

Lab 5 Quality of Service: Impact of Queuing Policy

Overview

In a store-and-forward network, routers maintain one or more queues for each output line. These are necessary as a packet may arrive and be destined for a line which is already busy. A queuing policy defines a set of rules for placing packets into the queue and taking them back out. The traditional policy is First-In, First-Out (FIFO), which is easy to implement and treats all data streams the same. A packet which has newly arrived is placed at the end of the queue and waits its turn to be sent.

Now that the Internet is also used to carry voice and video streams, simple FIFO mechanisms are not sufficient. Voice and video applications require bounds on the delay and delay variation (jitter) that a packet will experience. One way to implement these bounds is to treat the packets differently within the router's queues. In the Weighted Fair Queuing (WFQ) policy, one queue is maintained for each priority class. Weights are associated with the classes based on their importance. Queues are then serviced (i.e., packets are taken from the queues and sent on the outgoing line) at rates based on their weights. For instance, if queue A was assigned a weight of one, and queue B was assigned a weight of two, then two packets would be sent from queue B for every one sent from queue A. By assigning voice and video streams to a queue with higher weight, they can be given precedence over standard data traffic.

In the Priority Queuing policy, multiple queues are again maintained based on the priority classes assigned to the packets. In this case though, *all* high-priority packets get sent before any low-priority packets. If we have two queues, one configured to handle priority-one traffic, and one configured to handle priority-two traffic, the priority-two queue will be serviced until it is empty, and only then will the priority-one queue be serviced. Priority one transmissions will be preempted if any new priority-two packets arrive.

Objective

To examine the effects of applying different router queuing policies. We will examine packet loss rate due to buffer overflow at the router, queuing delay, and queuing delay variation.

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_QOS_Queueing** (where **xx** are your initials). Set the **Scenario Name** to **PQ** and click on **OK**.

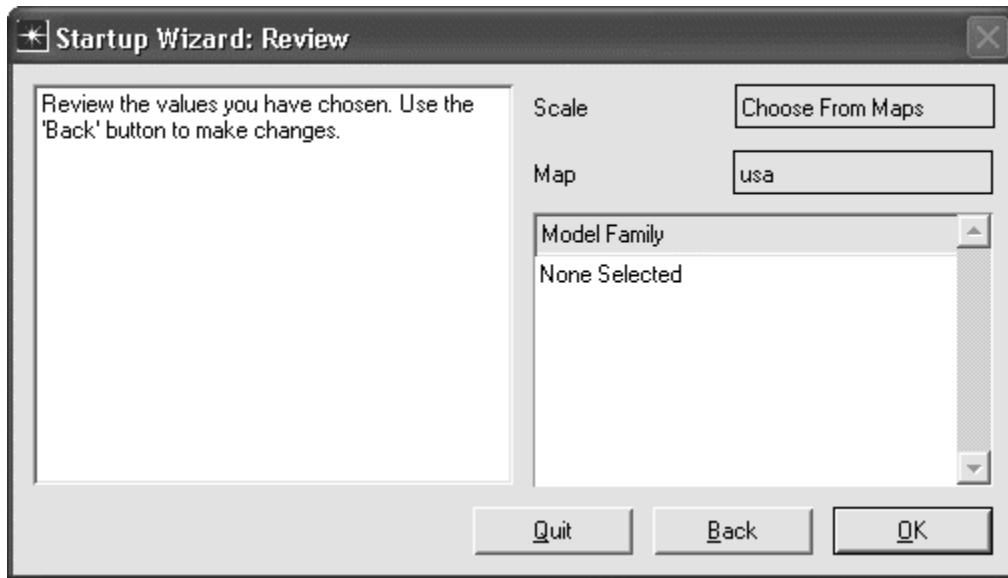
In the **Initial Topology** window, select **Create Empty Scenario** and click on **Next**.

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

In the **Choose Map** window, choose **usa** and click on **Next**.

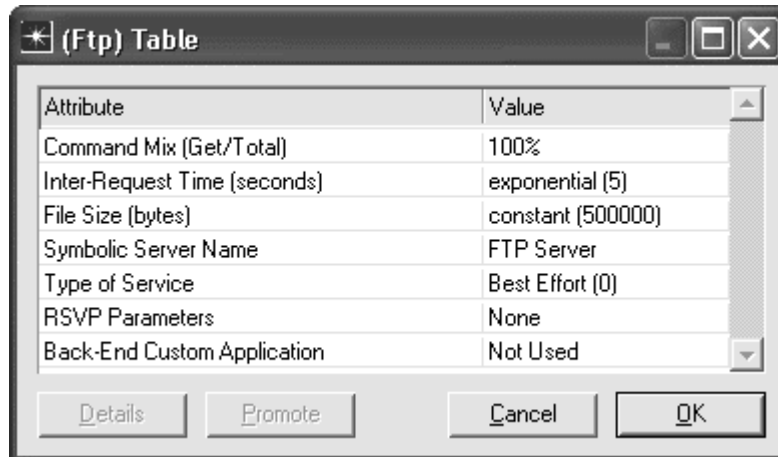
In the **Select Technologies** window, click on **Next**.

