Switched LANs
A Set of Local Area Networks Interconnected by Switches

OBJECTIVES
This lab is designed to demonstrate the implementation of switched local area networks. The simulation in this lab will help you examine the performance of different implementations of local area networks connected by switches and hubs.

OVERVIEW
There is a limit as to how many hosts can be attached to a single network and to the size of a geographic area that a single network can serve. Computer networks use switches to enable the communication between one host and another, even when no direct connection exists between the hosts. A switch is a device with several inputs and outputs leading to and from the hosts that the switch interconnects. The core job of a switch is to take packets that arrive on an input and forward (or switch) them to the right output so that they will reach their appropriate destination.

A key problem that a switch must deal with is the finite bandwidth of its outputs. If packets destined for a certain output arrive at a switch and their arrival rate exceeds the capacity of that output, then we have a problem of contention. In this case, the switch will queue, or buffer, the packets until the contention subsides. If the contention lasts too long, however, the switch will run out of buffer space and be forced to discard packets. When packets are discarded too frequently, the switch is said to be congested.

In this lab, you will set up switched LANs using two different switching devices: hubs and switches. A hub forwards the packet that arrives on any of its inputs to all the outputs regardless of the destination of the packet. However, a switch forwards incoming packets to one or more outputs, depending on the destination(s) of the packets. You will study how the throughput and collision of packets in a switched network are affected by the configuration of the network and the types of switching devices that are used.

PRE-LAB ACTIVITIES
Go to www.net-seal.net and play the following animations:
- Switch
- Switched Network With No Server
- Switched Network With Server
**PROCEDURE**

**Create a New Project**

1. Start the OPNET IT Guru Academic Edition → Choose New from the File menu.
2. Select Project and click OK → Name the project `<your initials>_SwitchedLAN`, and the scenario `OnlyHub` → Click OK.
3. In the Startup Wizard: Initial Topology dialog box, make sure that Create Empty Scenario is selected → Click Next → Choose Office from the Network Scale list → Click Next three times → Click OK.
4. Close the Object Palette dialog box.

**Create the Network**

To create a switched LAN:

1. Select Topology → Rapid Configuration. From the drop-down menu choose Star and click OK.
2. Click the Select Models button in the Rapid Configuration dialog box. From the Model List drop-down menu choose `ethernet` and click OK.
3. In the Rapid Configuration dialog box, set the following five values: Center Node Model = `ethernet16_hub`, Periphery Node Model = `ethernet_station`, Link Model = `10BaseT`, Number = 16, Y = 50, and Radius = 42 → Click OK.

![Rapid Configuration: Star](image)

4. Right-click on node_16, which is the hub → Edit Attributes → Change the name attribute to `Hub1` and click OK.
5. Now that you have created the network, it should look like the following one.
6. Make sure to save your project.
Configure the Network Nodes

Here you will configure the traffic generated by the stations.

1. Right-click on any of the 16 stations (node_0 to node_15) → Select Similar Nodes. Now all stations in the network are selected.

2. Right-click on any of the 16 stations → Edit Attributes.
   a. Check the Apply Changes to Selected Objects check box. This is important to avoid reconfiguring each node individually.

3. Expand the hierarchies of the Traffic Generation Parameters attribute and the Packet Generation Arguments attribute → Set the four values indicated by the arrows in the figure to the right.

4. Click OK to close the attribute editing window(s).

5. Save your project.
Choose Statistics

To choose the statistics to be collected during the simulation:

1. Right-click anywhere in the project workspace and select Choose Individual Statistics from the pop-up menu.
2. In the Choose Results dialog box, choose the shown four statistics.
3. Click OK.

Configure the Simulation

Here we need to configure the duration of the simulation:

1. Click on the Configure/Run Simulation button:
2. Set the duration to 2.0 minutes.
3. Click OK.

Duplicate the Scenario

The network we just created utilizes only one hub to connect the 16 stations. We need to create another network that utilizes a switch and see how this will affect the performance of the network. To do that, we will create a duplicate of the current network:

1. Select Duplicate Scenario from the Scenarios menu and give it the name HubAndSwitch.
2. Open the Object Palette by clicking on . Make sure that Ethernet is selected in the pull-down menu on the object palette.
3. We need to place the hub and switch shown here in the new scenario.

