

Lab 2 Switches versus Hubs

Overview

Ethernet hubs work at the physical layer, simply repeating any frames they receive on one port onto all other ports. For this reason, they are also called multiport repeaters. Switches, on the other hand, forward frames only to the port that is connected to the frame's destination. All the nodes connected to a hub are considered to be part of the same broadcast domain. In other words, any frame transmitted by one of the nodes will be received by all the rest. This configuration can limit throughput, as all nodes must share the capacity of the LAN. Since switches forward frames only on a single line, they create multiple broadcast domains, leading to great gains in throughput. The throughput of a switch is restricted, however, by its processing speed, the speed at which it can forward frames onto the correct outgoing link.

Objective

To examine the change in throughput in a local area network when upgrading from a hub to a switch.

Build the Simulation Model

Start up OPNET IT Guru Academic Edition.

Select the **File** tab => **New...**

Choose **Project** and click on **OK**.

Change the **Project Name** to **xx_Switch_vs_Hub** (where **xx** are your initials). Set the **Scenario Name** to **Hub** and click on **OK**.

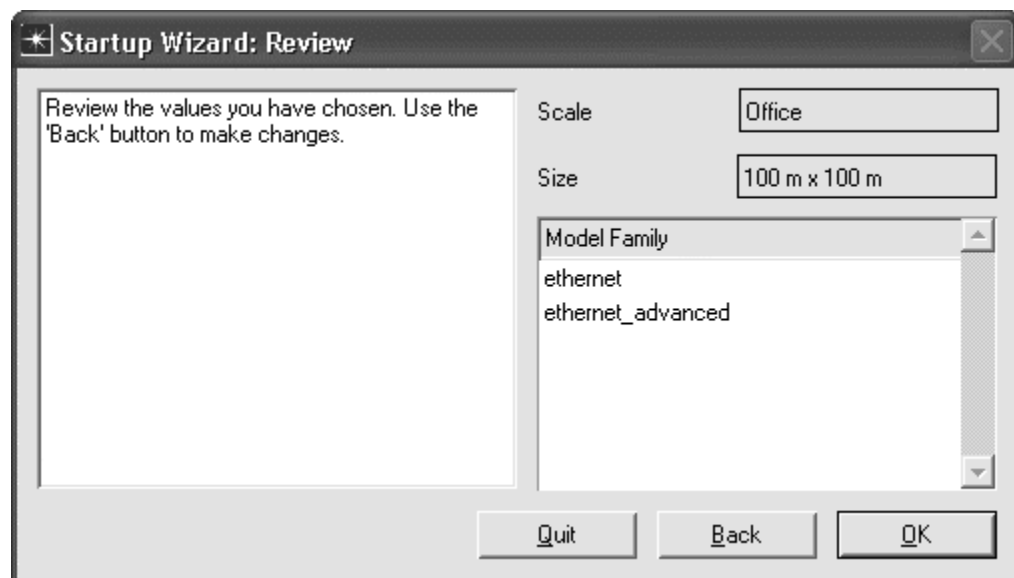
In the **Initial Topology** window, select **Create Empty Scenario** and click on **Next**.

In the **Choose Network Scale** window, select **Office** and click on **Next**.

In the **Specify Size** window, accept the default values and click on **Next**.

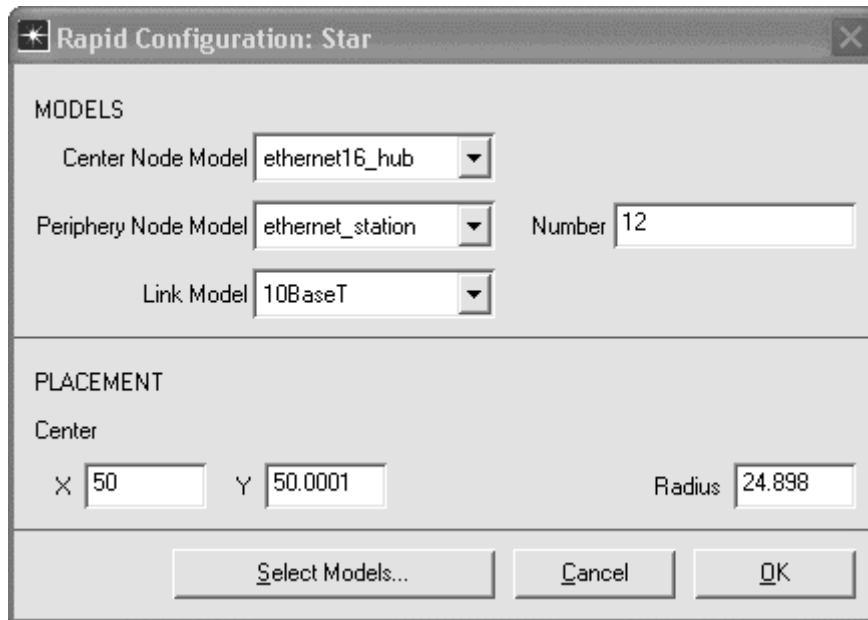
In the **Select Technologies** window, include the **ethernet** and **ethernet_advanced** model families, and click on **Next**.

In the **Review** window, click on **OK**.



First, we will build a LAN in which the workstations are connected together with an Ethernet hub. An easy way to create a network with a large number of nodes in OPNET is with the Rapid Configuration tool.