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

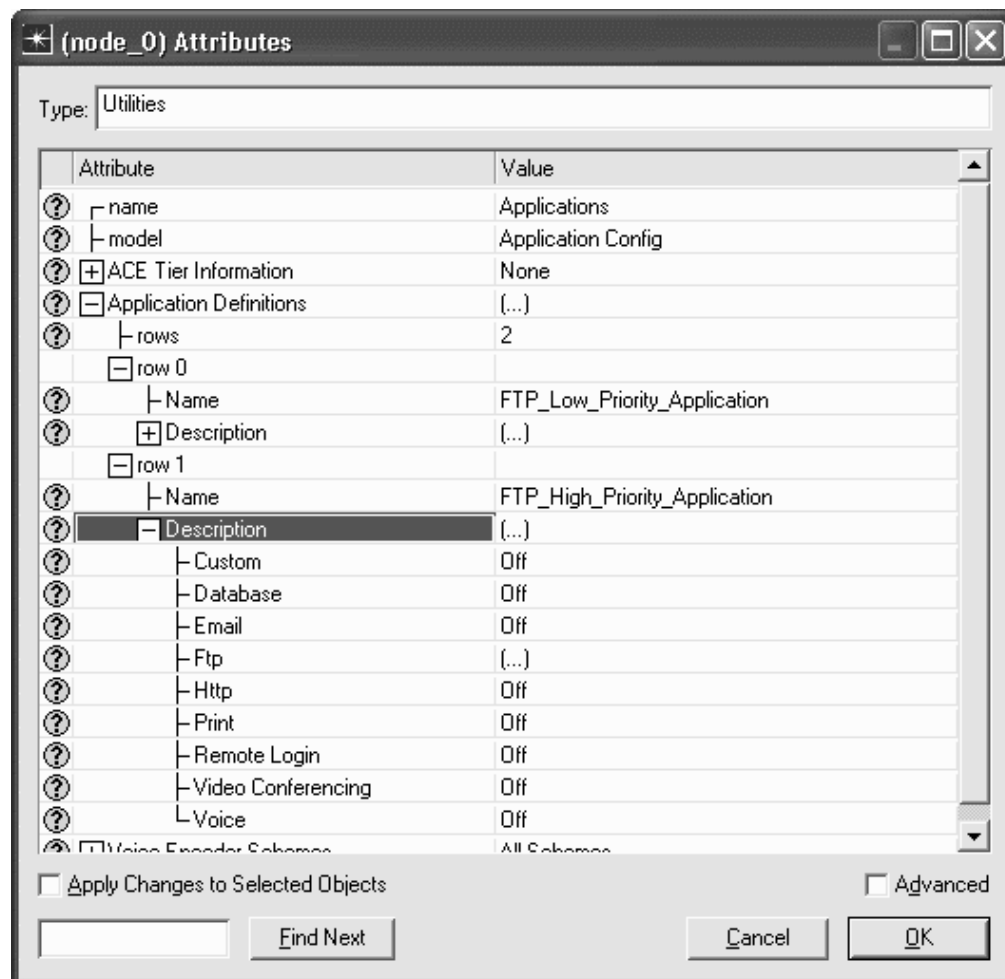
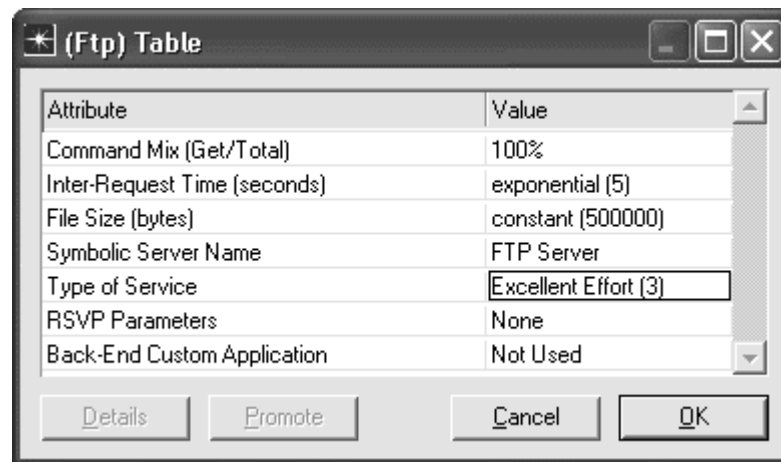


First, we will configure two FTP-based applications which are identical, except for the priorities associated with them.

Select an **Application Config** object from the Object Palette and place it in the project workspace. Right click on the object and choose **Edit Attributes**. Set the **name** attribute to **Applications**. Expand the **Application Definitions** attribute and set the **rows** attribute to **2**. Expand the **row 0** attribute and set the **Name** attribute to **FTP_Low_Priority_Application**. Expand the **Description** attribute and edit the value of the **Ftp** attribute. Set the **Inter-Request Time (secs)** attribute to **exponential(5)**. Set the **File Size (bytes)** attribute to **constant(500000)**. In both cases, you will need to set the **Special Value** field to **Not Used** in order to modify the attribute values. Notice that the **Type of Service** field is set to **Best Effort (0)**. Best Effort is the lowest priority level. The application you have now defined will transfer one 500 KB file after another with an average of 5 seconds between the transfers. Click on **OK** to close the window.



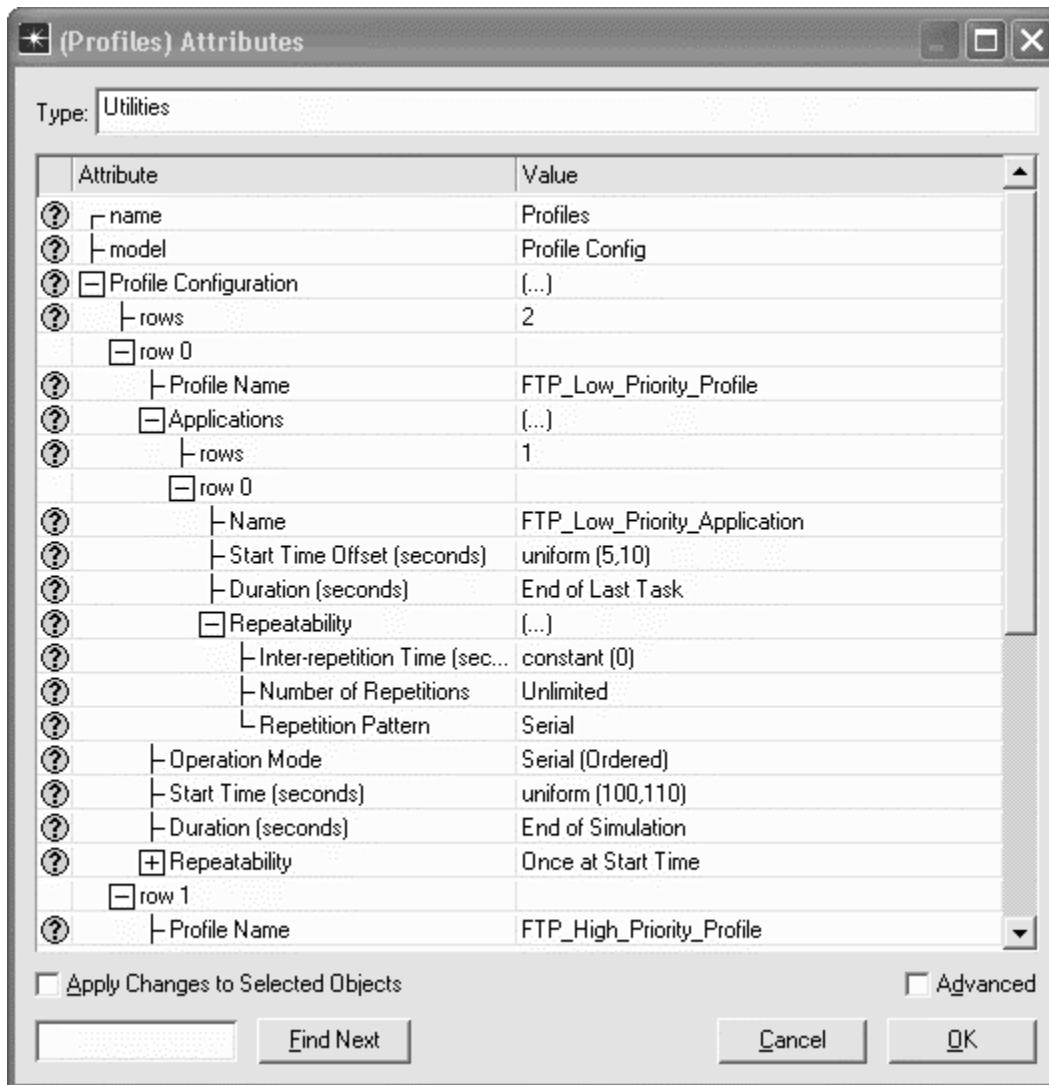
Now expand the **row 1** attribute and set the name to **FTP_High_Priority_Application**. Again, set the **Inter-Request Time (secs)** to **exponential(5)** and the **File Size (bytes)** to **constant(500000)**. Next, change the **Type of Service** field to **Excellent Effort (3)**. Excellent Effort provides a higher priority than Best Effort. Click on **OK** twice to close the windows.



