RSVP: Resource Reservation Protocol

Providing QoS by Reserving Resources in the Network

OBJECTIVES

The objective of this lab is to study the Resource Reservation Protocol (RSVP) as part of the integrated services approach that provides quality of service (QoS) to individual applications or flows.

OVERVIEW

For many years, packet-switched networks have offered the promise of supporting multimedia applications. Multimedia applications combine audio, video, and data. Audio and video applications are examples of real-time applications. In the best-effort model, the network tries to deliver your data but makes no promises and leaves the "cleanup operation" to the edges. This model is not sufficient for real-time applications. What we need is a new service model—one in which applications that need better assurances can request such service from the network. The network may then respond by providing an assurance that it will do better or perhaps by saying that it cannot promise anything better at the moment. A network that can provide different levels of service is often said to support QoS.

Two approaches have been developed to provide a range of QoS: integrated services and differentiated services. The Resource Reservation Protocol (RSVP) follows the integrated services approach, whereby QoS is provided to individual applications or flows. The differentiated services approach provides QoS to large classes of data or aggregated traffic.

Although connection-oriented networks have always needed some sort of setup protocol to establish the necessary virtual circuit state in the routers, connectionless networks, like the Internet, have had no such protocols. One of the key assumptions underlying RSVP is that it should not detract from the robustness that we find in the Internet. Therefore, RSVP uses the idea of soft state in the routers. Soft state—in contrast to the hard state found in connection-oriented networks—does not need to be explicitly deleted when it is no longer needed. Instead, it times out after some fairly short period if it is not periodically refreshed. RSVP adopts the receiver-oriented approach, where the receivers keep track of their own resource requirements, and they periodically send refresh messages to keep the soft state in place.

In this lab, you will set up a network that carries real-time applications and that utilizes RSVP to provide QoS to one of these applications. You will study how RSVP contributes to the performance of the application that makes use of it.

PRE-LAB ACTIVITIES

📖 Read Section 6.5.2 from *Computer Networks: A Systems Approach, 5th Edition*.

💻 Go to www.net-seal.net and play the following animation:
  ❍ TCP Flow Control

PROCEDURE

Create the Project

1. Start **OPNET IT Guru Academic Edition** → Choose **Open** from the menu.

2. Select the project you created in the "Queuing Disciplines" lab: **<your initials>_Queues** → Click **OK**.

3. From the **File** menu, choose **Save As** → Rename the project to **<your initials>_RSVP** → Click **OK**.

4. From the **Scenarios** menu, choose **Manage Scenarios** → Click on **FIFO** → Click **Delete** → Click on **PQ** → Click **Delete**.

The idea of the **FQ** (fair queuing) discipline is to maintain a separate queue for each flow currently being handled by the router. The router then services these queues in a round-robin manner. **WFQ** allows a weight to be assigned to each flow (queue). This weight effectively controls the percentage of the link's bandwidth each flow receives. We could use the **ToS** (Type of Service) field in the IP header to identify that weight.
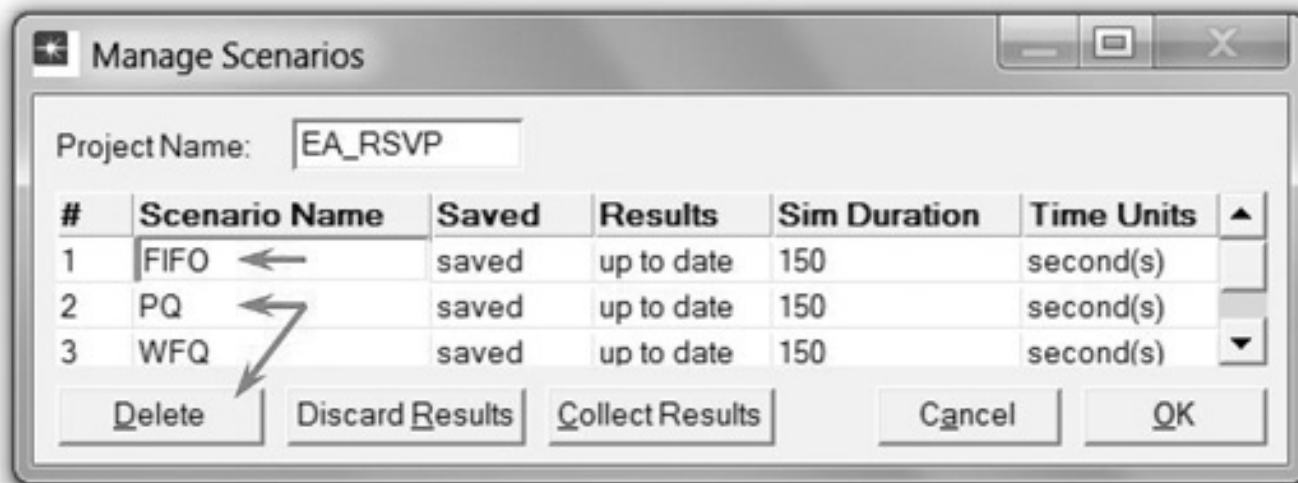
122

5. Click on **WFQ**, and rename it to **QoS_RSVP** → Click **OK**.

6. Make sure that you have only the **QoS_RSVP** scenario in your project. The following figure shows one way to check the available scenarios in the project.

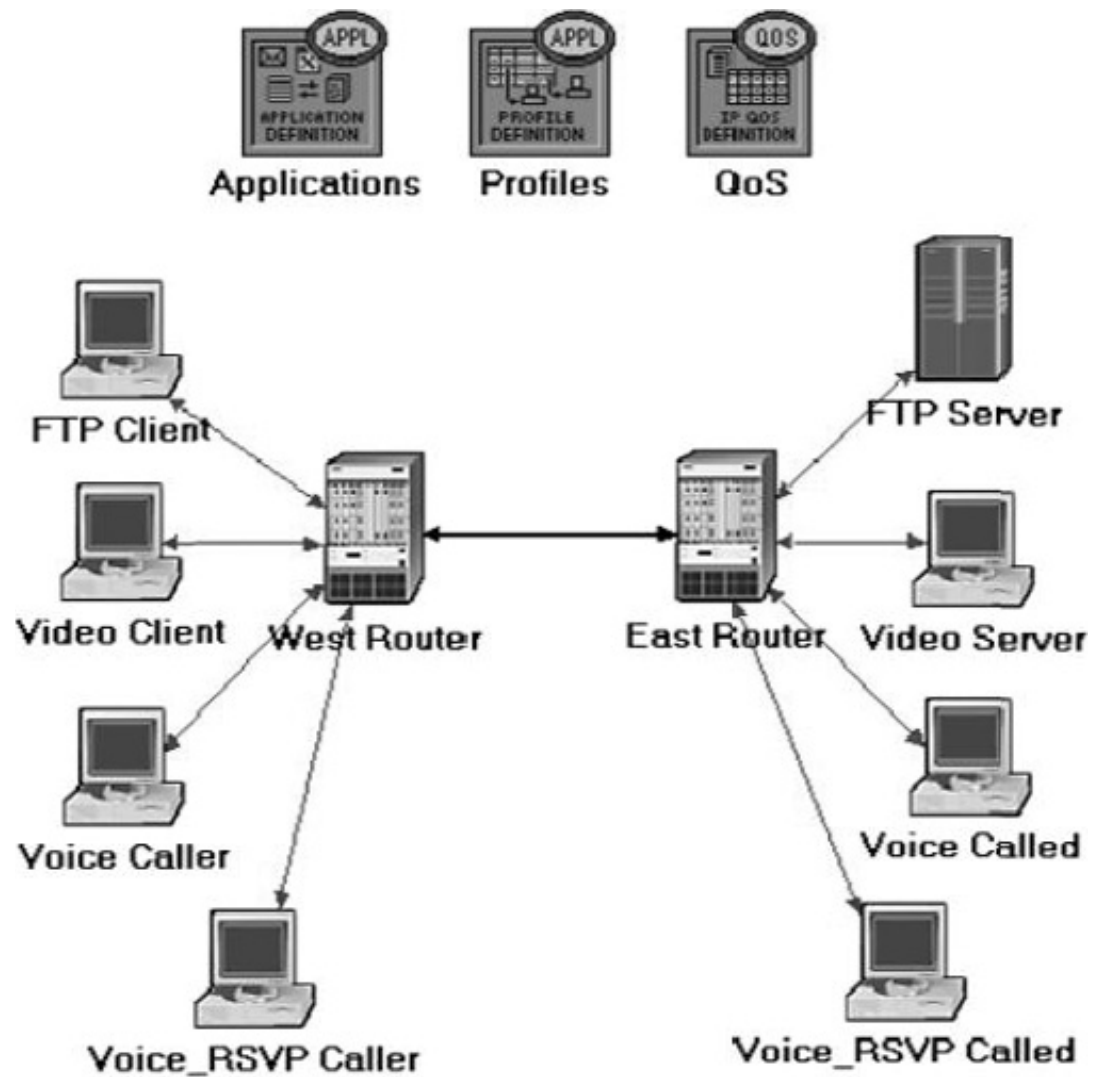**7.** **Save** your project.