Select the **Topology** tab => **Rapid Configuration**. Set the **Configuration** to **Star**, and click on **OK**. Set the **Center Node Model** to **ethernet16_hub**. Set the **Periphery Node Model** to **ethernet_station**. Set the **Link Model** to **10BaseT**. Set the **Number** to **12**, and click on **OK** to create the LAN.

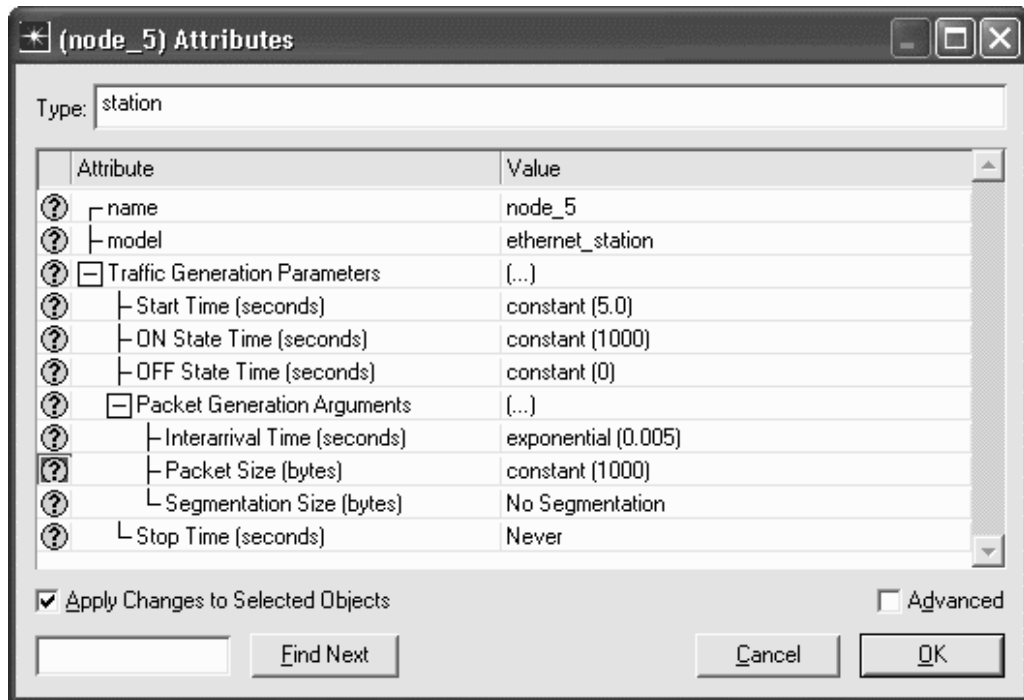


Right click on the hub and select **Set Name**. Set the **Name** to **Hub**. Click on **OK** to close the window.

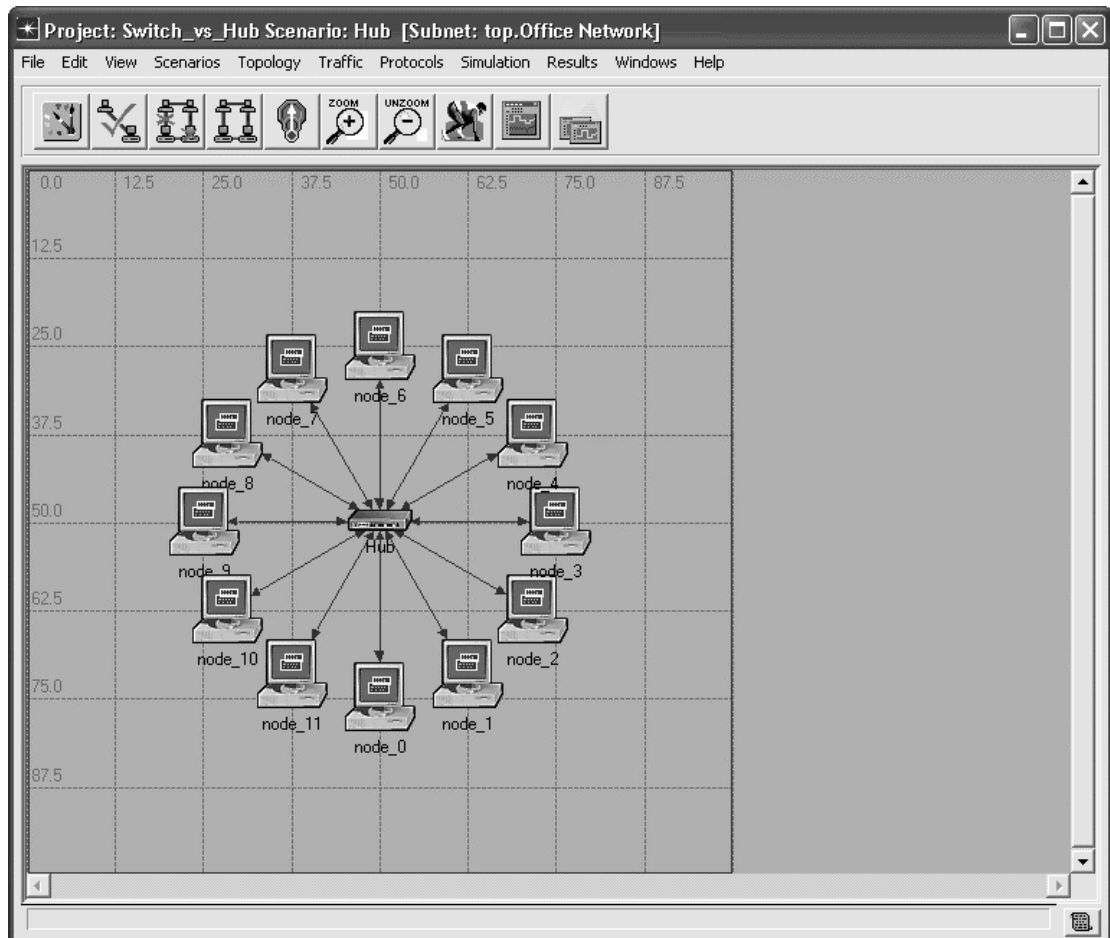
Now we need to set up the traffic patterns for the Ethernet stations. Right click on any of the stations and choose **Select Similar Nodes**. Next, right click on one of the stations and choose **Edit Attributes**. Put a check in the checkbox next to **Apply Changes to Selected Objects**. Expand the **Traffic Generation Parameters** and **Packet Generation Arguments** attributes. Set the **ON State Time** to **constant(1000)**, and the **OFF State Time** to **constant(0)**. This will ensure that the stations are always sending. Set the **Interarrival Time (seconds)** to **exponential(0.005)** and the **Packet Size (bytes)** to **constant(1000)**. Click on **OK** to apply the changes and close the window. Each station will now generate traffic at an average rate of one 1000-byte packet every 5 milliseconds.

