LAB 3

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


Read Section 3.1 from *Computer Networks: A Systems Approach, 5th Edition*.


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

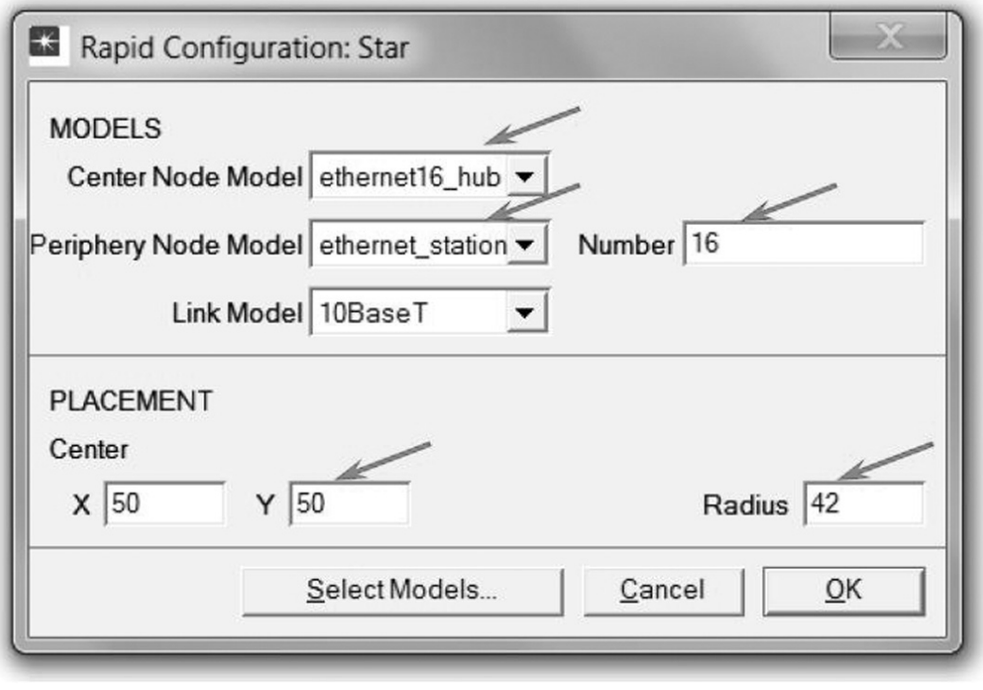
1. Start the **OPNET IT Guru Academic Edition** → Choose **New** from the **File** menu.
2. Select **Project** and click **OK** → Name the project **<your initials>_SwitchedLAN**, and the scenario **OnlyHub**→ Click **OK**.
3. In the *Startup Wizard: Initial Topology* dialog box, make sure that **Create 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:

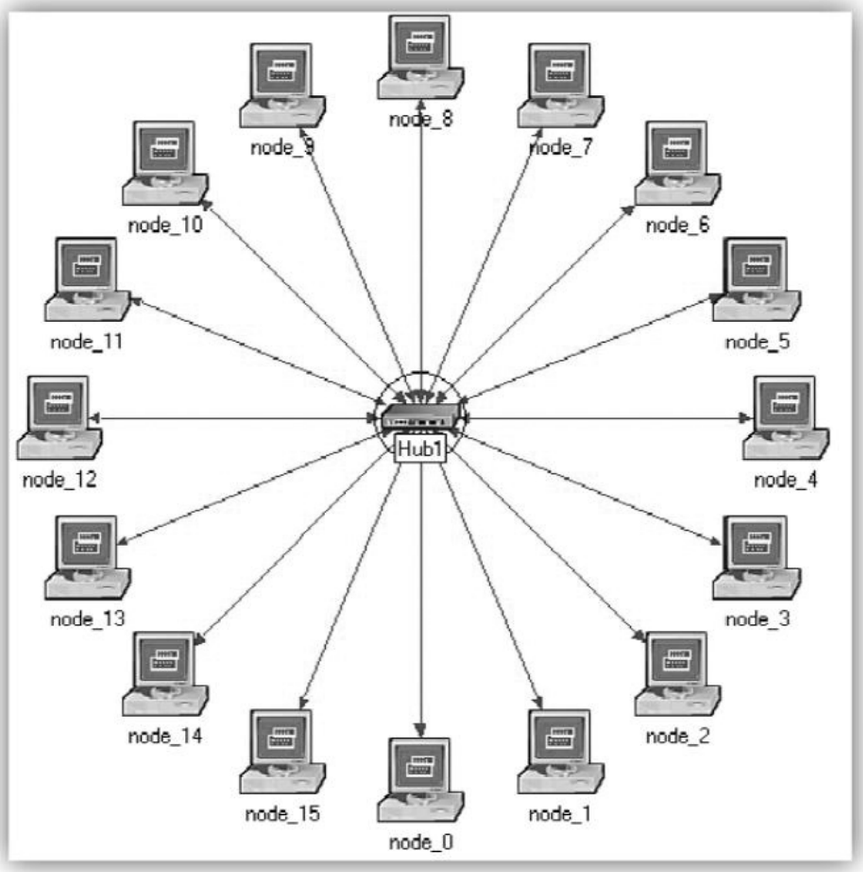
1. Select **Topology** → **Rapid Configuration**. From the drop-down menu choose **Star** and click **OK**.
2. Click the **Select Models** button in the *Rapid Configuration* dialog box. From the *Model List* drop-down menu choose **ethernet** and click **OK**.
3. In the *Rapid Configuration* dialog 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**.