Configure the Network

Add more VoIP nodes:

In this project, we will set up the two VoIP nodes so that one will always be the *Caller* party and the other will be the *Called* party. In addition, we will add two new VoIP *Caller* and *Called* nodes. These new nodes will utilize RSVP to reserve their required resources through the network.

1. Right-click on the **VoIP East** node → **Edit Attributes** → Rename the node to **Voice Called** → Assign **None** to the **Application: Supported Profiles** attribute → Assign **Voice Called** to the **Client Address** attribute → Click **OK**.
2. Right-click on the **VoIP West** node → **Edit Attributes**.
   a. Rename the node to **Voice Caller**.
   b. Assign **None** to the **Application: Supported Services** attribute.
   c. Edit the value of the **Application: Destination Preferences** attribute → Set **Rows** to 1 → Assign **Voice Destination** to the **Symbolic Name** of the new row → Edit the **Actual Name** attribute → Set **Rows** to 1 → Assign **Voice Called** to the **Name** attribute of the new row as shown.
3. Click **OK** three times, and **Save** your project.
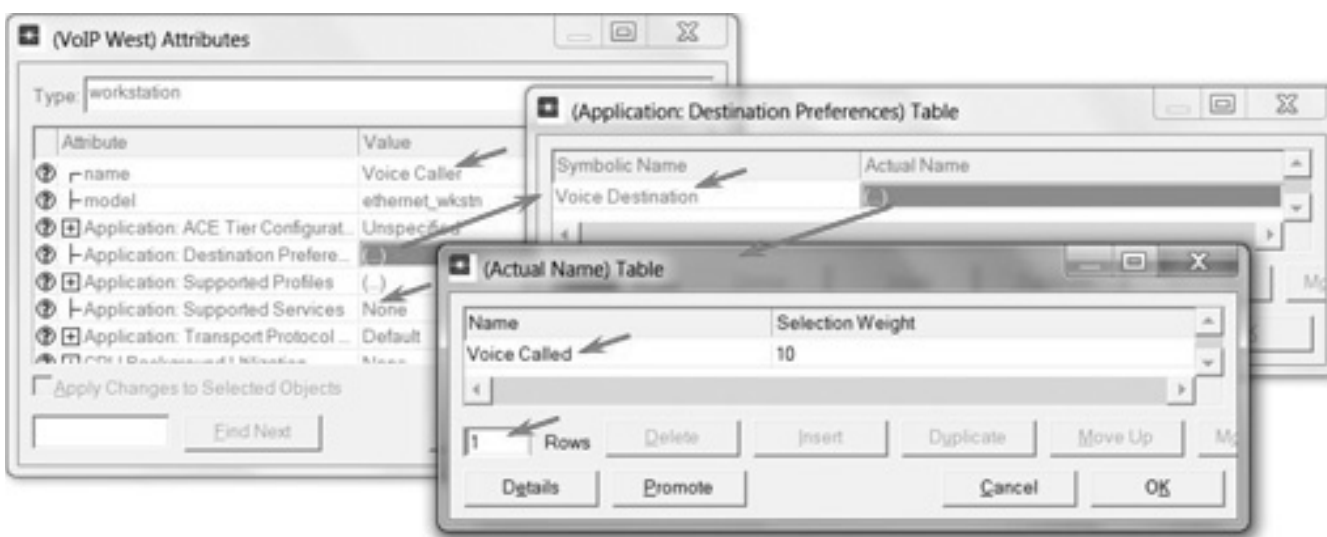
4. Click on the **Voice Called** node to select it → From the **Edit** menu, select **Copy** → From the **Edit** menu, select **Paste** (alternatively, use the standard keyboard shortcuts, **Ctrl + C** and **Ctrl + V**).
   a. Locate the new node somewhere below the **Voice Called** node on the screen → Connect the new node to the **East Router** using a **10BaseT** link.
   b. Right-click on the new node → **Edit Attributes**.
   c. Click on the **ethernet_wkstn** value of the **model** attribute → Select **Edit** → Select the **ethernet_wkstn_adv** model.
   d. Rename it to **Voice_RSVP Called** → Assign **Voice_RSVP Called** to its **Client Address** attribute.
   e. Click **OK**.
5. Copy and paste the **Voice Caller** node:
   a. Locate the new node somewhere below the **Voice Caller** node → Connect the new node to the **West Router** using a **10BaseT** link.
   b. Right-click on the new node → **Edit Attributes** → Click on the **ethernet_wkstn** value of the **model** attribute → Select **Edit** → Select the **ethernet_wkstn_adv** model.
   c. Rename it to **Voice_RSVP Caller**.
   d. Edit the **Application: Destination Preferences** attribute → Open the **Actual Name** table by clicking in the value field of **Actual Name** → Assign **Voice_RSVP Called** to the **Name** attribute (this is to replace the current value, which is **Voice Called**).
   e. Click **OK** three times.