You can calculate the average traffic that each node will generate from the interarrival time and the packet size. For instance,

$$1000 \text{ bytes/packet} * 8 \text{ bits/byte} * 1 \text{ packet}/0.005 \text{ sec} = 1.6 \text{ Mbps}$$



We are done creating the hub-based LAN. Your model should look like the one presented next.



Configure the Simulation

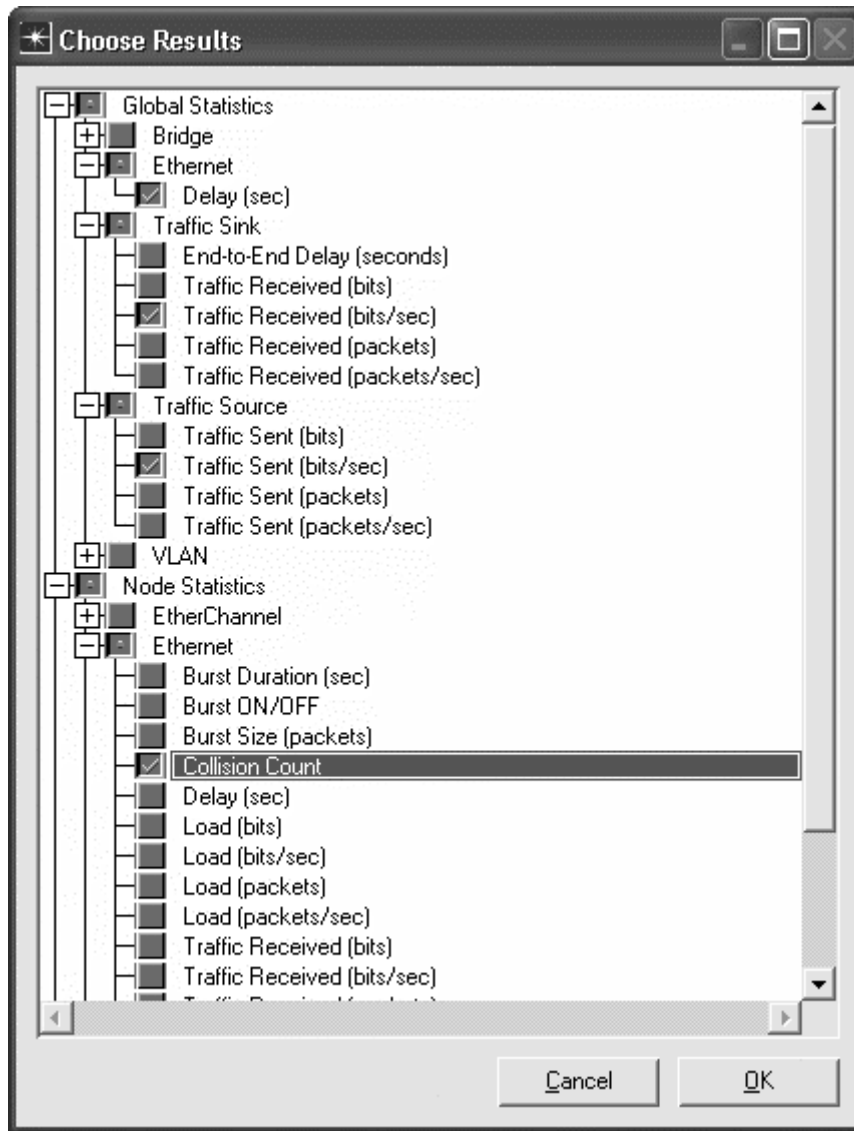
Select the **Simulation** tab => **Choose Individual Statistics...**

Expand the **Global Statistics** item and the **Ethernet** item, and select the **Delay (sec)** statistic.

Expand the **Traffic Sink** item and select the **Traffic Received (bits/sec)** statistic. Expand the **Traffic Source** item and select the **Traffic Sent (bits/sec)** statistic.