The prefix **ethernet16_** indicates that the device supports up to 16 Ethernet connections.



The **10BaseT** link represents an Ethernet connection operating at 10 Mbps.

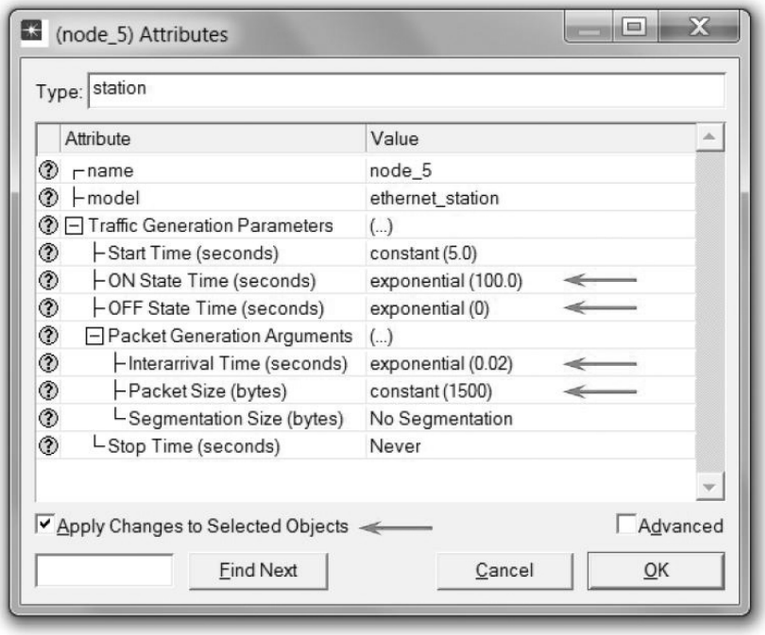
4. Right-click on **node_16**, which is the hub → **Edit Attributes** → Change the **name** attribute to **Hub1** and click **OK**.
5. Now that you have created the network, it should look like the following one.
6. Make sure to save your project.



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

The **Ethernet Delay** represents the end-end delay of all packets received by all the stations.

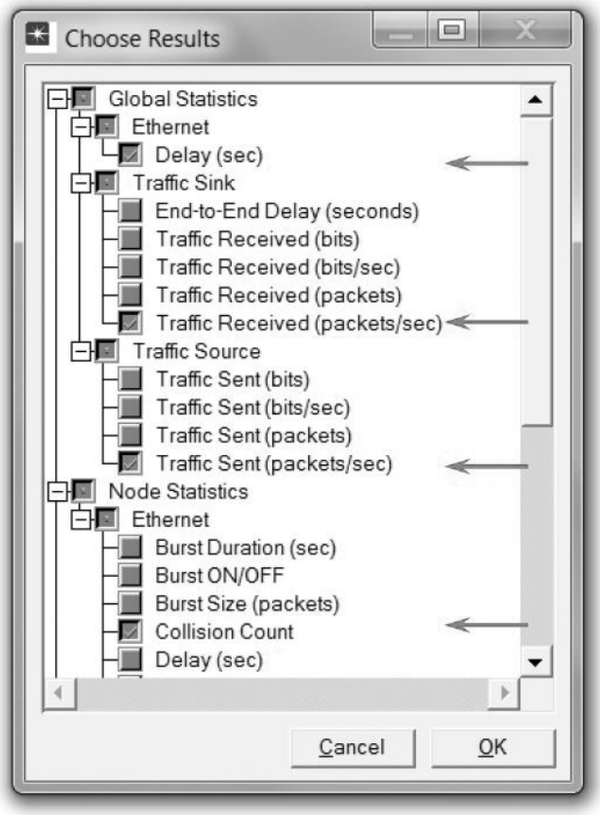
Traffic Received (in packets/sec) by the traffic sinks across all nodes.