6. Rename the **Queues** node in the project to **QoS**. Your project should look like the diagram shown.
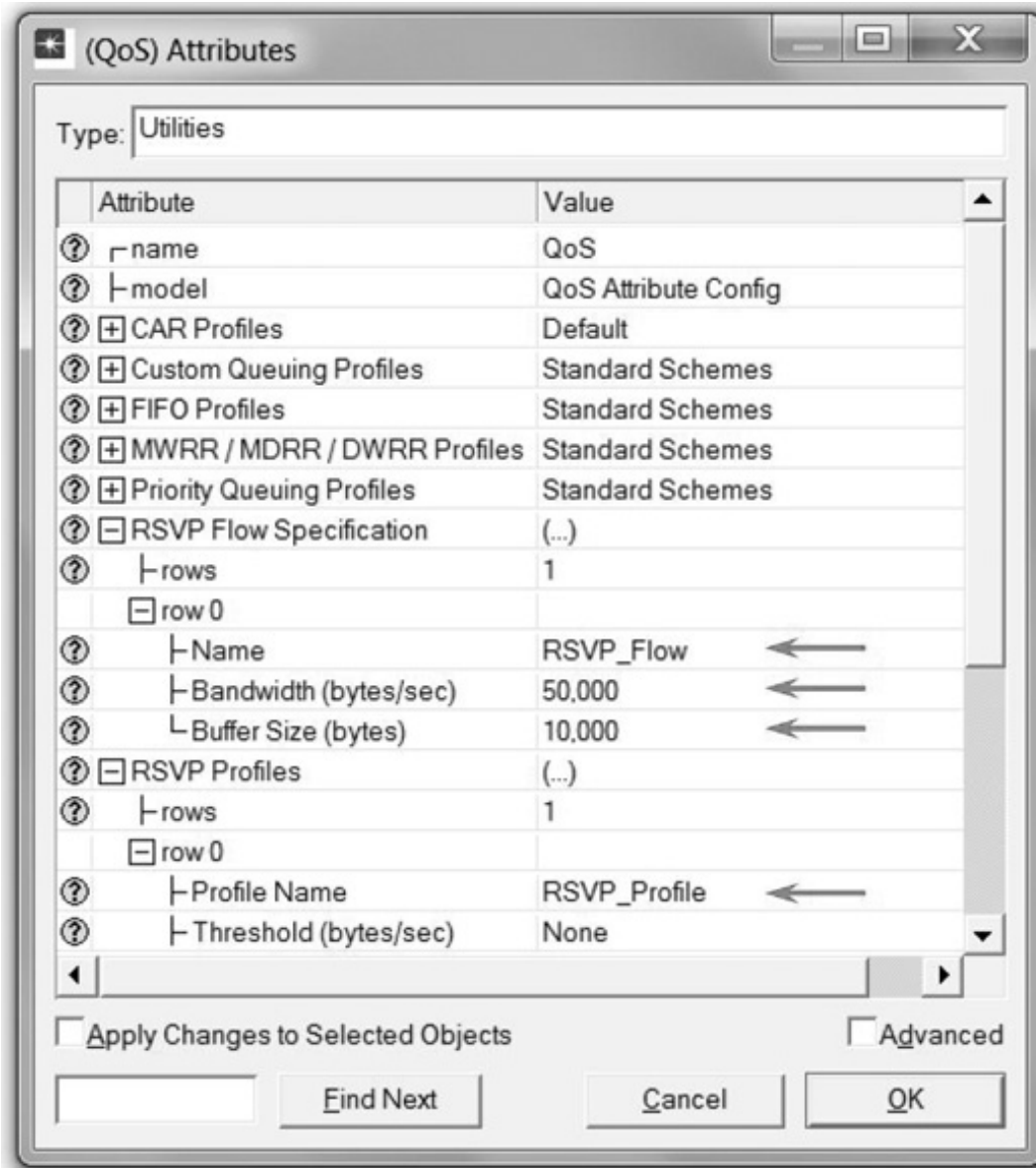
7. Save your project.

Define the data flow:

Here we will define the data flow characteristics of the voice traffic in the network. The sender's RSVP module periodically sends RSVP Path messages that use the data flow characteristics to describe the traffic generated by the sender. When the receiver's RSVP module receives the Path message, the receiver host application checks the characteristics of the requested data flow and decides whether resources should be reserved. Once a decision is made, the receiver host application sends a request to the host RSVP module to assist in the reservation setup. The receiver's RSVP module then carries the request as Resv messages to all nodes along the reverse data path to the sender.

The flow is defined by its required bandwidth and buffer size. Bandwidth is set to be the *token bucket rate* in the flow specification of the Path and Resv messages. The buffer size represents the amount of the application "bursty" data to be buffered. It specifies the *token bucket size* that will be set in the Path or Resv messages for the session.

1. Right-click on the **QoS** node → **Edit Attributes**.
   a. Expand the **RSVP Flow Specification** hierarchy and its **row 0** hierarchy → Set **Name** to **RSVP_Flow** → Assign **50,000** to the **Bandwidth (bytes/sec)** attribute → Assign **10,000** to the **Buffer Size (bytes)** attribute.
   b. Expand the **RSVP Profiles** hierarchy and its **row 0** hierarchy → Set **Profile Name** to **RSVP_Profile** → Click **OK**, and **Save** your project.

RSVP Flow defines traffic requirements (bandwidth and requested buffer size) for which RSVP reservation will be attempted.

125

(QoS) Attributes	
Type: Utilities	

Attribute	Value
⌐name	QoS
⊢model	QoS Attribute Config
⊞ CAR Profiles	Default
⊞ Custom Queuing Profiles	Standard Schemes
⊞ FIFO Profiles	Standard Schemes
⊞ MWRR / MDRR / DWRR Profiles	Standard Schemes
⊞ Priority Queuing Profiles	Standard Schemes
⊟ RSVP Flow Specification	(...)
⊢rows	1
⊟ row 0	
⊢Name	RSVP_Flow ←
⊢Bandwidth (bytes/sec)	50,000 ←
⌐Buffer Size (bytes)	10,000 ←
⊟ RSVP Profiles	(...)
⊢rows	1
⊟ row 0	
⊢Profile Name	RSVP_Profile ←
⊢Threshold (bytes/sec)	None

☐ Apply Changes to Selected Objects   ☐ Advanced

[   ]   Find Next   Cancel   OK

Configure the application:

Here we will create a VoIP application that utilizes the RSVP flow specifications we configured.