Select a **Profile Config** object from the Object Palette and place it in the project workspace. Right click on the object and choose **Edit Attributes**. Set the **name** attribute to **Profiles**.

Expand the **Profile Configuration** attribute and set the **rows** attribute to **2**. Expand the **row 0** attribute and set the **Profile Name** to **FTP_Low_Priority_Profile**. Expand the **Applications** attribute and set the **rows** attribute to **1**. Expand the **row 0** attribute and set the **Name** to **FTP_Low_Priority_Application**. Set the **Duration (seconds)** to **End of Last Task**. Expand the **Repeatability** attribute and set the **Inter-repetition Time (seconds)** to **constant(0)**.

Expand the **row 1** attribute, and set the **Profile Name** to **FTP_High_Priority_Profile**. Expand the **Applications** attribute and set the **rows** attribute to **1**. Expand the **row 0** attribute and set the **Name** to **FTP_High_Priority_Application**. Set the **Duration (seconds)** to **End of Last Task**. Expand the **Repeatability** attribute and set the **Inter-repetition Time (seconds)** to **constant(0)**. Click on **OK** to close the window.



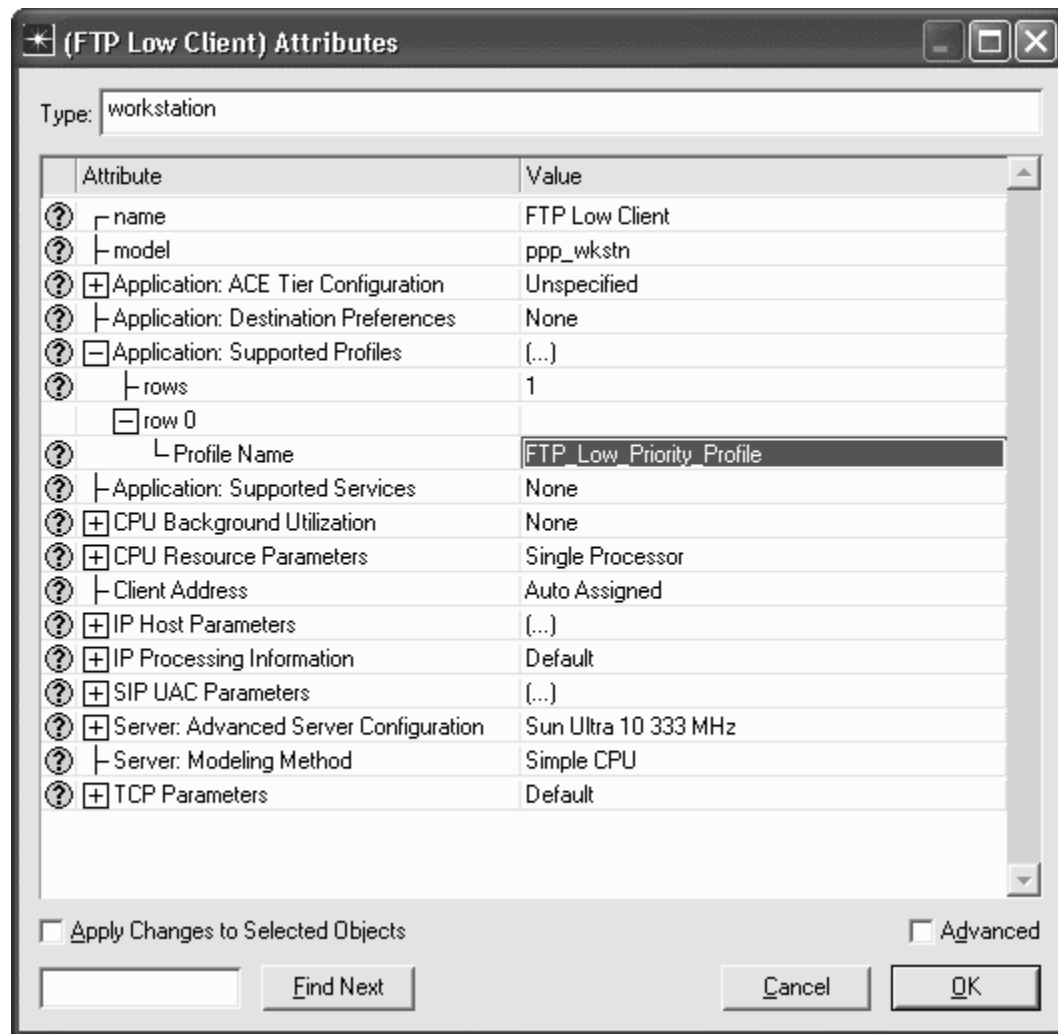
Now that we have profiles created, we will build a network to use them.

Select a **ppp_wkstn** device from the Object Palette and place it in the project workspace.

Right click on the station and choose **Edit Attributes**. Modify the **name** attribute of the device to **FTP Low Client**.

Edit the **Application: Supported Profiles** attribute. Set the **rows** attribute to **1**, expand the **row 0** attribute, and set the **Profile Name** to **FTP_Low_Priority_Profile**.