Expand the **Node Statistics** item and the **Ethernet** item, and select the **Collision Count** statistic.

Click on **OK** to close window.



Select **Simulation** => **Configure Discrete Event Simulation...**

Under the **Common** tab, set the **Duration** to **2**, and the unit to **minute(s)**.

Click on **OK** to close the window.

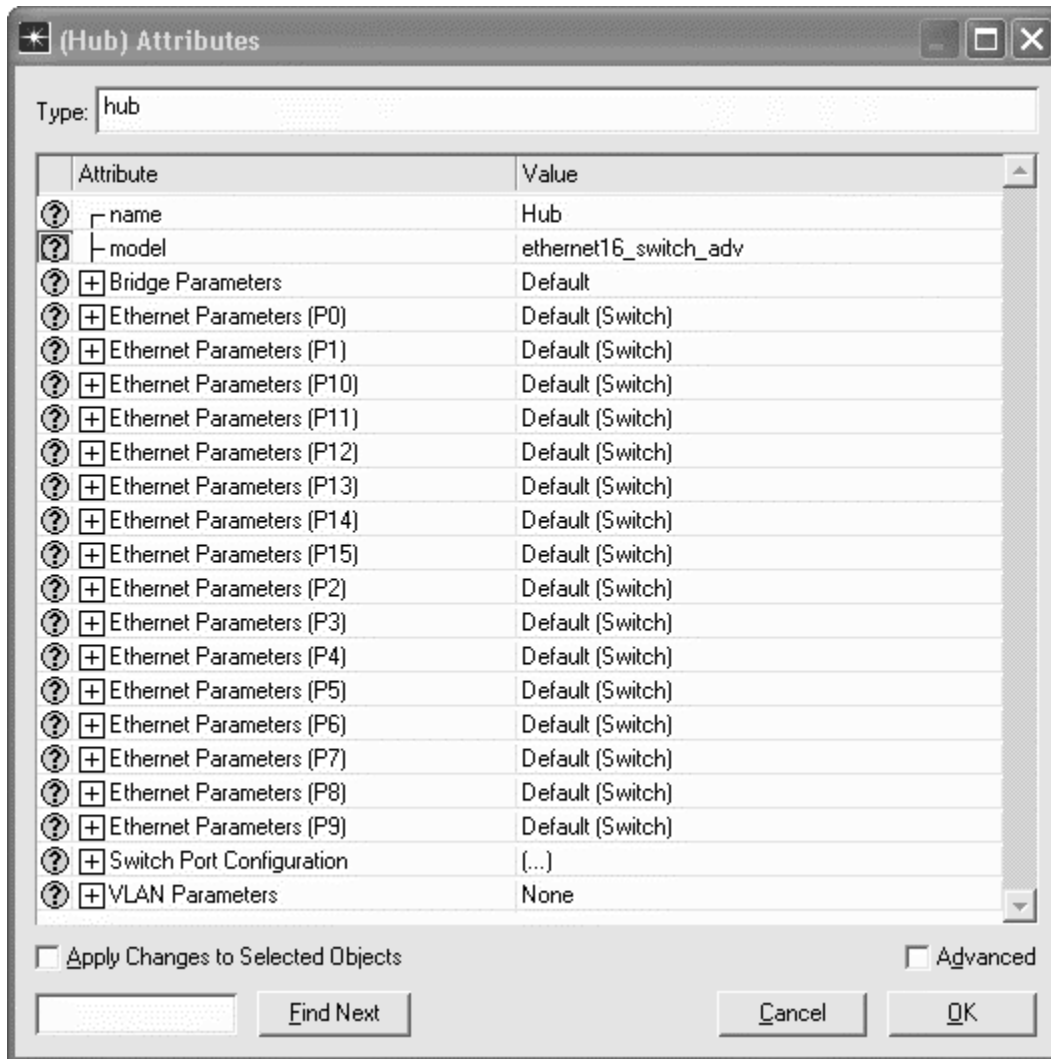


Duplicate the Scenario

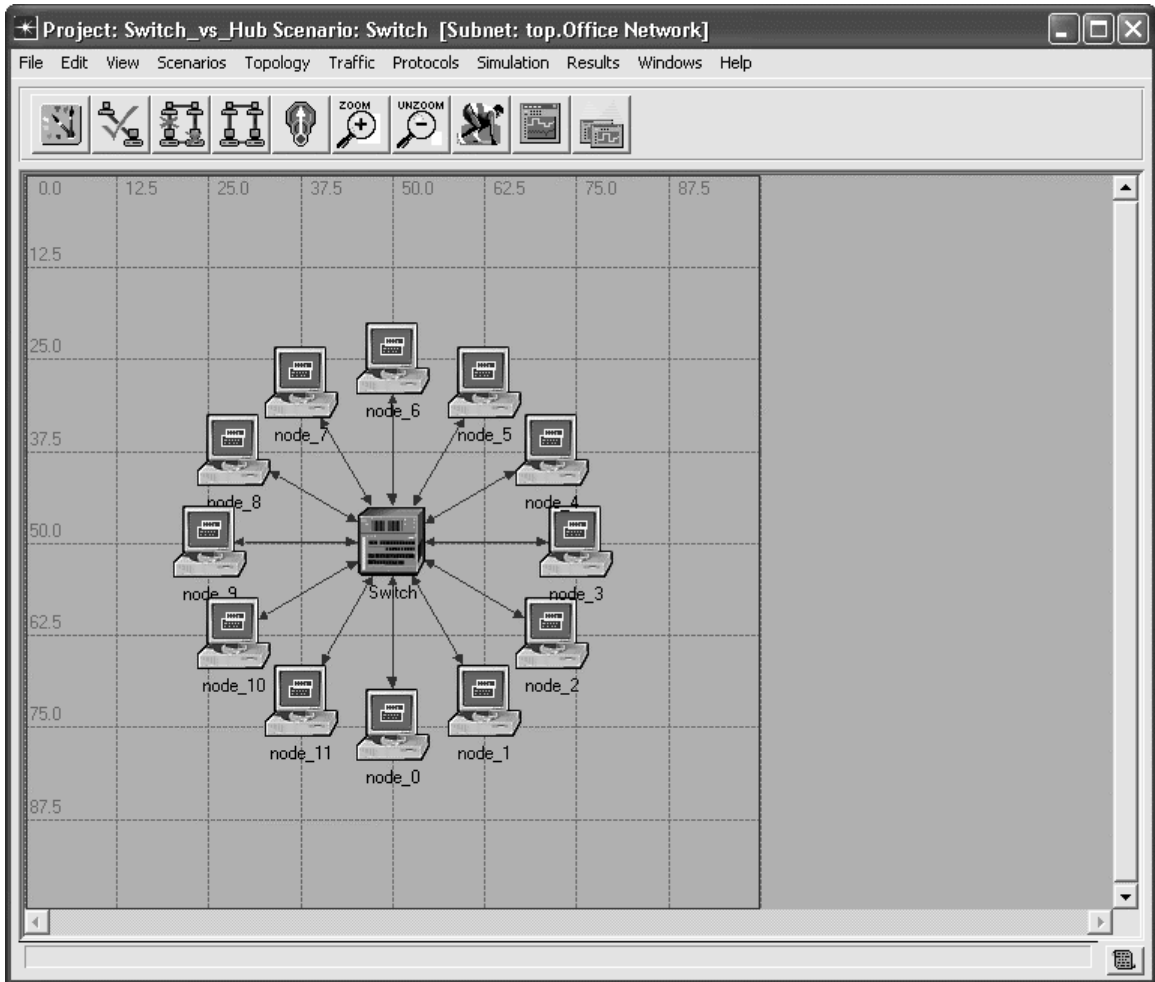
Let us now build another scenario which uses an Ethernet switch as the center of the LAN instead of the hub. This will allow us to compare the performance of the two designs.