1. Right-click on the **Applications** node → **Edit Attributes** → Expand the **Applications Definitions** hierarchy → Set **rows** to 4 (to add a fourth row to the **Application Definitions** attribute).
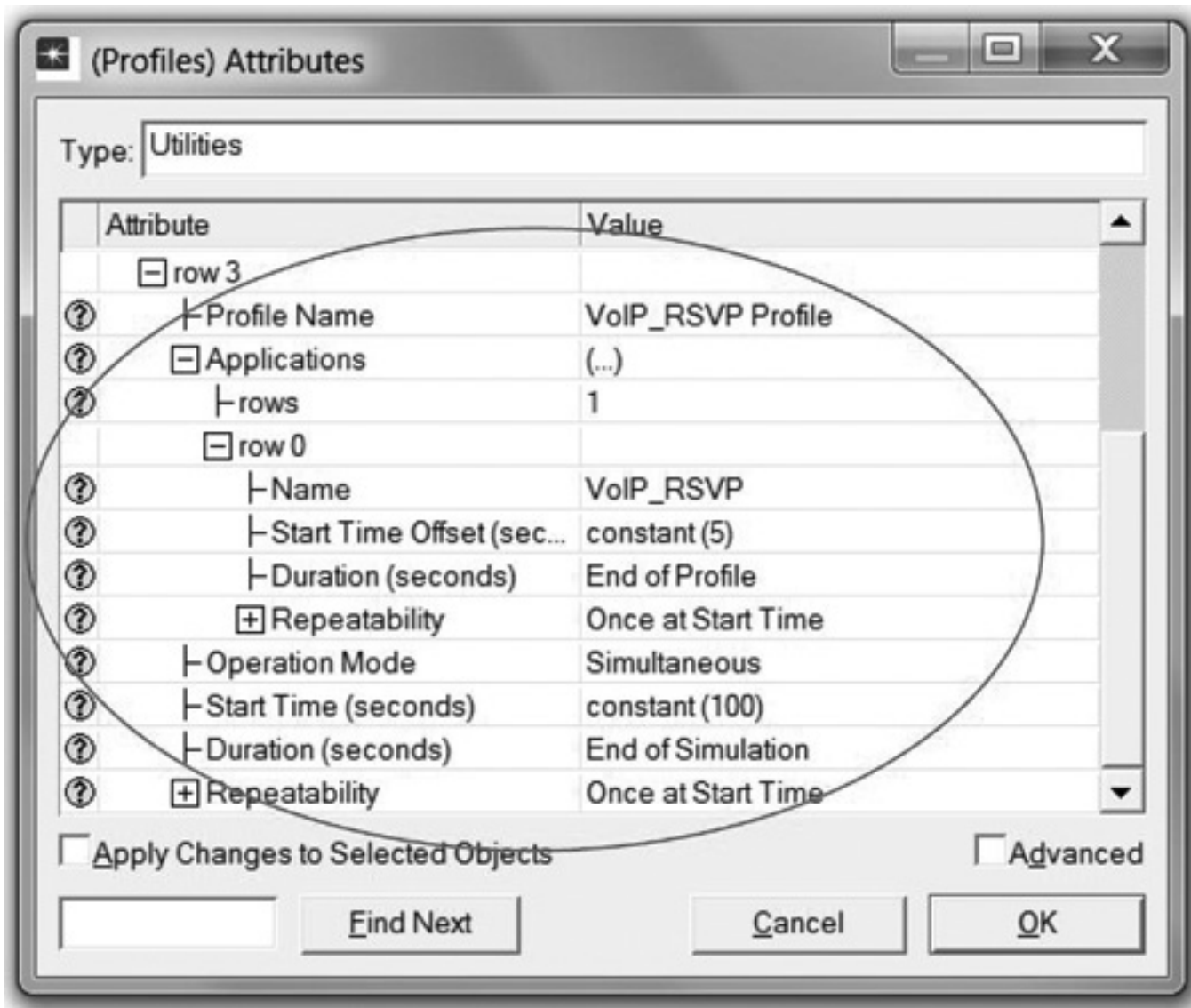
a. Name and set the attributes of row 3 as shown.
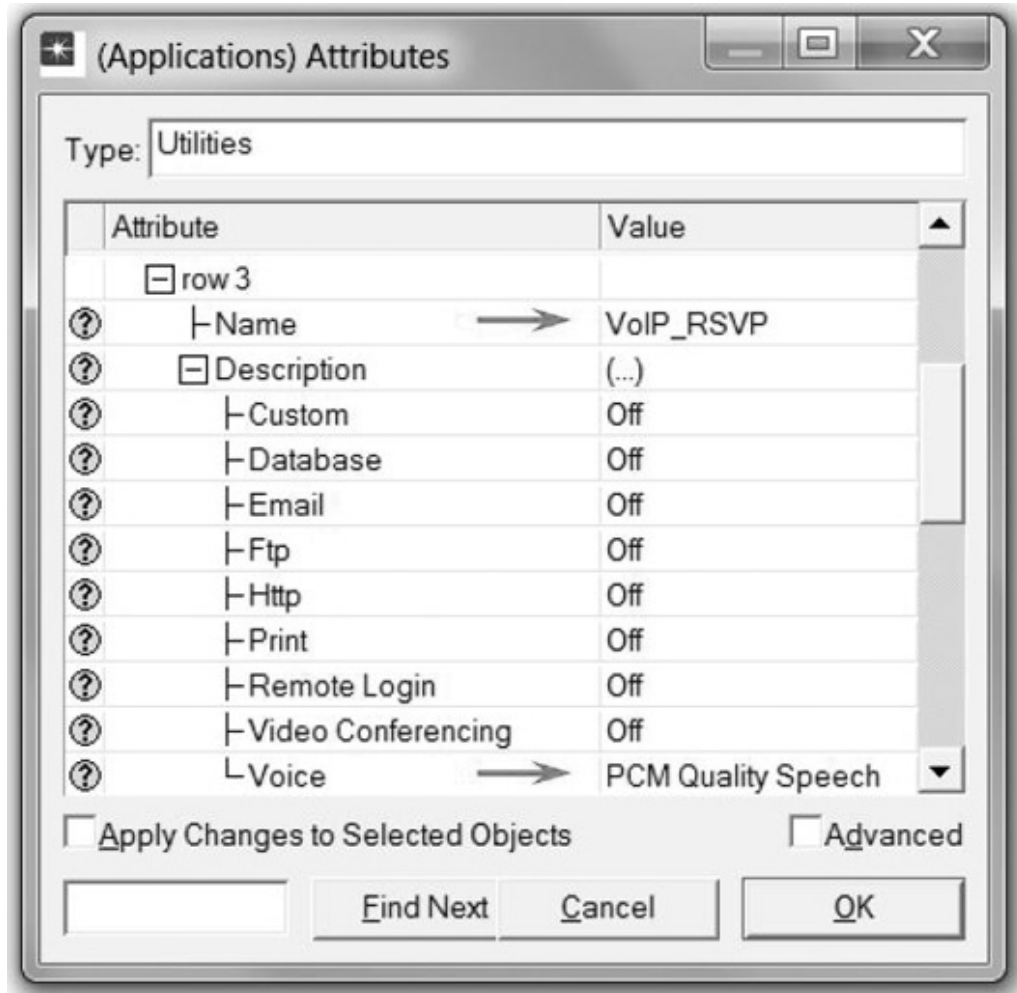
b. Click on the **PCM Quality Speech** value (shown in the previous figure) → Select **Edit** → Edit the value of the **RSVP Parameters** attribute → Assign the following values (recall that we defined the **RSVP_Flow** in the QoS node) → Click **OK** three times.
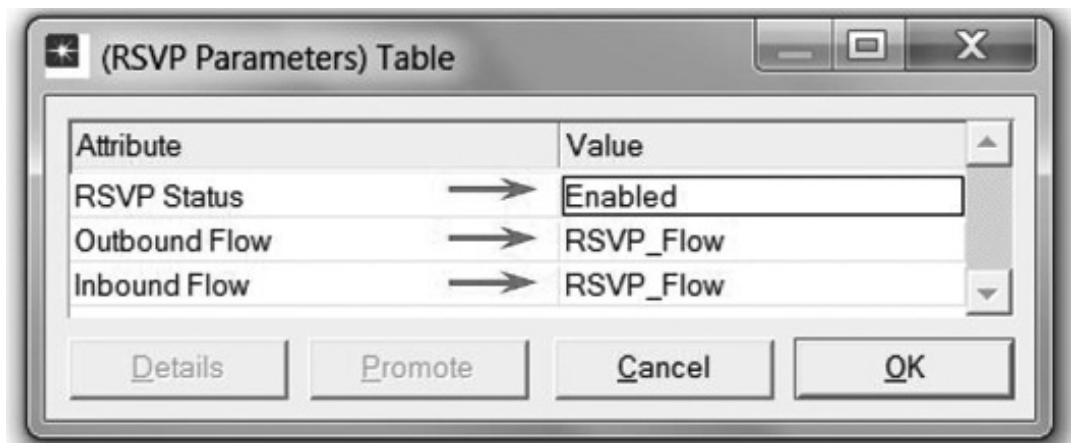
Note that the characteristics of the **Outbound Flow** are carried in the Path messages to be sent from sender to receiver, and the characteristics of the **Inbound Flow** parameters are carried in the Resv messages to be sent from the receiver to the sender.