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



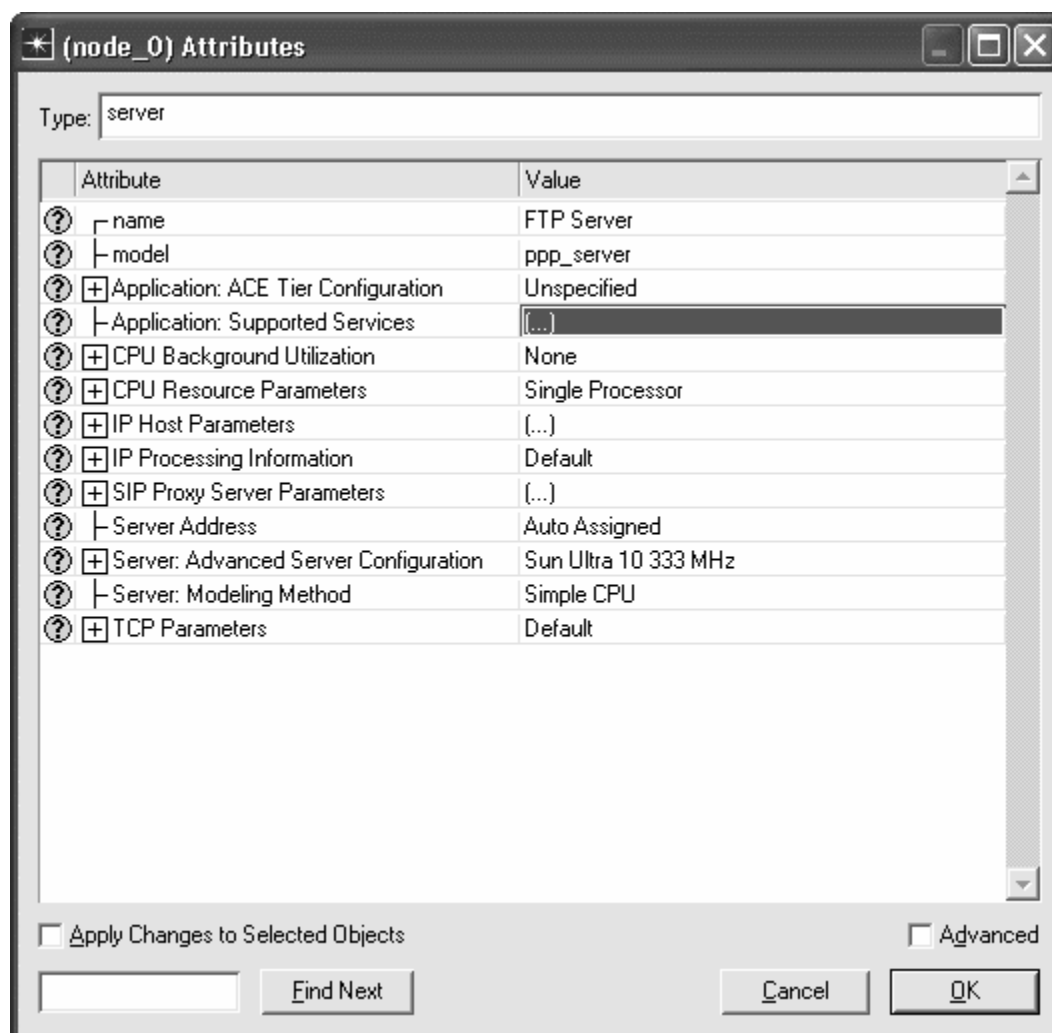
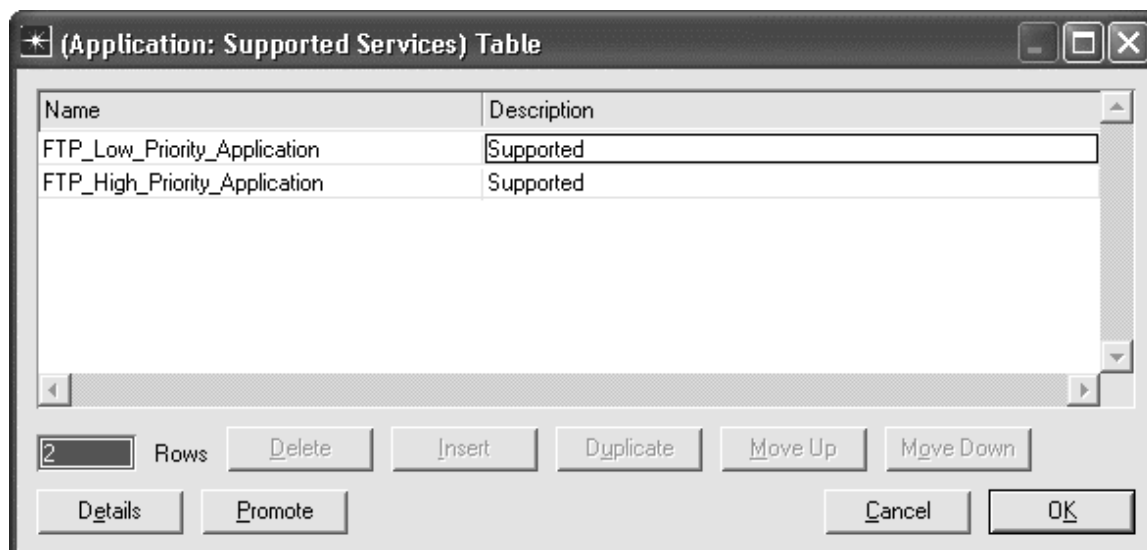
Select another **ppp_wkstn** device from the Object Palette and place it in the project workspace. Right click on the station and choose **Edit Attributes**. Modify the **name** attribute of the device to **FTP High Client**.

Edit the **Application: Supported Profiles** attribute. Set the **rows** attribute to **1**, expand the **row 0** attribute, and set the **Profile Name** to **FTP_High_Priority_Profile**. Click on **OK** to close the window.

Select a **ppp_server** device from the Object Palette and place it in the project workspace.

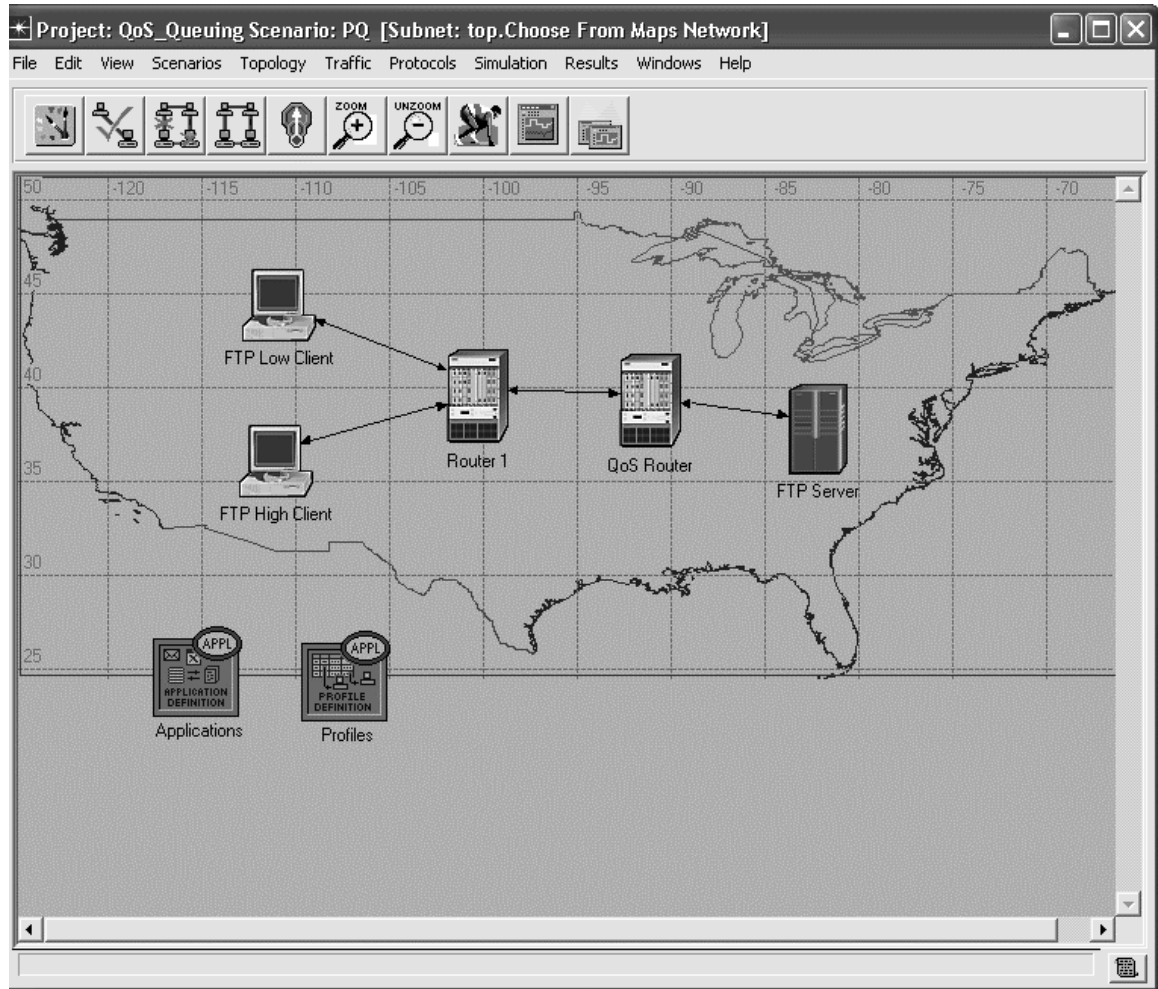
We will now set up the server to support both FTP applications that we defined.