Choose **Scenarios => Duplicate Scenario**, and name the new scenario **Switch**. Click on **OK** to create the scenario.

Right click on the hub and choose **Edit Attributes**. Left click on the **model** attribute and choose **ethernet16_switch_adv** from the pull-down menu. Click on **OK** to make the change.



Right click on the switch and choose **Set Name**. Set the **Name** to **Switch** and click on **OK** to close the window.



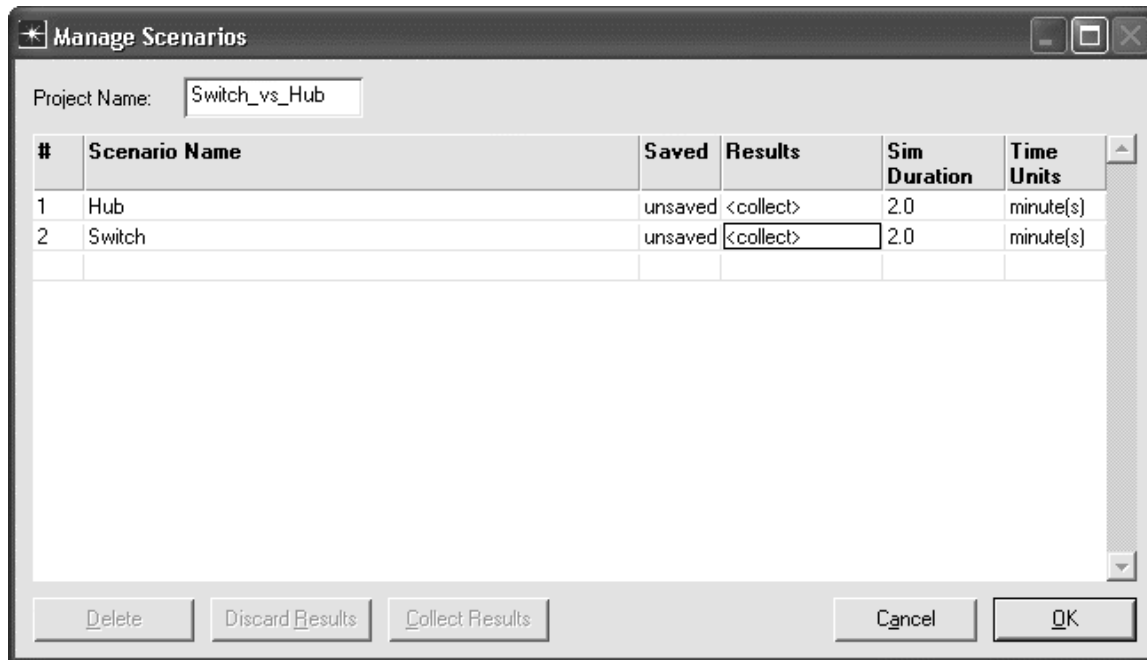
Run the Simulation

Select the **Scenarios** tab => **Manage Scenarios...**

Edit the **Results** field in both rows and set the values to <collect> or <recollect>.