Configure the profile:

1. Right-click on the **Profiles** node → **Edit Attributes** → Expand the **Profile Configuration** hierarchy → Set **rows** to 4 → Name and set the attributes of **row 0** as shown:

(Profiles) Attributes

Type: Utilities

Attribute	Value
⊟ row 3	
⊢Profile Name	VoIP_RSVP Profile
⊟ Applications	(...)
⊢rows	1
⊟ row 0	
⊢Name	VoIP_RSVP
⊢Start Time Offset (sec...	constant (5)
⊢Duration (seconds)	End of Profile
⊞ Repeatability	Once at Start Time
⊢Operation Mode	Simultaneous
⊢Start Time (seconds)	constant (100)
⊢Duration (seconds)	End of Simulation
⊞ Repeatability	Once at Start Time

☐ Apply Changes to Selected Objects   ☐ Advanced

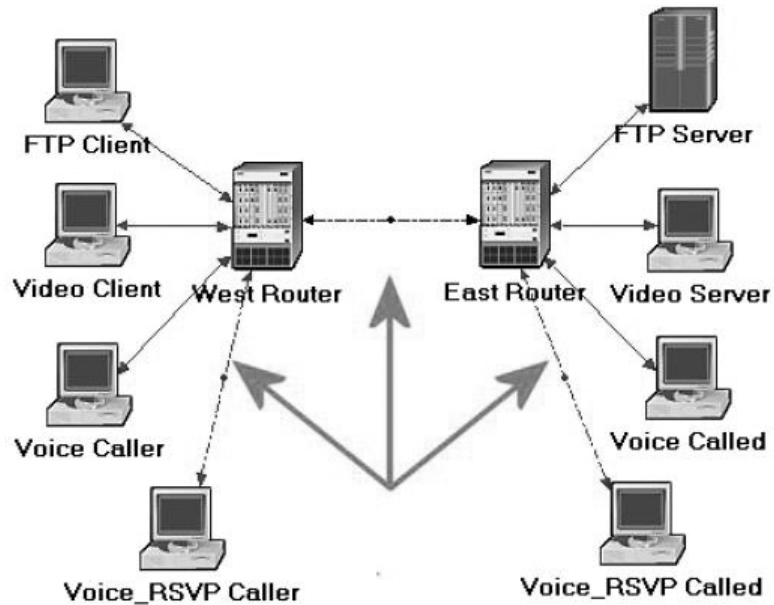[   ]   **Find Next**   **Cancel**   **OK**

127

2. Click **OK**, and **Save** your project.

Configure the interfaces:

OPNET IT Guru supports RSVP on a per-interface basis; RSVP can be enabled or disabled for each node's interface.

1. Simultaneously select (Shift + left-click) the three links shown:

2. From the **Protocols** menu, select **RSVP** → Select **Configure Interface Status** → Make the selections shown in the *Configure* dialog box → Click **OK**, and then **Save** your project.

This process enables RSVP on all interfaces along the path between the two voice parties that need to utilize RSVP.

Configure the hosts and routers:

In OPNET IT Guru, the RSVP process runs only in IP-enabled nodes. The advanced versions (***_adv**) of those node models must be used, as we did already, to configure RSVP-related parameters. In addition, the RSVP model in OPNET IT Guru requires either WFQ or custom queuing schemes.

1. Right-click on the **Voice_RSVP Caller** node → **Edit Attributes**.
   a. Expand the **Application: Supported Profiles** hierarchy and its **row 0** hierarchy → Assign **VoIP_RSVP Profile** to the **Profile Name** attribute.
   b. Expand the **Application: RSVP Parameters** hierarchy → Expand its **Voice** hierarchy → **Enable** the **RSVP Status** → Expand the **Profile List** hierarchy → Assign to the **Profile** attribute of row 0 the value **RSVP_Profile** as shown.
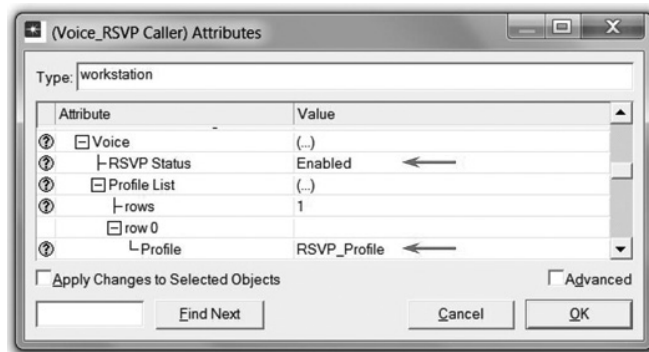
   c. Expand the **IP Host Parameters** hierarchy → Expand its **Interface Information** hierarchy → Expand the **QoS Information** hierarchy → Assign **WFQ** to the **Queuing Scheme** attribute → Assign **ToS Based** to the **Queuing Profile** attribute → Assign **RSVP Enabled** to the **RSVP Info** attribute as shown.
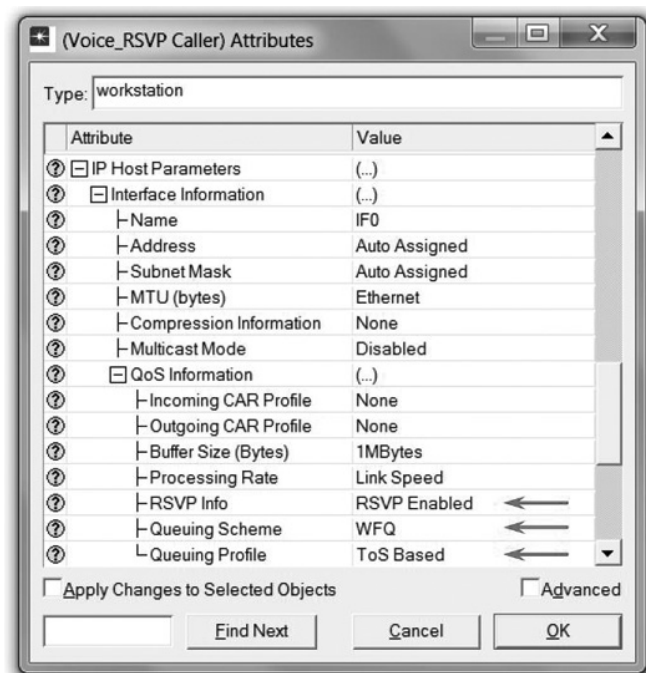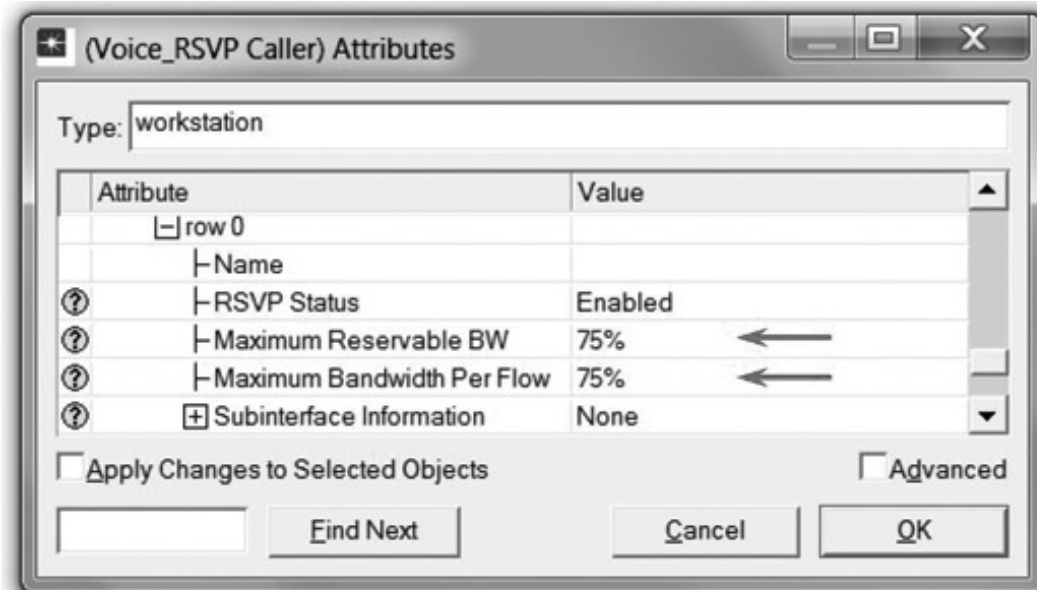
Type of Service (ToS) is assigned to the IP packets. It represents a session attribute that allows packets to be provided the appropriate service in the IP queues.