Right click on the device and choose **Edit Attributes**. Modify the **name** attribute of the server to **FTP Server**. Edit the **Application: Supported Services** attribute. Set the **rows** attribute to **2**. Set the **Name** in the first row to **FTP_Low_Priority_Application**. Set the **Name** in the second row to **FTP_High_Priority_Application**. Click on **OK** twice to close the windows.



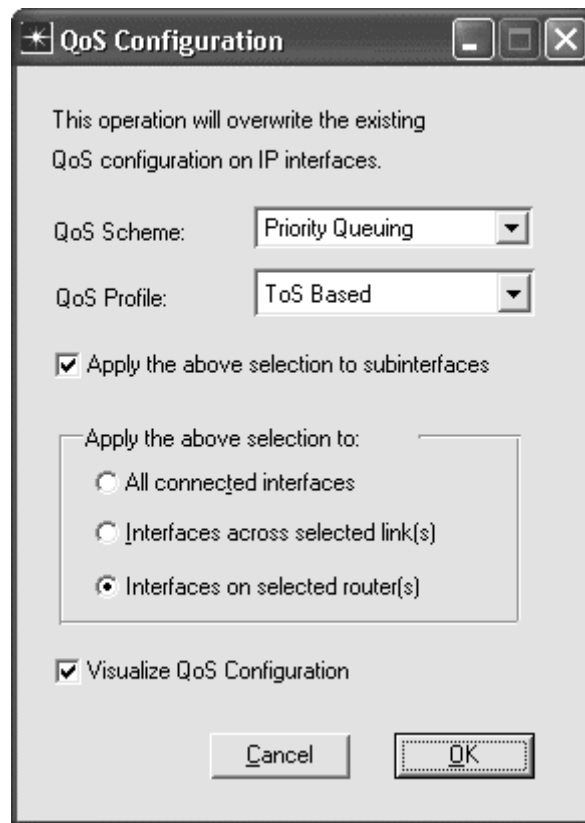
Select 2 **ethernet4_slip8_gtwy** devices from the Object Palette and place them in the project workspace. Right click on the first router and choose **Set Name**. Set the **Name** to **Router 1**. Right click on the second router and choose **Set Name**. Set the **Name** to **QoS Router**.

Select **PPP_DS1** links from the Object Palette and use them to connect the two FTP clients to Router 1, and to connect the two routers together. Select a **PPP_DS3** link from the Object Palette and use it to connect the FTP Server to the QoS Router.



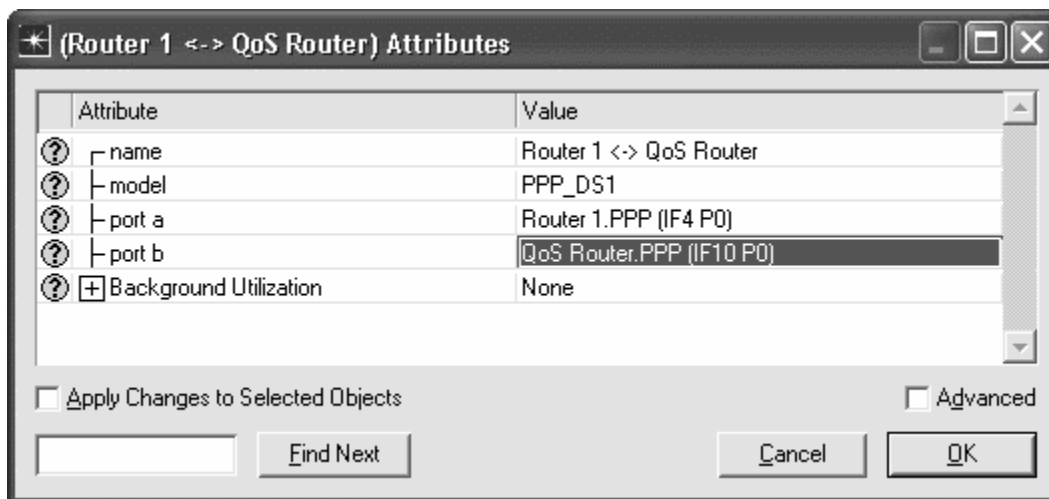
Then we need to set up the queuing mechanisms to be used by the routers.

Right click on the QoS Router and choose **Select Similar Nodes** so that we can apply changes to both routers at the same time. Select the **Protocols** tab => **IP** => **QoS** => **Configure QoS...** Set the **QoS Scheme** to **Priority Queuing**. Note that the **QoS profile** is **ToS Based**, which means that the router will use the Type of Service field in the IP packet header to determine which packets get priority. The Best Effort and Excellent Effort priorities that we defined earlier are represented using the ToS field. Click on the radio button next to **Interfaces on selected router(s)**. Click on **OK** to close the window.



You have now configured the QoS Router to use the priority queuing mechanism on its interfaces. Note that a **QoS Config** object automatically appears in the project workspace. This is due to the fact that we configured the QoS Router to use queuing mechanisms.

Right click on the PPP link that connects the QoS Router and Router 1, and choose **Edit Attributes**. Inspect the **port a** and **port b** attributes to see which interface is being used on the QoS Router (IF10 in our example). Your configuration may differ from the one shown, depending on how you placed your PPP link. Click on **OK** to close the window.



