cancel** whenever you wish to get out of any dialog box without changing the attribute values.

For purposes of this lab, the attribute values have been tuned to ensure correct results and conclusions. Any change in these values may alter the results significantly.

Understanding the network infrastructure: Here you will understand your network infrastructure, namely switches and links.

6. Right click on one of the switches labeled **1st_Floor_Switch** or **2nd_Floor_Switch**, and click **Edit Attributes.**

7. Expand **Switch Port Configuration**, and then, expand **row 0** (or any row) to see other details. Note the cost is set to **Link Speed Based**. Click on the help icon ⊚ across that row to learn what this costs basis means.

8. In OPNET modeling environment, the data rate a switch can support is specified by the link data rate which connects to the switch. Right click on the links between 1st_Floor_Switch and 2nd_Floor_Switch. Click **Edit Attributes** and note the data rate of the link. The units are in bits/sec. All links in this scenario are configured to be 100 Mbps.

By now, you should have a feel of how to navigate the project workspace, and have an understanding of this scenario. You are now set to run the simulation.

Part 2: Configure and Run the Simulation
The goal is to evaluate the network performance for a simulated 1 hour of the busy part of the day by running a high-fidelity Discrete Event Simulation.

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

2. Make sure the Simulation **Duration** is set to **1** hour.

3. Click **Run.** Monitor the progress bar as the simulation proceeds.

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

Part 3: View Results
Application Response Times for Email, FTP, HTTP and Radiology Images applications as observed by end-user and link utilization statistics will be reviewed in this section. It is important to note their values because in the next scenario we will improve this performance by upgrading switch hardware.

1. Click on **Results->View Results**.

<u>View Application Response Times:</u>

2. Expand **Global Statistics, Email** and **FTP**.

3. Select **Download Response Time (sec)** and **Upload Response Time (sec)** for both Email and FTP. The selected graphs will be plotted on the right-side of the frame. On the lower-right side, make sure the settings are **Stacked Statistics**, **This Scenario** and **As Is**. Click **Show**. A window is created with the graphs containing the raw data for the Email and FTP application response times.

4. Click the **As Is** drop-down menu and select **average**. This will convert the raw data into an average curve. Click **Add** and then <u>click on the top-most graph</u> of the window that you created in step 3. Now you have both the raw data and average graphs for Email and FTP application response times.

Note: If you did not follow the underlined instructions above, you may have mismatched raw data and average graphs, so close the graph, choose **Delete** and go through steps 3 and 4 again.

You may place the resulting window anywhere on your desktop by dragging it by its header bar.

5. Go back to the 'View Results' window and unselect the previously selected choices for **Email** and **FTP.**

6. Repeat steps 2-4 for **HTTP** and **Custom Application**. Select **Page Response Time (seconds)** for **HTTP** and **Application Response Time (sec)** for **Custom Application**. Close the **View Results** window when done.

<u>View Top 10 Link Utilization and Queuing Delay Values:</u>

7. Click **Results -> Find Top Results**. Expand **Link Statistics -> point-to-point** and select **utilization** and click **Find Top Results** button. You will see link utilization values in a table sorted in descending order based on **Average** column.