4. To add the **Hub**, click its icon in the object palette → Move your mouse to the workspace → Click to drop the hub at a location you select. Right-click to indicate you are done deploying hub objects.

5. Similarly, add the **Switch**, and then close the **Object Palette**.

6. Right-click on the new hub → **Edit Attributes** → Name it **Hub2** and click **OK**.

7. Right-click on the switch → **Edit Attributes** → Name it **Switch** and click **OK**.

8. Reconfigure the network to look like the following one.
   a. To remove a link, select it and choose **Cut** from the **Edit** menu (or simply press the **Delete** key). You can select multiple links and delete all of them at once.
   b. To add a new link, use the **10BaseT** link available in the **Object Palette**.
Run the Simulation
To run the simulation for both scenarios simultaneously:

1. Select Manage Scenarios from the Scenarios menu.
2. Change the values under the Results column to <collect> (or <recollect>) for both scenarios. Compare with the following figure.

3. Click OK to run the two simulations. Depending on the speed of your processor, this may take several minutes to complete.
4. After the two simulation runs complete, one for each scenario, click Close.
5. Save your project.

View the Results
To view and analyze the results:

1. Select Compare Results from the Results menu.
2. Change the drop-down menu in the lower-right part of the Compare Results dialog box from As Is to time_average, as shown.
3. Select the Traffic Sent (packets/sec) statistic and click Show. The resulting graph should resemble the one below. As you can see, the traffic sent in both scenarios is almost identical.

![Graph of traffic sent](image)

The time_average is the average value over time of the values generated during the collection window. This average is performed assuming a "sample-and-hold" behavior of the data set (i.e., each value is weighted by the amount of time separating it from the following update, and the sum of all the weighted values is divided by the width of the collection window). For example, suppose you have a 1-s bucket in which 10 values have been generated. The first seven values were generated between 0 and 0.3 s, the eighth value at 0.4 seconds, the ninth value at 0.6 s, and the tenth at 0.99 s. Because the last three values have higher durations, they are weighted more heavily in calculating the time average.

4. Select the Traffic Received (packets/sec) statistic and click Show. The resulting graph should resemble the one following. As you see, the traffic received with the second scenario, HubAndSwitch, is higher than that of the OnlyHub scenario.

![Graph of traffic received](image)
5. Select the **Delay (sec)** statistic and click **Show**. The resulting graph should resemble the one that follows. *(Note: Results may vary slightly due to different node placement.)*

![Graph of Delay (sec)](image)

6. Select the **Collision Count** statistic for **Hub1** and click **Show**.

7. On the resulting graph, right-click anywhere on the **graph area** → Choose **Add Statistic** → Expand the hierarchies as shown below → Select the **Collision Count** statistic for **Hub2** → Change **As Is** to **time_average** → Click **Add** → Click **Close**.

The resulting graph should resemble the one that follows.

![Graph of Collision Count](image)

8. **Save** your project.
FURTHER READING

OPNET Building Networks: From the Protocols menu, select Methodologies → Building Network Topologies.

EXERCISES

1. Explain why adding a switch makes the network perform better in terms of throughput and delay.
2. We analyzed the collision counts of the hubs. Can you analyze the collision count of the “switch”? Explain your answer.
3. Create two new scenarios. The first new scenario is the same as the OnlyHub scenario with the hub replaced by a switch. The second new scenario is the same as the HubAndSwitch scenario with both hubs replaced by two switches, the old switch removed, and the two switches you just added together connected with a 10BaseT link. Compare the performance of the four scenarios in terms of delay, throughput, and collision count. Analyze the results.

Note: To replace a hub with a switch, right-click on the hub and assign ethernet16_switch to its model attribute.

LAB REPORT

Prepare a report that follows the guidelines explained in the Introduction Lab. The report should include the answers to the preceding exercises as well as the graphs you generated from the simulation scenarios. Discuss the results you obtained and compare these results with your expectations. Mention any anomalies or unexplained behaviors.