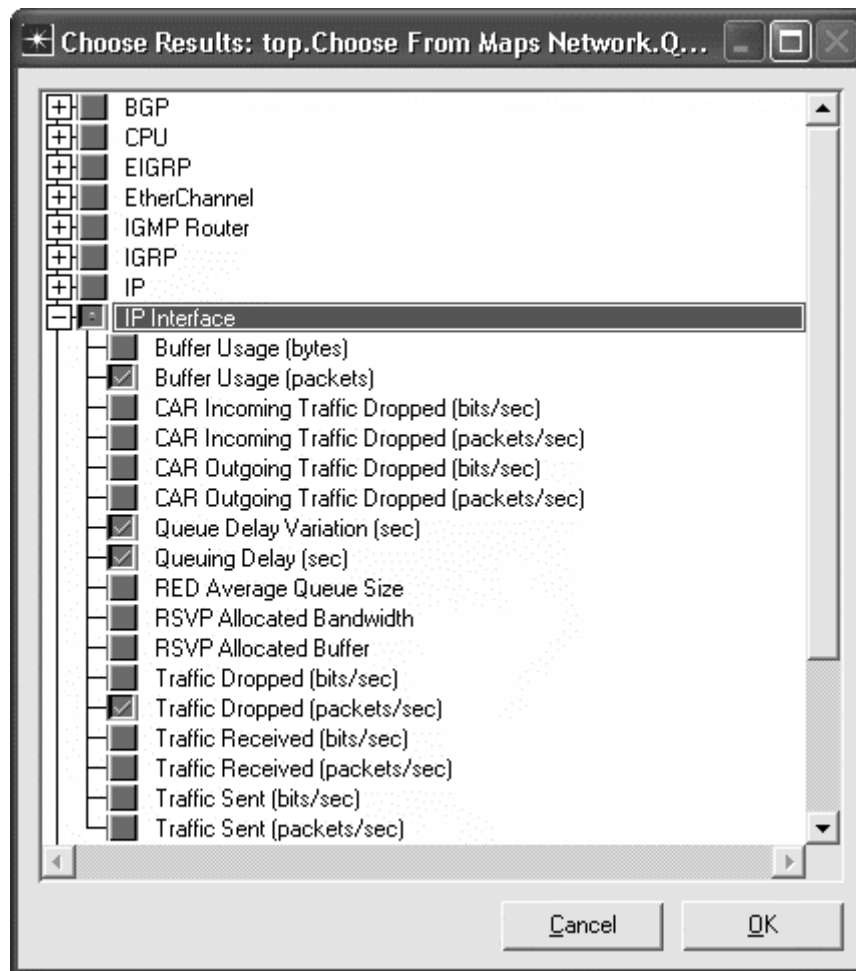
Right click on the QoS Router and choose **Edit Attributes**. Expand the **IP Routing Parameters** item, the **Interface Information** item, and the row item for the interface you just found, **row 10** in our example. Expand the **QoS Information** item. Edit the **Buffer Size (bytes)** attribute and set the value to **100000**. By making the

buffer size on this interface relatively small, buffer overflow will occur more quickly, allowing us to see the results of the different queuing mechanisms more easily. Note that overflow would eventually occur anyway since the FTP Server is generating lots of traffic over the DS3 line which connects it to the QoS Router, but the QoS Router has only a DS1 line to forward traffic on to the clients. Click on **OK** to close the window.



Configure and Run the Simulation

Right click on the QoS Router and select **Choose Individual Statistics**. Expand the **IP Interface** item, and select the **Buffer Usage (packets)**, the **Queue Delay Variation (sec)**, the **Queuing Delay (sec)**, and the **Traffic Dropped (packets/sec)** statistics. Click on **OK** to close the window.

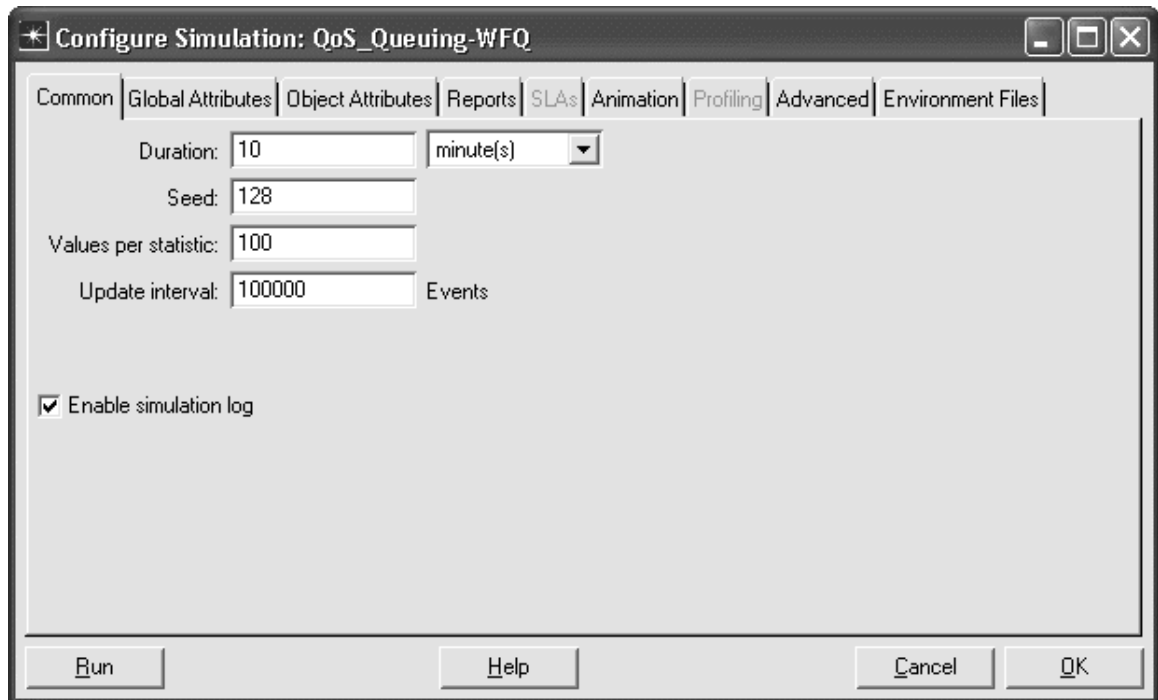


Select **Simulation => Configure Discrete Event Simulation...**

Under the **Common** tab, set the **Duration** to **10**, and the unit to **minute(s)**.

Click on **Run** to run the simulation.

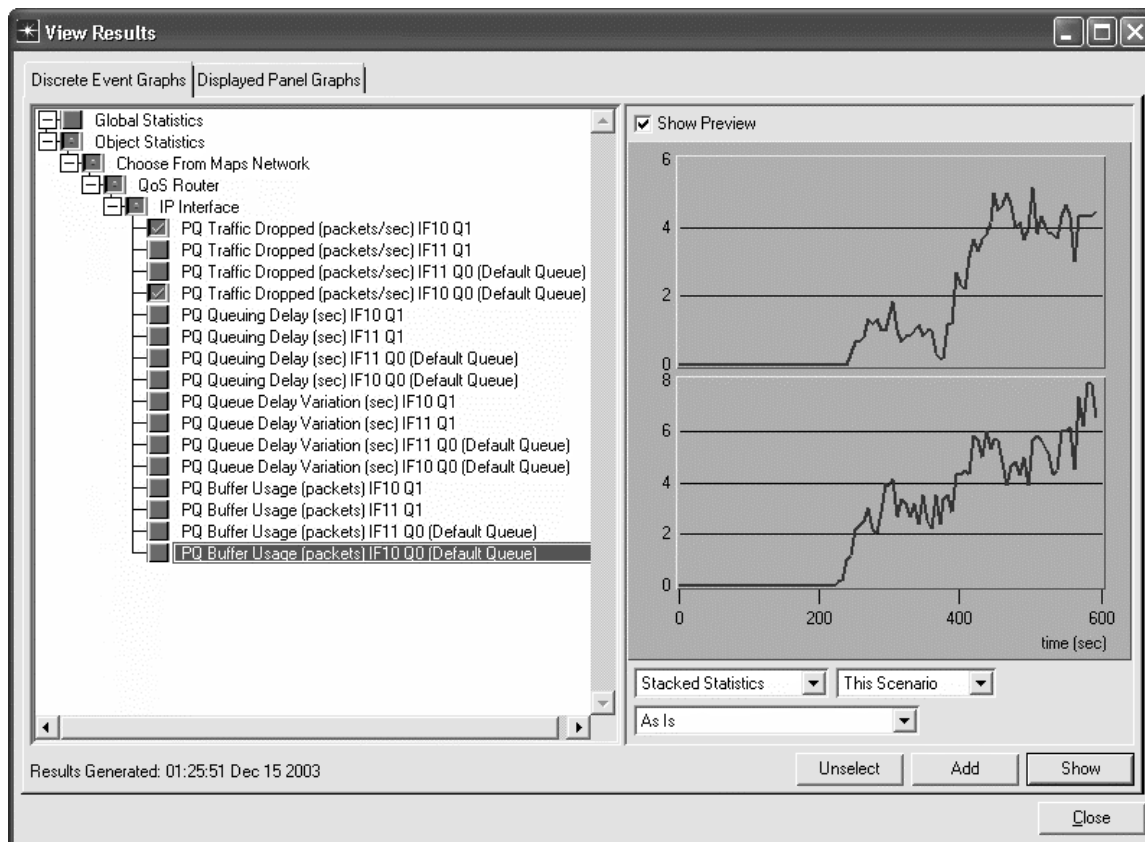
When the simulation has completed, click on **Close** to close window.