Traffic Sent (in packets/sec) by the traffic sources across all nodes.

Collision Count is the total number of collisions encountered by the hub during packet transmissions.

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:

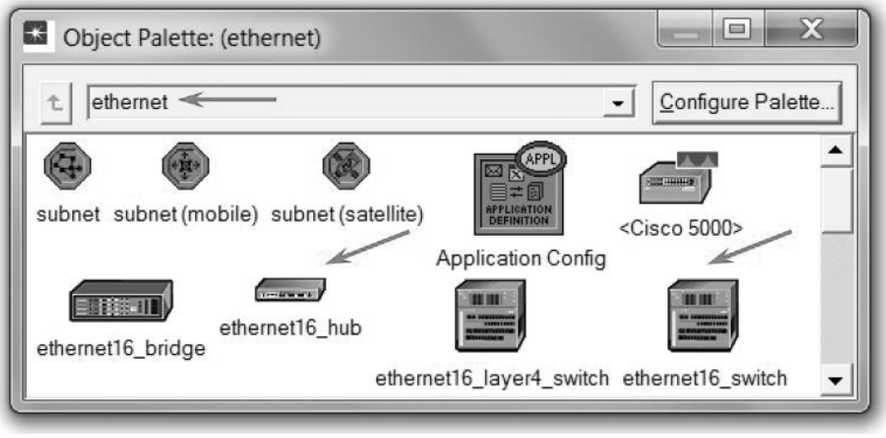
1. Click on the **Configure/Run Simulation** button: 
2. Set the duration to **2.0 minutes**.
3. Click **OK**.

Duplicate the Scenario

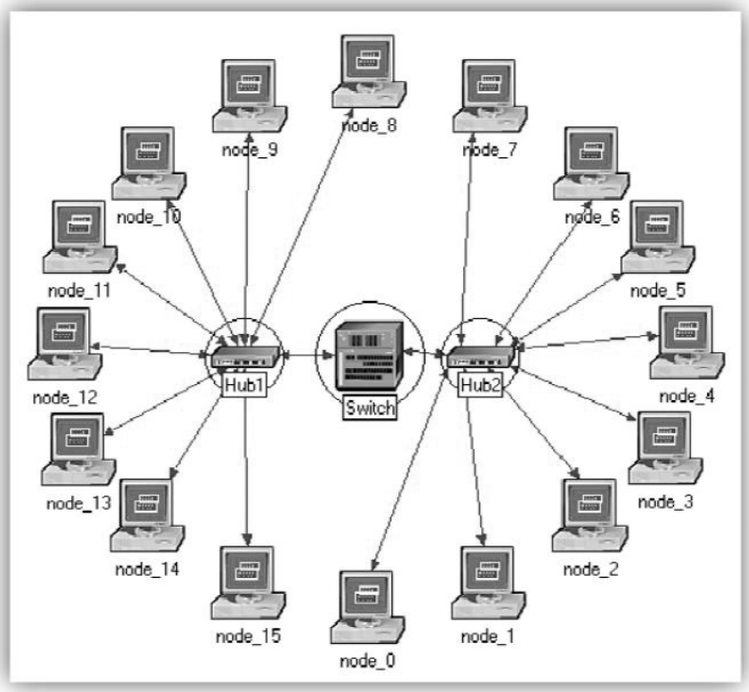
The network we just created utilizes only one hub to connect the 16 stations. We need to create another network that utilizes a switch and see how this will affect the performance of the network. To do that, we will create a duplicate of the current network:

1. Select **Duplicate Scenario** from the **Scenarios** menu and give it the name **HubAndSwitch** → Click **OK**.
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.