Click on **OK** to run both scenarios (one after the other).

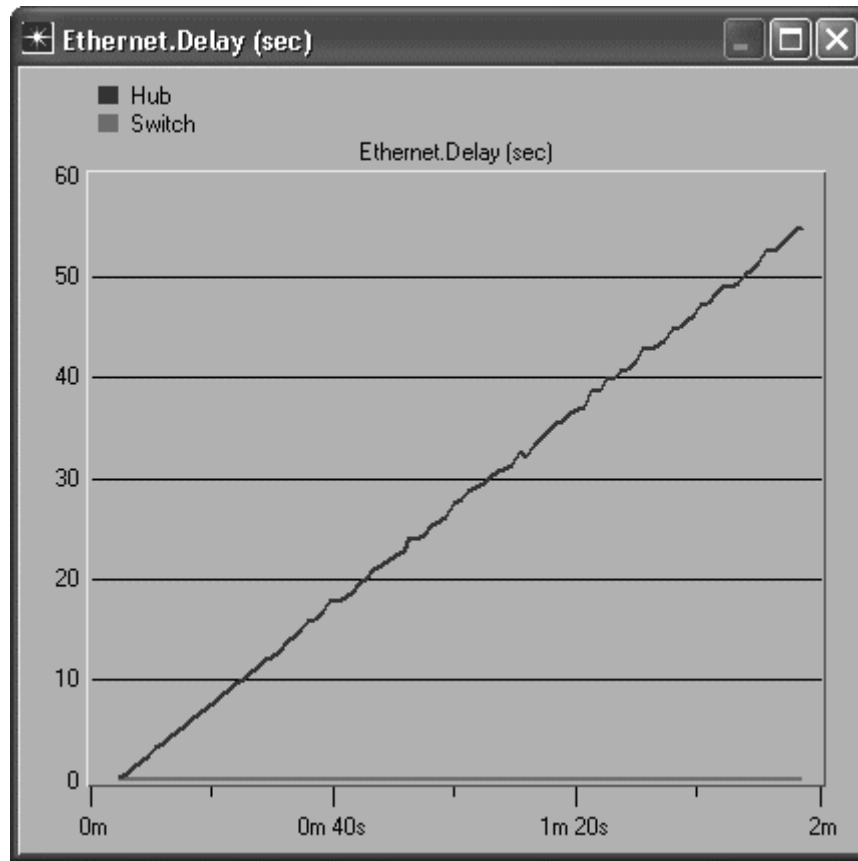
When the simulation has completed, click on **Close** to close the window.



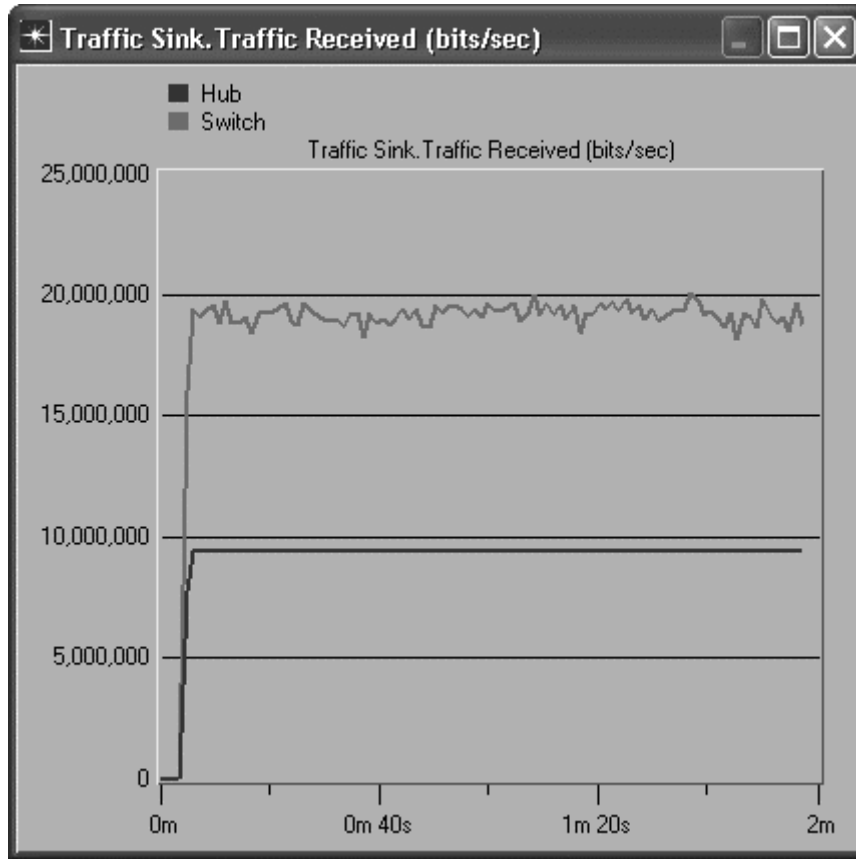
Inspect and Analyze Results

Select the **Results** tab => **Compare Results...**

Select and expand the **Global Statistics** item, and the **Ethernet** item and select the **Delay (sec)** statistic. View the statistic in **As Is** mode. Click on **Show** for a more detailed graph. This statistic shows the delivery delay for Ethernet frames. You can see that the delay for the switch scenario is small and constant, while the delay for the hub scenario is growing without bound. This is to be expected as we are loading the hub far past its capacity. Remember that we said each node was generating 1.6 Mbps of traffic. With 12 nodes in the system, that comes to $12 * 1.6 \text{ Mbps} = 19.2 \text{ Mbps}$ of offered load. The hub is operating at only 10 Mbps (since we specified 10BaseT links in the configuration). Click on the close window icon and **Delete** the panel. Click on the statistic again to disable the preview.