Maximum Reservable BW specifies the percentage of the bandwidth of the connected link that RSVP can reserve on the interface.

Maximum Bandwidth Per Flow specifies the amount of reservable bandwidth that can be allocated to a single flow.

d. Expand the **RSVP Protocol Parameters** hierarchy → Expand the **Interface Information** hierarchy. (You should notice that the word *Enabled* is listed in the summary line. When you expand it, you will see that it is the value of **RSVP Status**. If *Enabled* is not listed, go back to the *Configure the Interfaces* steps.) → Expand the hierarchy of the row of that interface → Assign **75%** to both the **Maximum Reservable BW** and **Maximum Bandwidth Per Flow** attributes as shown:

Attribute	Value
⊟ row 0	
├ Name	
├ RSVP Status	Enabled
├ Maximum Reservable BW	75% ⟵
├ Maximum Bandwidth Per Flow	75% ⟵
⊞ Subinterface Information	None

(Voice_RSVP Caller) Attributes — Type: workstation. Apply Changes to Selected Objects. Advanced. Find Next. Cancel. OK.)

e. Click **OK**.

2. Right-click on the **Voice_RSVP Called** node → **Edit Attributes**.

a. Edit the **Application: Supported Services** attribute. The *Application: Supported Services Table* will pop up → In that table, replace the **VoIP Application** with **VoIP_RSVP** and click **OK**.

b. Expand the **Application: RSVP Parameters** hierarchy → Expand its **Voice** hierarchy → **Enable** the RSVP Status → Expand the **Profile List** hierarchy → Edit the value of the **Profile** attribute of row 0 and enter **RSVP_Profile**.

c. Expand the **IP Host Parameters** hierarchy → Expand its **Interface Information** hierarchy → Expand the **QoS Information** hierarchy → Assign **WFQ** to the **Queuing Scheme** attribute → Assign **ToS Based** to the **Queuing Profile** attribute → Assign **RSVP Enabled** to the **RSVP Info** attribute.

d. Expand the **RSVP Protocol Parameters** hierarchy → Expand the **Interface Information** hierarchy. (You should notice that the RSVP Status of the interface that is connected to the router is *Enabled*. If not, go back to the *Configure the Interfaces* steps.) → Expand the hierarchy of the row of that interface → Assign **75%** to both **Maximum Reservable BW** and **Maximum Bandwidth Per Flow** attributes.

e. Click **OK**, and **Save** your project.

3. Right-click on the **East Router** node → **Edit Attributes**.

a. Click on the **Ethernet4_slip8_gtwy** value of the model attribute → Select **Edit** → Select the **Ethernet4_slip8_gtwy_adv** model.

b. Expand the **RSVP Protocol Parameters** hierarchy → Expand the **Interface Information** hierarchy. (You should notice that the RSVP Status of two interfaces, which are connected to the **West Router** and the **Voice_RSVP Called** nodes, are *Enabled*. If not, go back to the *Configure the Interfaces* steps.) → Expand the hierarchies

of the rows of these two enabled interfaces → Assign **75%** to both **Maximum Reservable BW** and **Maximum Bandwidth Per Flow** attributes.

 c. Expand the **IP Routing Parameters** hierarchy → Expand the **Interface Information** hierarchy → Expand the hierarchies of the rows of the same two interfaces you con-figured in the previous step (step b) → Expand the **QoS Information** hierarchy for both → Set **Queuing Scheme** to **WFQ** and **Queuing Profile** to **ToS Based** for both.

 d. Click **OK**, and **Save** your project.

4. Right-click on the **West Router** node → **Edit Attributes**.

 a. Click on the **Ethernet4_slip8_gtwy** value of the model attribute → Select **Edit** → Select the **Ethernet4_slip8_gtwy_adv** model.

 b. Expand the **RSVP Protocol Parameters** hierarchy → Expand the **Interface Information** hierarchy. (You should notice that the RSVP Status of two interfaces, which are connected to the **East Router** and the **Voice_RSVP Caller** nodes, are *Enabled*. If not, go back to the *Configure the Interfaces* steps.) → Expand the hierar-chies of the rows of these two enabled interfaces → Assign **75%** to both **Maximum Reservable BW** and **Maximum Bandwidth Per Flow** attributes.

 c. Expand the **IP Routing Parameters** hierarchy → Expand the **Interface Information** hierarchy → Expand the hierarchies of the rows of the same two interfaces you con-figured in the previous step (step b) → Expand the **QoS Information** hierarchy for both → Set **Queuing Scheme** to **WFQ** and **Queuing Profile** to **ToS Based** for both.

 d. Click **OK**, and **Save** your project.

Choose the Statistics

We will select statistics from three different nodes:

Voice_RSVP caller statistics:

1. Right-click on the **Voice_ RSVP Caller** node and select **Choose Individual Statistics** from the pop up menu.

2. Expand the **RSVP** hierarchy and select **Number of Path States**.

3. Right-click on the **Number of Path States** statistic → Select **Change Draw Style** from the pop up menu → Choose **bar chart**.

4. Right-click on the **Number of Path States** statistic → Select **Change Collection Mode** from the pop up menu → Check the **Advanced** checkbox → From the **Capture mode** drop-down menu, select **all values,** as shown → Click **OK**.

5. Expand the **Voice Calling Party** hierarchy and select the following statistics: **Packet Delay Variation** and **Packet End-to-End Delay (sec)**.

6. Click **OK**.

Voice_RSVP called statistics:

1. Right-click on the **Voice_ RSVP Called** node and select **Choose Individual Statistics** from the pop up menu.

2. Expand the **RSVP** hierarchy and select **Number of Resv States**.

3. Right-click on the **Number of Resv States** statistic → Select **Change Draw Style** from the pop up menu → Choose **bar chart**.

4. Right-click on the **Number of Resv States** statistic → Select **Change Collection Mode** from the pop up menu → Check the **Advanced** checkbox → From the **Capture mode** drop-down menu, select **all values** → Click **OK** twice.

Voice caller statistics:

1. Right-click on the **Voice Caller** node and select **Choose Individual Statistics** from the pop up menu.

2. Expand the **Voice Calling Party** hierarchy and select the following statistics: **Packet Delay Variation** and **Packet End-to-End Delay (sec)** →Click **OK**.

Packet Delay Variation is the variance among end-to-end delays for voice packets received by this node.

Packet End-to-End Delay for a voice packet is measured from the time it is created to the time it is received.