8. Click on the **Maximum** column name and sort by decreasing order. You should observe two links with 100% maximum utilization.
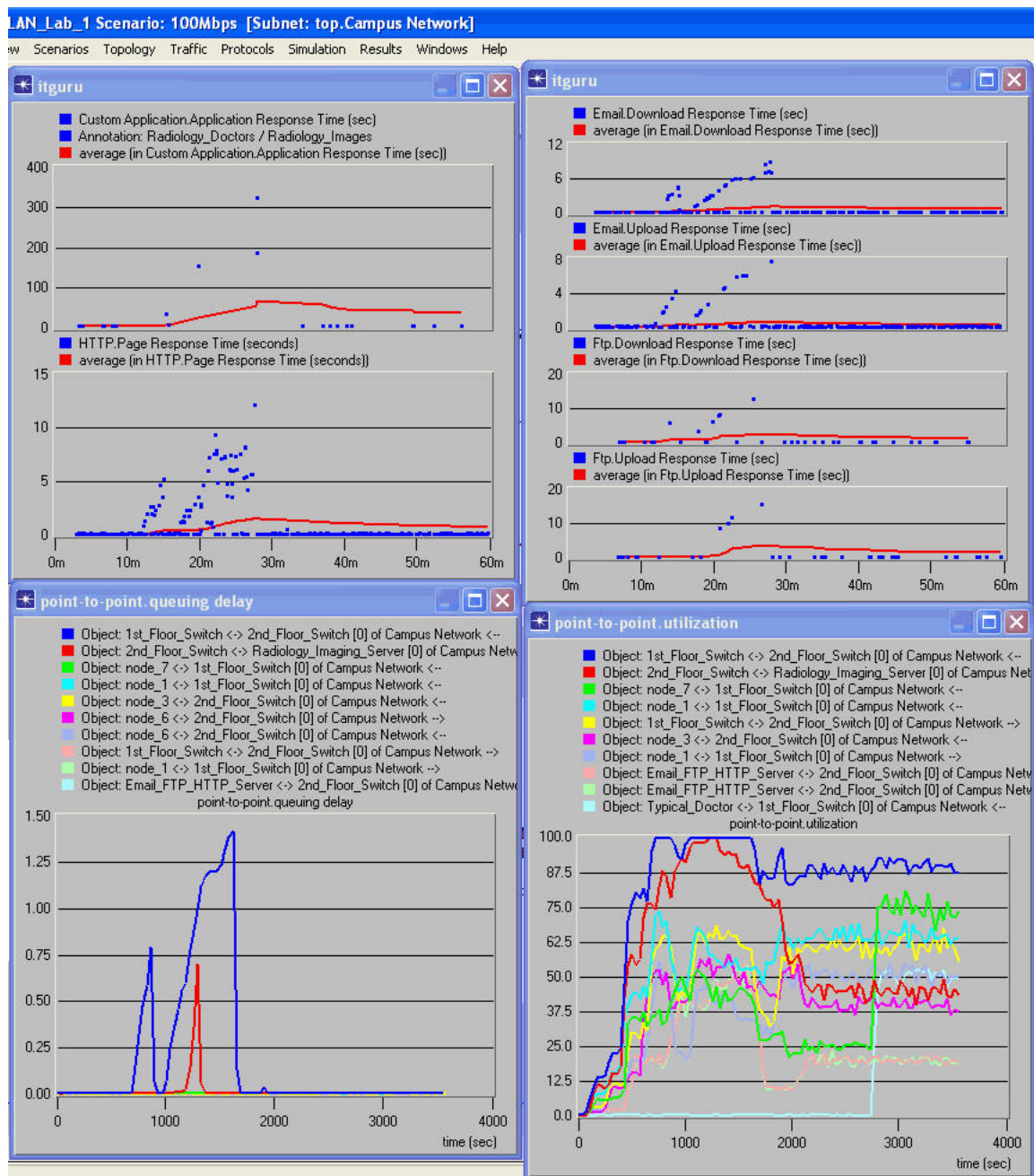
9. Click on **Graphs Stacked** drop-down menu and select **Graphs Overlaid**. Click **Graph**. Close the **Top Objects** window.

10. Repeat steps 7-9 for **queuing delays** instead of **utilization**. Click **Close** on the **Select Statistic for Top Results** window.

What do you observe?

Answer: Link utilization reaches 100% at times causing application response times to peak.

You should now have 4 graphs as shown below.

Note: To toggle the graphs on and off, use the **hide or show all graphs**

button.

11. Hide the graphs so that you now see the topology.

12. To visualize link statistics in yet another way, click on **Results -> Visualize Link Statistics…** In the left box, increase the Red number from 75 to 85. Click **Show**. You will see the links colored based on the utilization threshold set earlier. Red color indicates link which has peak utilization values greater than 85%. The utilization values are directional indicated by split colors on links. Verify the two links with 100% maximum utilization in red are the same you saw in the graph. You can view peak link utilization values in the tool tip when you move your mouse on top of the colored link.

Part 4: Switch scenarios to simulate the same network with 1 Gbps links

1. Click on **Scenarios ->Switch Scenarios**.

2. Choose **1 Gbps** scenario.

3. Read the README file by clicking the icon. It is important to understand how switch hardware upgrades are modeled in OPNET software.