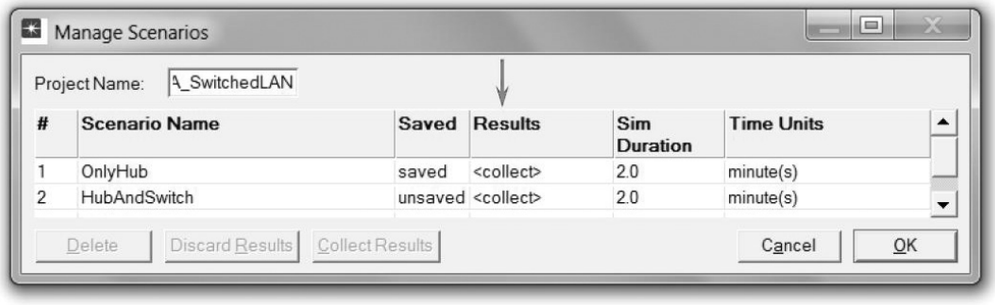
4. To add the **Hub**, click its icon in the object palette → Move your mouse to the workspace → Click to drop the hub at a location you select. Right-click to indicate you are done deploying hub objects.
5. Similarly, add the **Switch**, and then close the **Object Palette**.
6. Right-click on the new 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.

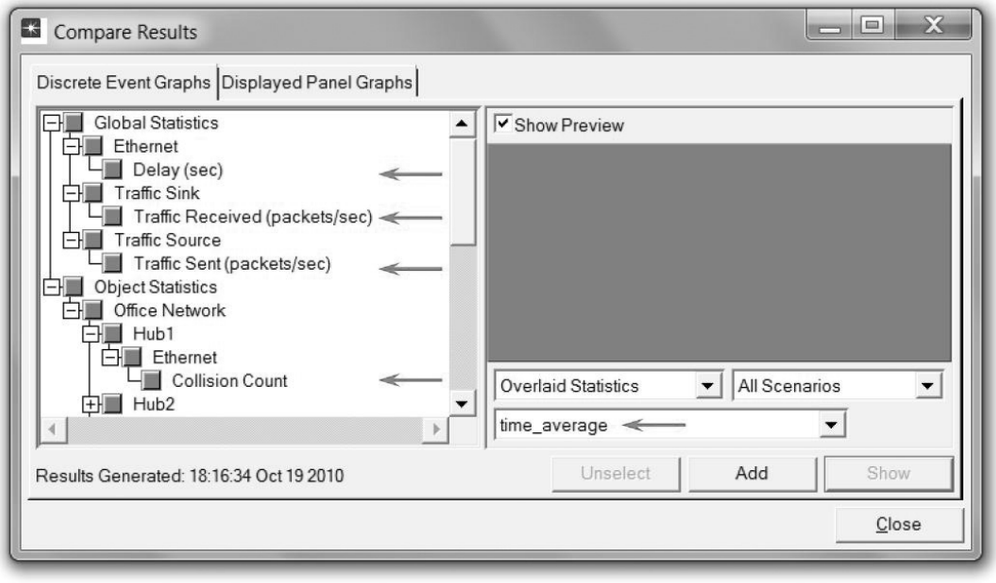


3. Click **OK** to run the two simulations. Depending on the speed of your processor, this may take several minutes to complete.
4. After the two simulation runs complete, one for each scenario, click **Close**.
5. **Save** your project.

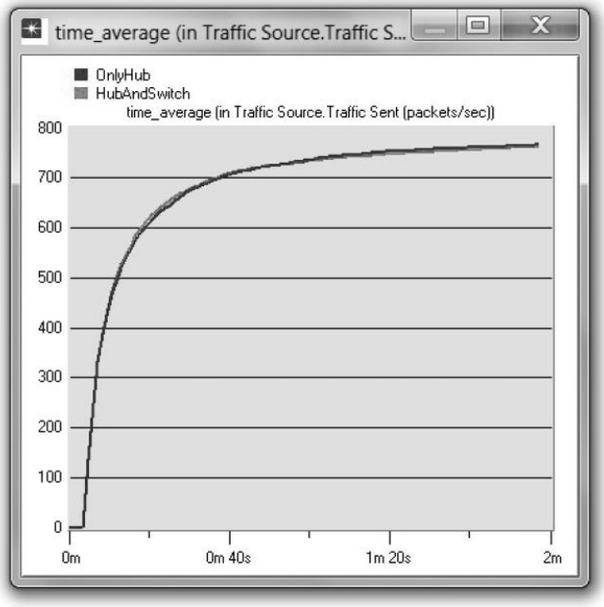
View the Results

To view and analyze the results:

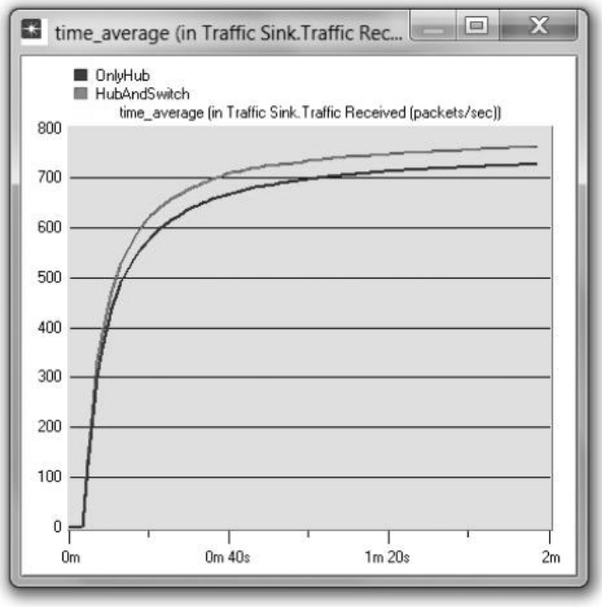
1. Select **Compare Results** from the **Results** menu.
2. Change the drop-down menu in the lower-right part of the *Compare Results* dialog box from **As Is** to **time_average**, as shown.



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.

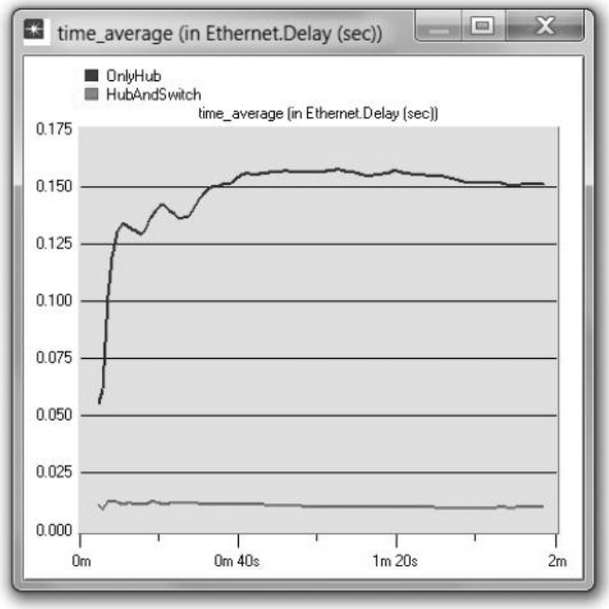


4. Select the **Traffic Received (packets/sec)** statistic and click **Show**. The resulting graph should resemble the one following. As you see, the traffic received with the second scenario, **HubAndSwitch**, is higher than that of the **OnlyHub** scenario.



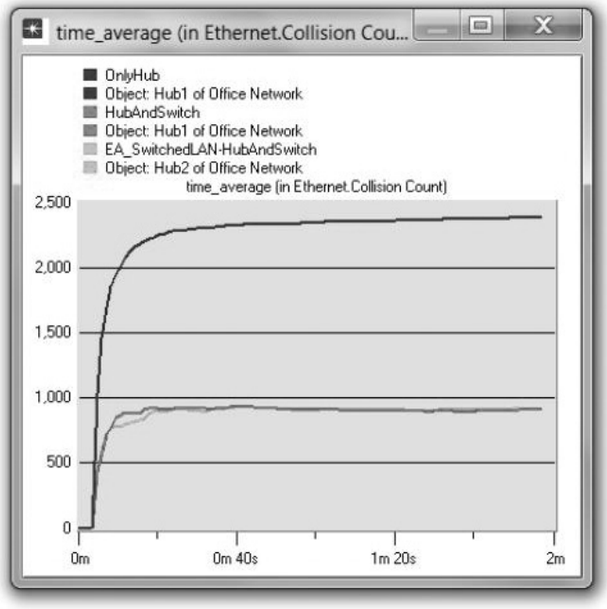
The **time_average** is the average value over time of the values generated during the collection window. This average is performed assuming a "sample-and-hold" behavior of the data set (i.e., each value is weighted by the amount of time separating it from the following update, and the sum of all the 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.

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.)



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.



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.