Configure the Simulation

Here we need to configure the duration of the simulation:

1. Click on ![icon] and the *Configure Simulation* window should appear.
2. Make sure that the duration is set to **150 seconds**.
3. Click on the **Global Attributes** tab and make sure that the following attribute is enabled:
   a. **RSVP Sim Efficiency = Enabled**. This decreases the simulation time and memory requirements by not sending refresh messages (i.e., Path and Resv refreshes).
4. Click **OK**, and **Save** your project.

Run the Simulation

To run the simulation:

1. Click on ![icon], and then click the **Run** button. Depending on the speed of your processor, this may take several seconds to complete.
2. After the simulation completes, click **Close**, and **Save** your project.

## View the Results

To view and analyze the results:

1. Select **View Results** from the **Results** menu.
2. As shown in the following figure, choose the **Packet End-to-End Delay** for both the **Voice Caller** and **Voice_RSVP Caller** nodes. Choose **Overlaid Statistics** and **time_average**.

132
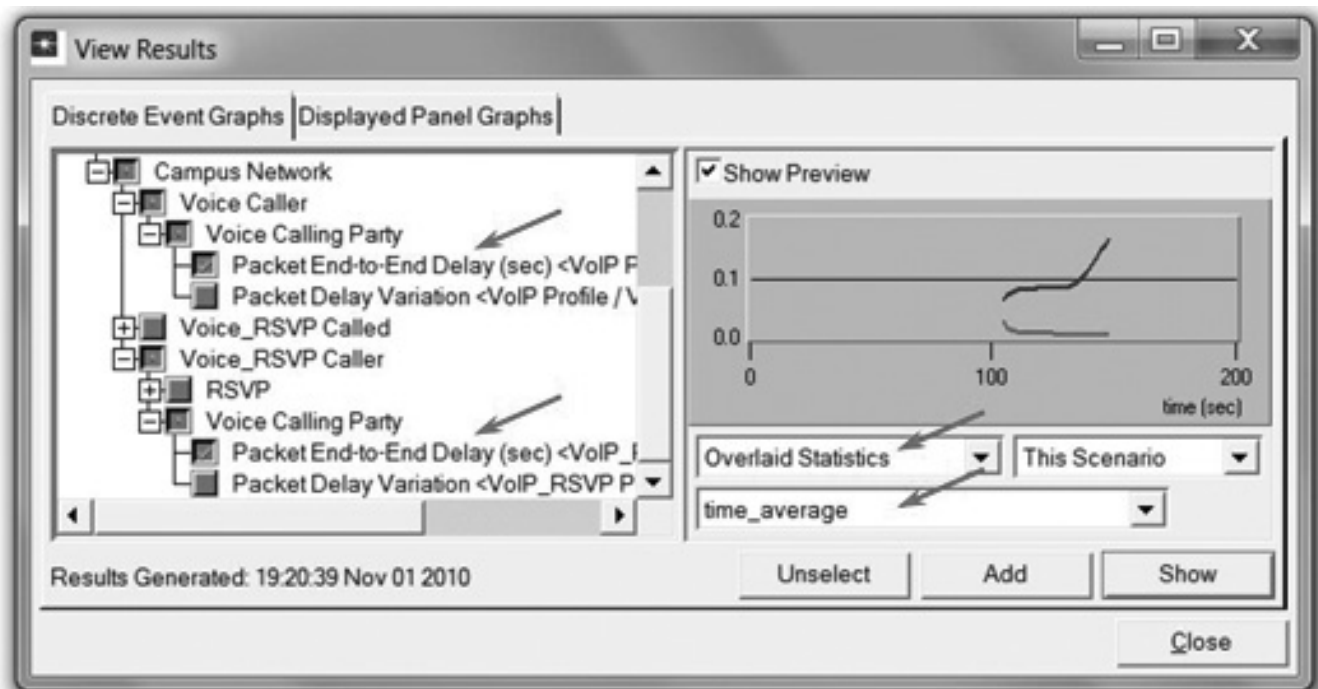
3. Click **Show** to get the following graph. (*Note:* To zoom in on the graph, click and drag your mouse to draw a rectangle around the area of interest and release the mouse button.)
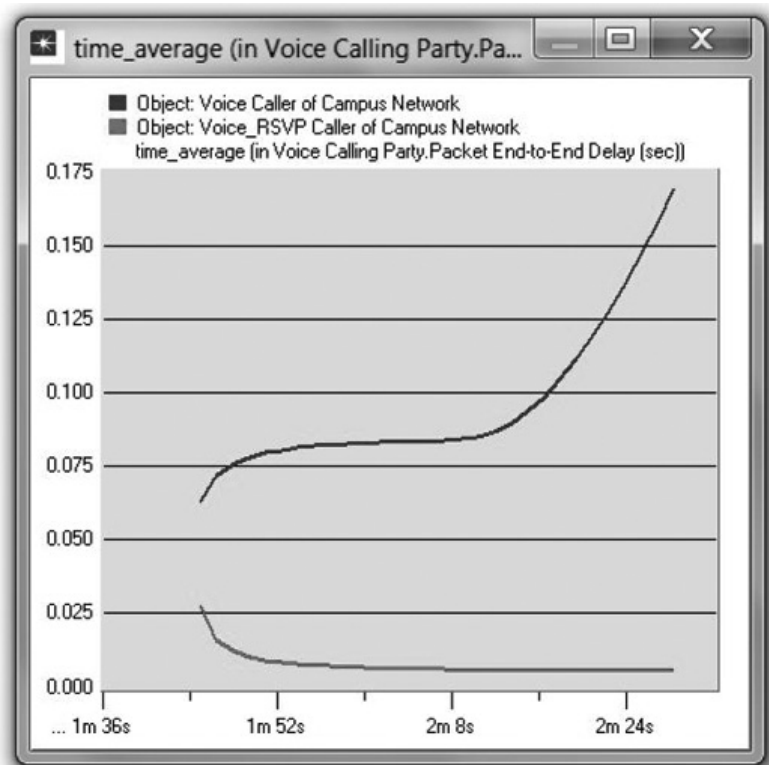
4. Similarly, you can get the following graph that compares the **Packet Delay Variation** for both the **Voice Caller** and **Voice_RSVP Caller** nodes. (*Note:* Make sure to "unselect" the statistics you chose for the previous graph.)
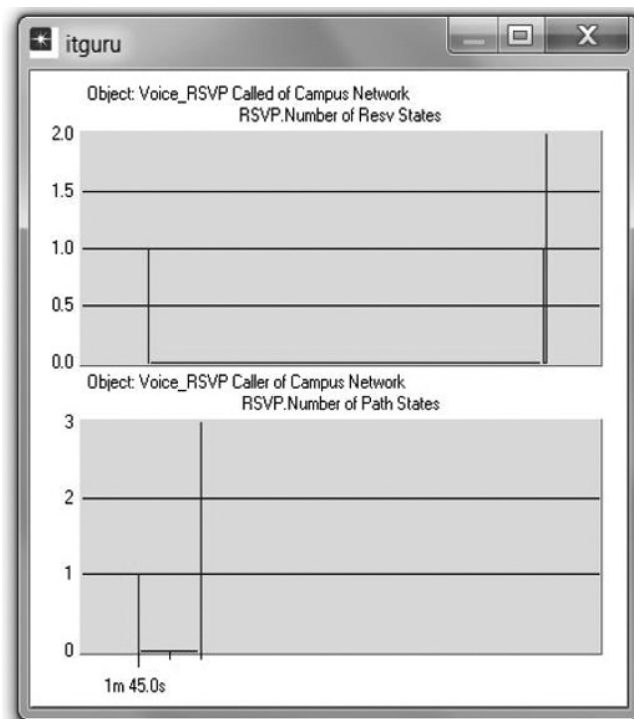
133
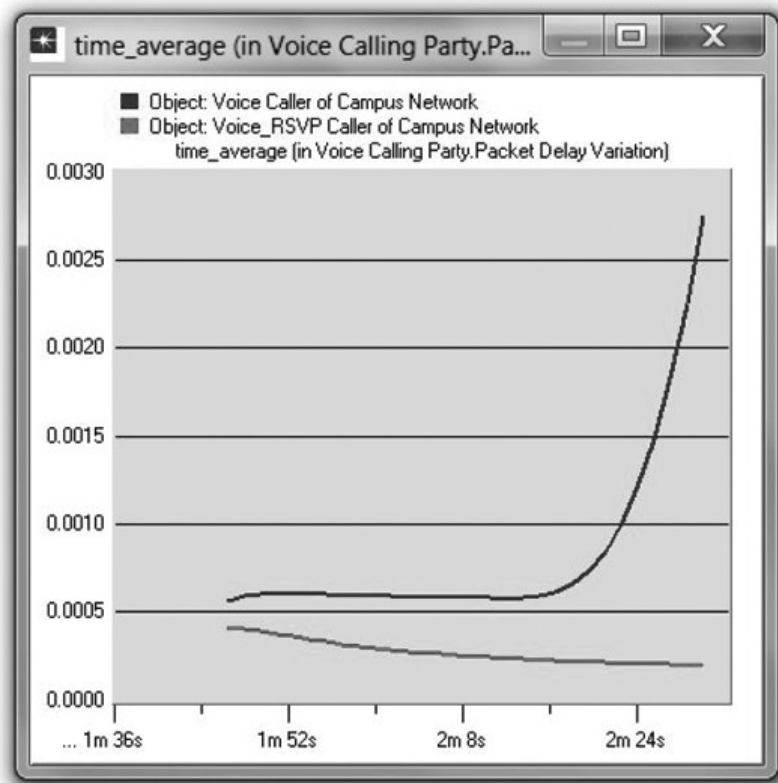
5. Finally, prepare the graph that displays the number of Path and Resv states by selecting the following statistics. Make sure to select **Stacked Statistics** and **As Is** as shown.
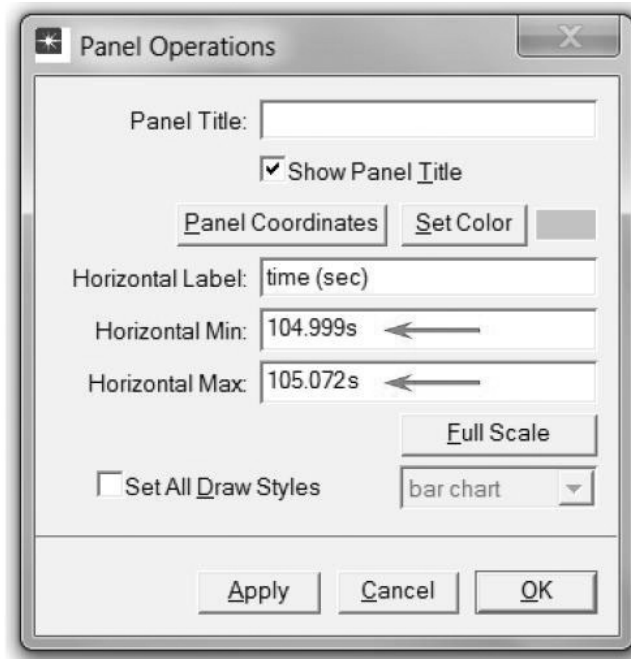