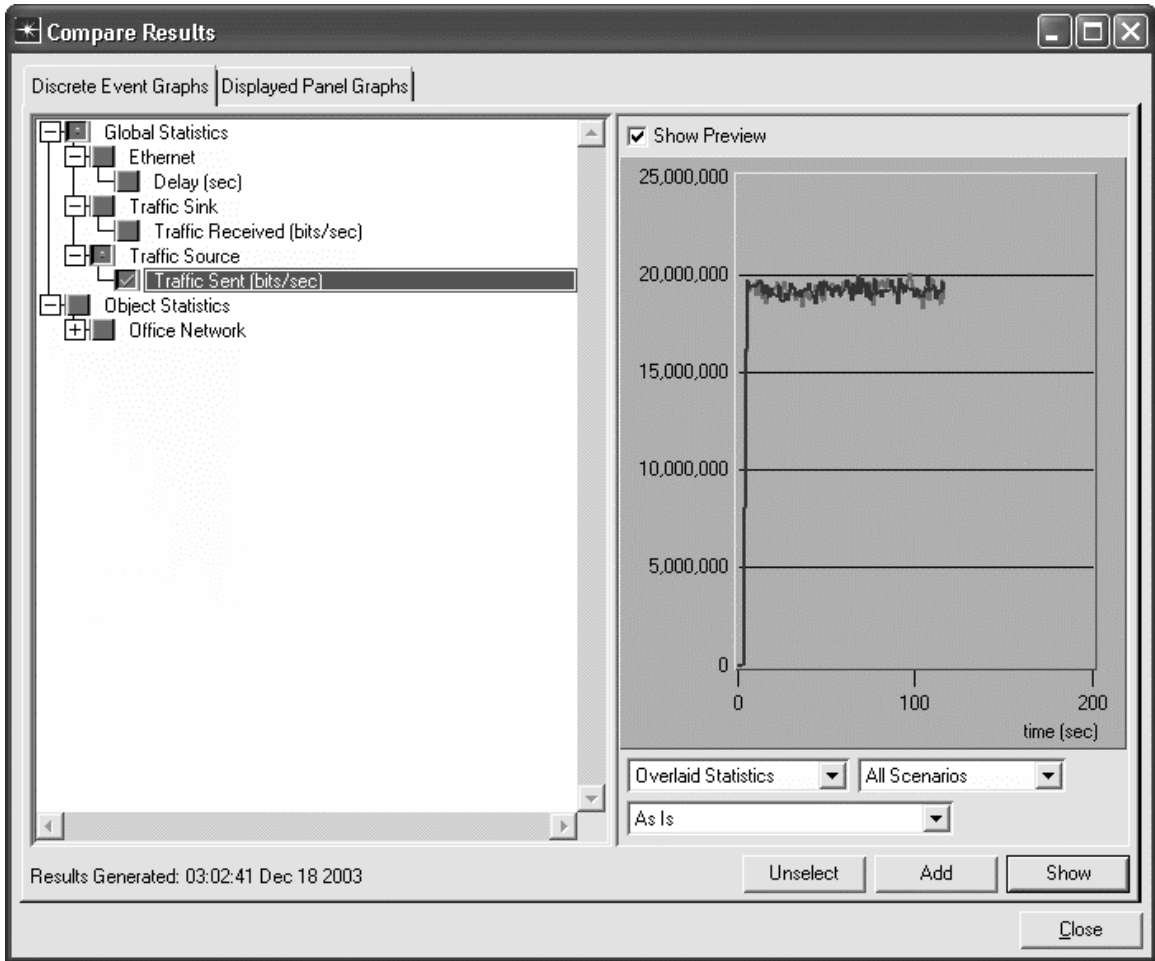


Expand the **Traffic Sink** item, and select the **Traffic Received (bytes/sec)** statistic. View the statistic in **As Is** mode. Click on **Show** for a more detailed graph. This statistic shows the sum total of traffic received by all stations in the LAN. You can see that the traffic received in the hub case tops out near 10 Mbps, the rated speed of the hub. The switch, on the other hand, easily delivers nearly twice that much traffic. Click on the close window icon and **Delete** the panel. Click on the statistic again to disable the preview.



Expand the **Traffic Source** item, and select the **Traffic Sent (bytes/sec)** statistic. View the statistic in **As Is** mode. This statistic shows the sum total of traffic sent by all stations in the LAN. You can see that the same amount of traffic was generated in both scenarios. The switch, however, can actually carry this much traffic. Click on the statistic again to disable the preview. You can always click on **Show** for more detail.

Click on **Close** to close the **Compare Results** window.