4. To examine the change in attributes of the links, right-click on the two links which had reached 100% peak utilization in the previous scenario, and click **Edit Attributes**. Note the data rate of these links has increased to 1 Gbps.

5. Repeat all the steps in **Part 2: Configure and Run the Simulation**

6. You may choose to repeat all steps in **Part 3: View Results** to view the results separately for this scenario OR you may choose to compare results between this and the previous scenario for selected metrics.

7. To compare results, click **Results -> Compare Results**. Expand **Global Statistics** and any application of your choice. Click on the various application response time metrics we saw in **Part 3: View Results** (e.g **Download Response Time** for Email, **Upload Response Time** for FTP, and **Application Response Time** for Custom Application etc). You will be able to select only one metric at a time since you are comparing. Make sure you have the options **Overlaid Statistics**, **All Scenarios**, and **As Is** set in their respective drop-down menus. Click **Show**. Repeat this step for as many metrics as you want.

What do you observe?

Answer: The spikes in the application response time metrics have disappeared. The reason is the switch hardware upgrade (modeled by a link data rate increase in OPNET software) which now supports 1 Gbps line data rate is now capable of handling the traffic load thereby removing any bottlenecks in the network. Users (doctors) would now be able to access the applications and experience no slowness in response times.

8. Repeat steps 7-12 in **Part 3: View Results** to verify that the link utilization and queuing delay values have dropped significantly in this scenario due to hardware upgrade.

Note: Components of Network Delays are Bandwidth Delay, Protocol Delay, Delay due to Latency, and Congestion Delay. Delay due Bandwidth and Latency are typically not found in LAN. Queuing delay falls within Congestion Delay category.

Part 5: Assessing Wireless LANs

Friendly Care Hospital is contemplating moving towards wireless offices in future months. With growth, they expect to relocate to 4 buildings, each connected to the outside by a wired router. Within each building, the workstations will be wireless, connected to a wireless access point. This is their first (preliminary) wireless design, and they want to evaluate it using OPNET software. Hence, they have decided to keep the topology and traffic straightforward with workstations running only Web-based applications.

In this lab exercise, we will focus on examining Media Access Delay values, an important component of characterizing Wireless LANs.

1. Switch Scenarios to **WLAN** Scenario. Refer Step 1 in **Part 4: Switch Scenarios** to switch.

2. To understand this new topology, double click on any of the office building

subnet icon .

3. Each building is configured with workstations connected wirelessly to an access point (an Ethernet router) supporting a 1 Mbps data link. Explore attribute

values of various devices. Click the icon in the toolbar to return up a level in the subnet hierarchy.

4. Configure and Run the Discrete Event Simulation as outlined **Part 2: Configure and Run the Simulation**. Ensure the simulation run time is set to 8 hours.

5. Click on **Results->View Results**.

6. Expand **Global Statistics -> HTTP**. Click **Page Response Time** and **Show.** Note the time it takes for an end-user to load an HTTP page.

HTTP Page Response Time:
Min _____   Max _____ Avg _____

7. Deselect all options.

8. Expand **Wireless LAN**. Click **Media Access Delay (sec)** and **Show**. Note the value.
Note: Should you choose to do the extra credit assignment, you will need this value for comparison purposes.

MAC Delay for Wireless LAN Scenario:
Min _____   Max _____ Avg _____

MAC Delay for Access Point (bldg1):
Min _____   Max _____ Avg _____

9. **Add** the **average** option to view both the raw data and running average curves. Refer to Step 4 of **Part 3: View Results** for instructions.

Optional: Graph the statistics for the various Access Points and wired Routers. Hint: Expand **Object Statistics->Campus Network** in the View Results window.

Extra Credit: Here we just saw two workstations per Wireless LAN. How would the values of Media Access Delay and HTTP Page Response Time change if there were 10 workstations per Wireless LAN … or 30? Duplicate the scenario (**Scenarios / Duplicate Scenario**) and create new ones to study the increased number of workstations. Use copy-paste functionality in OPNET software to increase the number of workstations in one of the buildings and run Discrete Event Simulation by going through the steps in **Part 5: Assessing Wireless LANs** section.