134
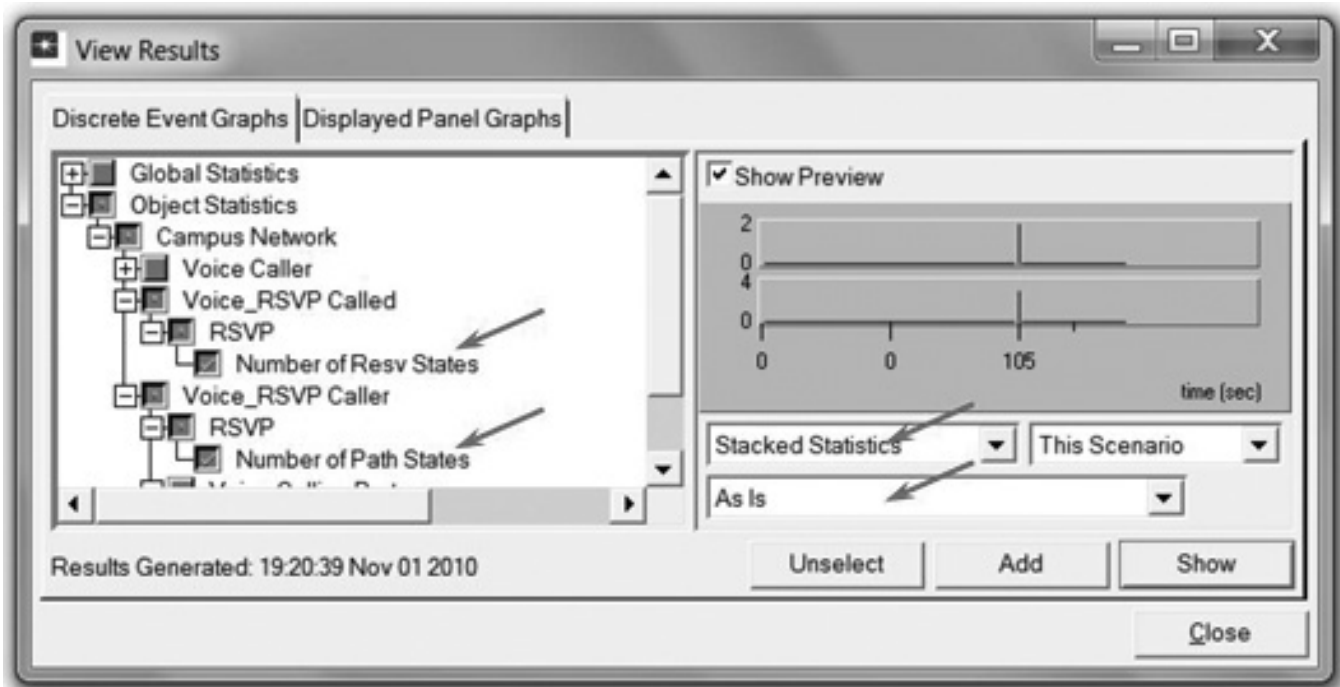
6. Click **Show** and **Right-click** on the resulting graph and choose **Edit Panel Properties →** Change the assigned values to the **Horizontal Min** and **Horizontal Max** fields as shown here:

7. Click **OK**. The resulting graph should resemble the one shown.

FURTHER READING

OPNET RSVP Model Description: From the **Protocols** menu, select **RSVP → Model Usage Guide**.

EXERCISES

1. Analyze the graphs we obtained in this lab. Show the effect of RSVP on the voice application and explain the obtained numbers of Path and Resv states.
2. How does the data rate of the link connecting the **East** and **West** routers affect the performance (e.g., **Packet End-to-End Delay)** of the voice and video conference applications? To answer this question, create a new scenario as a duplicate of the **QoS_RSVP** scenario. Name the new scenario **Q2_HighRate**. In the **Q2_HighRate** scenario, replace the current **PPP_DS1** link (data rate 1.544 Mbps) with a **PPP_DS3** link (data rate 44.736 Mbps).

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.