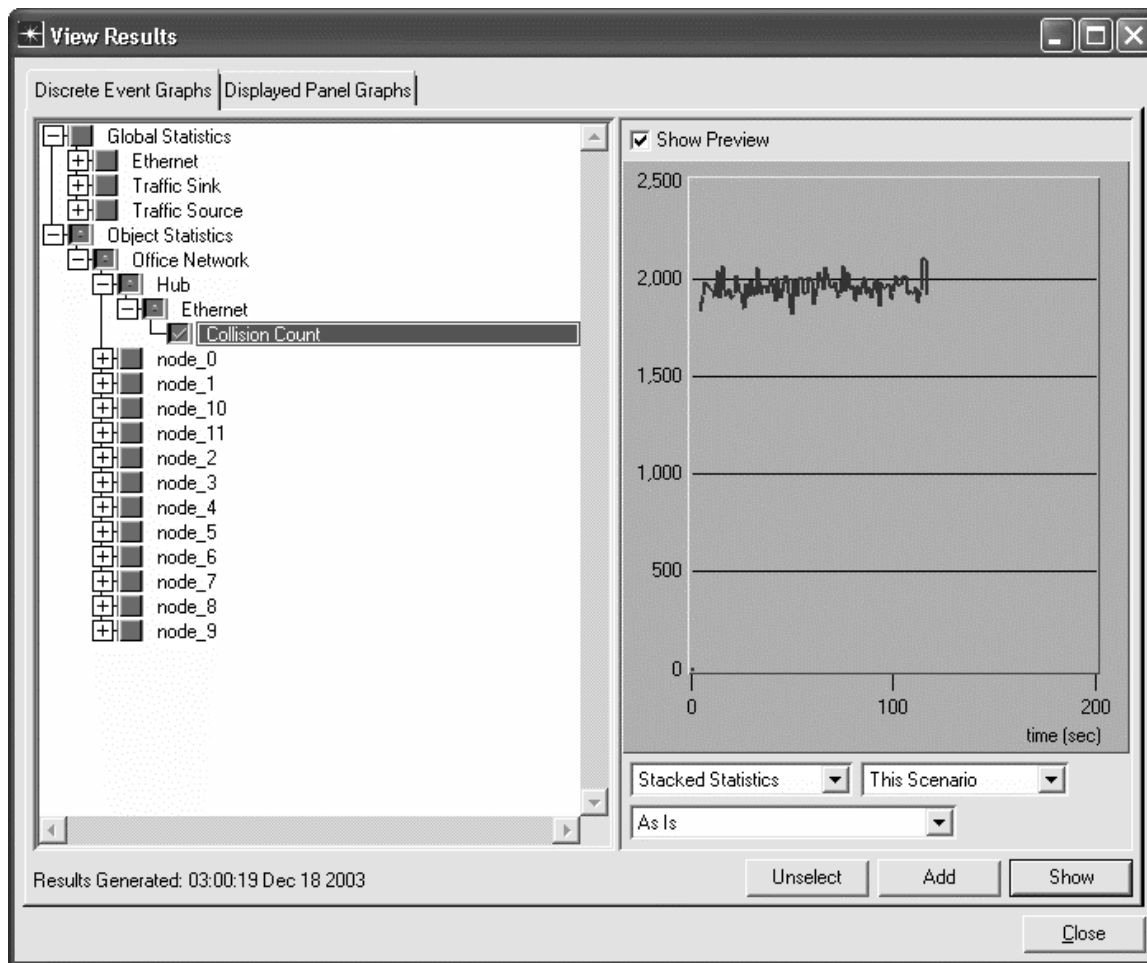


Lastly, we will look at a statistic which only applies to the hub scenario.

Select the **Scenarios** tab => **Switch to Scenario** and select the **Hub** scenario.
 Select the **Results** tab => **View Results...**

Expand the **Object Statistics**, **Office Network**, **Hub**, and **Ethernet** items. Select the **Collision Count** statistic. View the statistic in **As Is** mode. This statistic shows the number of collisions that occurred at the hub during the simulation. You can see that close to 2000 collisions per second occurred. This is due to the heavy overloading of the hub.

Click on **Close** to close the **View Results** window.



Save your model and close all windows.

Questions

1. The switching capacity of a switch determines the amount of load it can process. Duplicate the Switch scenario and name the new scenario **Switching_Speed**. Edit the switch and expand the **Bridge Parameters** attribute. Set the **Packet Service Rate (packets/sec)** attribute to **2000**. Now the switch can only handle 2000 frames per second. Calculate the number of packets generated (total) using the Packet Generation parameters of the Ethernet stations. Rerun the simulation and examine the Ethernet delay, Traffic Received, and Traffic Sent statistics. Explain your results.
2. Continue with the **Switching_Speed** scenario you created in Question 1. Determine how large **the Packet Service Rate** must be in order for the switch to handle all the offered load. In other words, how large must the rate be in order for the Traffic Received to equal the Traffic Sent? Explain your answer.
3. Duplicate the original Switch scenario and name the scenario **Smooth_Traffic**. Right click on one of the Ethernet stations and choose **Select Similar Objects**. Right click again on one of the Ethernet stations and choose **Edit Attributes**. Edit the **Packet Generation Parameters** and set the interarrival time to **constant(0.005)**. The average rate of traffic generation will be the same, but the frames will be generated regularly, rather than on the basis of an exponential (bursty) distribution. Rerun the simulation and compare your results to the Switch scenario results.