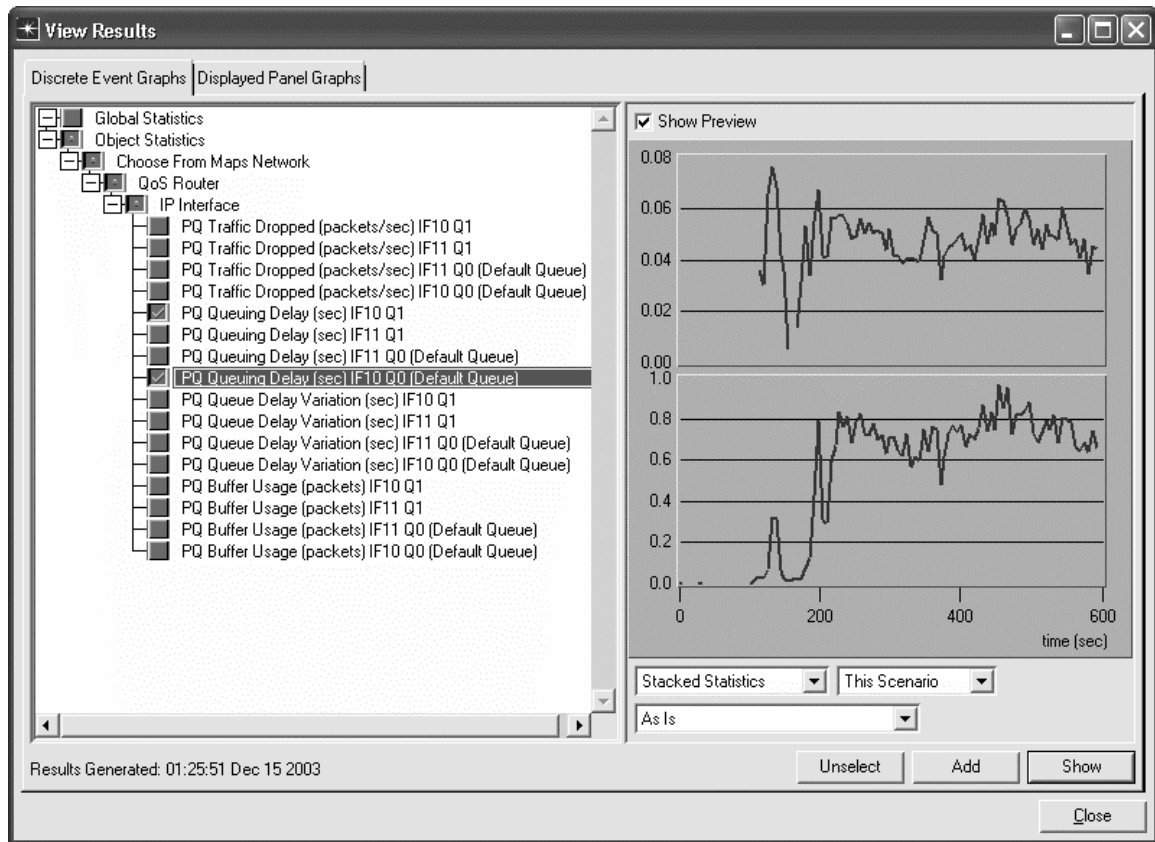
Inspect and Analyze Results

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

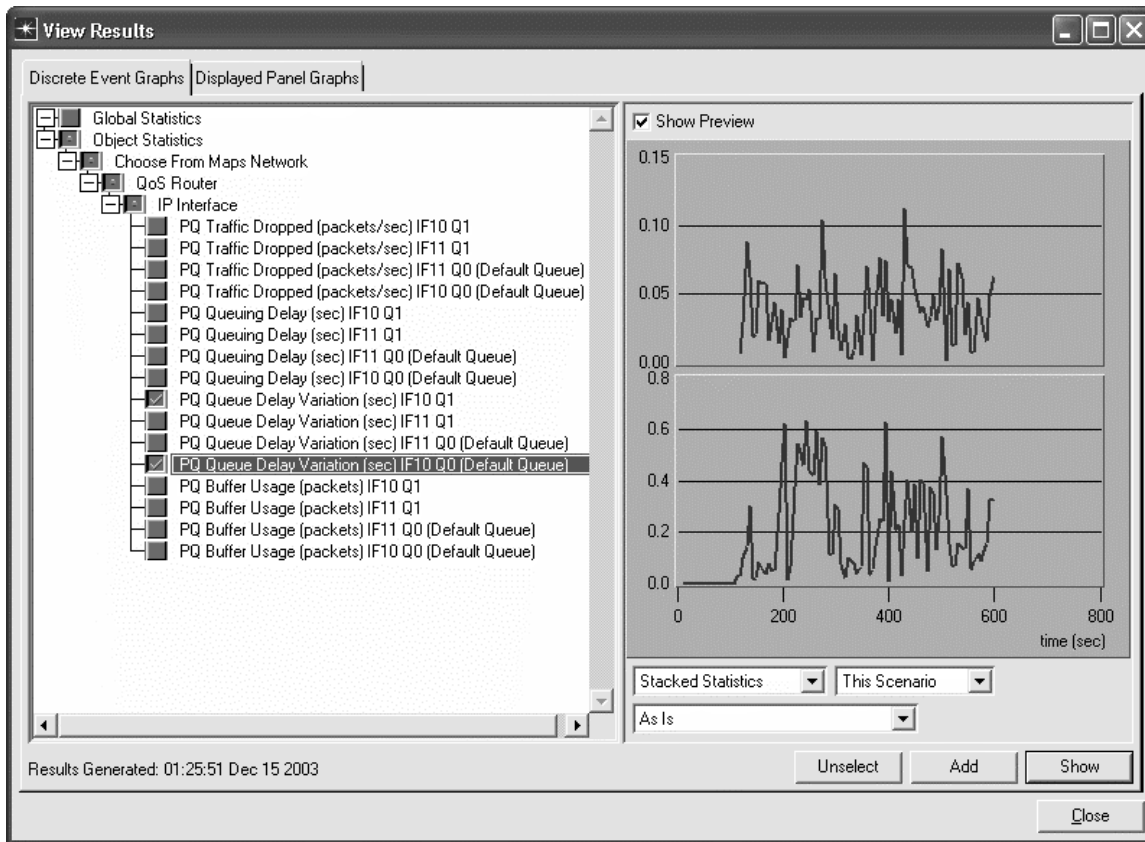
Select and expand the **Object Statistics** item, the **Choose From Maps Network** item, the **QoS Router** item, and the **IP Interface** item. Select the **PQ Traffic Dropped (packets/sec) IF10 Q1** and **PQ Traffic Dropped (packets/sec) IF10 Q0 (Default Queue)** statistics. Note that interface 10 (IF10) is the interface on the QoS router which connects it to Router 1. If, during configuration setup, you found that a different interface was used in your model, replace IF10 with that interface for the rest of the results analysis steps. Use the **As Is** mode to view all statistics. The selected statistics show how many packets were dropped due to buffer overflow. Q1 corresponds to the high-priority traffic and Q0 corresponds to the low-priority traffic. Note that the high-priority queue has a lower drop rate than the low-priority queue. Click on the statistics again to disable the preview.



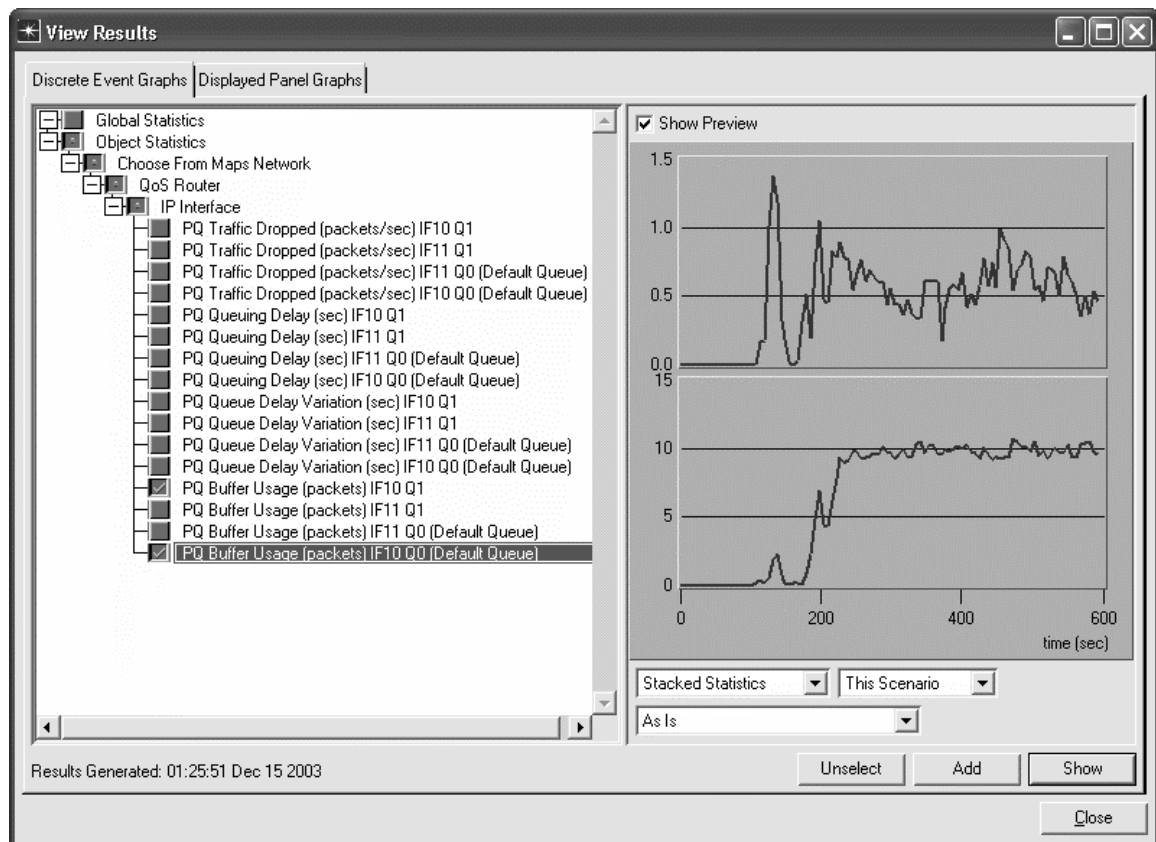
Select the **PQ Queuing Delay (sec) IF10 Q1** and **PQ Queuing Delay (sec) IF10 Q0 (Default Queue)** statistics. These statistics show how long packets had to wait in the queue before being sent. You can see that the low-priority traffic (Q0) experienced drastically longer queuing delay than the high-priority traffic (Q1). Click on the statistics again to disable the preview.



Select the **PQ Queue Delay Variation (sec) IF10 Q1** and **PQ Queue Delay Variation (sec) IF10 Q0 (Default Queue)** statistics. These statistics show the *variation* in queuing delay (jitter) that packets experienced. Again, the high-priority traffic experiences much less jitter than the low-priority traffic. Click on the statistics again to disable the preview.



Select the **PQ Buffer Usage (packets) IF10 Q1** and **PQ Buffer Usage (packets) IF10 Q0 (Default Queue)** statistics. These statistics show how many packets were waiting in the queue at any time during the simulation. You can see that many low-priority packets were waiting in the queue at all times, while high-priority packets were seldom kept waiting. Click on the statistics again to disable the preview.



Save your model and close all windows.

Questions

1. Duplicate your scenario and name it **WFQ** (for Weighted Fair Queuing). Select both routers and choose the **Protocols** tab => **IP** => **QoS** => **Configure QoS...** Set the **QoS Scheme** to **WFQ**. Note that the **QoS profile** is **ToS Based**, which means that the router will use the ToS field that we defined for the application to determine which packets get priority.

Click on the radio button next to **Interfaces on selected router(s)**.

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

Rerun the simulation and examine the relative packet drop rate, delay, delay variation, and buffer occupancy. Explain your results.

2. Duplicate your scenario and name it **FIFO**. Select the two routers and choose the **Protocols** tab => **IP** => **QoS** => **Configure QoS...** Set the **QoS Scheme** to **FIFO**. FIFO routers treat all packets the same. No priorities are implemented.

Click on the radio button next to **Interfaces on selected router(s)**.

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

Rerun the simulation and examine the relative packet drop rate, delay, delay variation, and buffer occupancy. Explain your results.

3. Compare the Weighted Fair Queuing, Priority Queuing, and FIFO schemes in terms of drop rate, delay, and delay variation. What are the advantages and disadvantages of each?

4. Edit the attributes of the QoS Parameters object. Look in the WFQ Profiles attribute at the ToS based profile. What weights are associated with the various ToS values in the WFQ scheme? How do these weights affect the operation of the router?

5. Edit the attributes of the QoS Parameters object. Look in the Priority Queuing Profiles at the ToS based profile. How many priority levels are defined? What ToS values are associated with each priority level?

6. Edit the attributes of the QoS Parameters object. Look in both the Priority Queuing Profiles and the WFQ Profiles. Other than ToS, how else may packets be classified for priority service?