Laboratory
5

ATM

A Connection-Oriented, Cell-Switching Technology

Objective

The objective of this lab is to examine the effect of ATM adaptation layers and service classes on the performance of the network.

Overview

Asynchronous Transfer Mode (ATM) is a connection-oriented, packet-switched technology. The packets that are switched in an ATM network are of a fixed length, 53 bytes, and are called *cells*. The cell size has a particular effect on carrying voice traffic effectively. The ATM Adaptation Layer (AAL) sits between ATM and the variable-length packet protocols that might use ATM, such as IP. The AAL header contains the information needed by the destination to reassemble the individual cells back into the original message. Because ATM was designed to support all sorts of services, including voice, video, and data, it was felt that different services would have different AAL needs. AAL1 and AAL2 were designed to support applications, like voice, that require guaranteed bit rates. AAL3/4 and AAL5 provide support for packet data running over ATM.

ATM provides QoS capabilities through its five service classes: CBR, VBR-rt, VBR-nrt, ABR, and UBR. With CBR (constant bit rate), sources transmit stream traffic at a fixed rate. CBR is well-suited for voice traffic that usually requires circuit switching. Therefore, CBR is very important to telephone companies. UBR, unspecified bit rate, is ATM's best-effort service. There is one small difference between UBR and the best-effort model. Because ATM always requires a signaling phase before data is sent, UBR allows the source to specify a maximum rate at which it will send. Switches may make use of this information to decide whether to admit or reject the new VC (virtual circuit).

In this lab you will set up an ATM network that carries three applications: Voice, Email, and FTP. You will study how the choice of the adaptation layer as well as the service classes can affect the performance of the applications.

Procedure

Create a New Project

1. Start **OPNET IT Guru Academic Edition** ⇒ Choose **New** from the **File** menu.

2. Select **Project** and click **OK** ⇒ Name the project **<your initials>_ATM**, and the scenario **CBR_UBR** ⇒ Click **OK**.

3. In the *Startup Wizard: Initial Topology* dialog box, make sure that **Create Empty Scenario** is selected ⇒ Click **Next** ⇒ Select **Choose From Maps** from the *Network Scale* list ⇒ Click **Next** ⇒ Choose **USA** from the maps ⇒ Click **Next** ⇒ From the *Select Technologies* list, include the **atm_advanced** Model Family as shown in the following figure⇒ Click **Next** ⇒ Click **OK**.

Create and Configure the Network

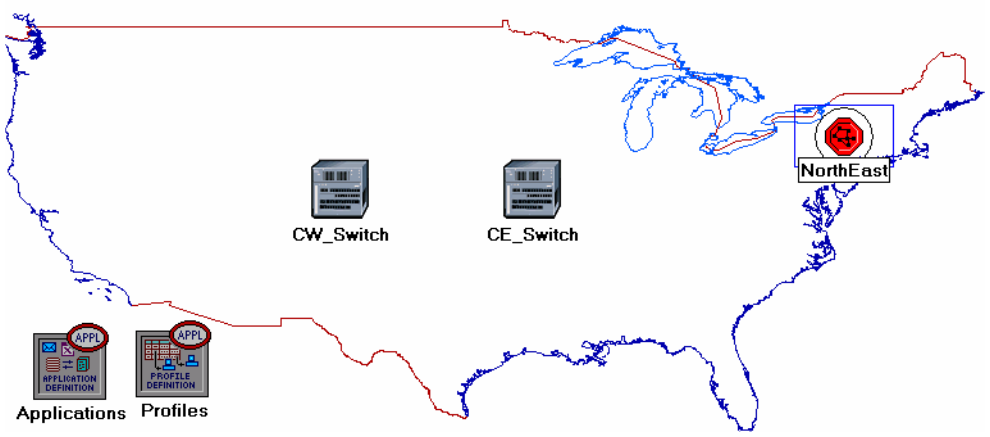
Initialize the Network:

1. The *Object Palette* dialog box should now be on the top of your project workspace. If it is not there, open it by clicking  . Make sure that **atm_advanced** is selected from the pull-down menu on the object palette.

2. Add to the project work space the following objects from the palette: **Application Config**, **Profile Config**, two **atm8_crossconn_adv** switches, and a **subnet**.

   a. To add an object from a palette, click its icon in the object palette ⇒ Move your mouse to the workspace and click to place the object ⇒ Right-click to get out of "object creation mode."

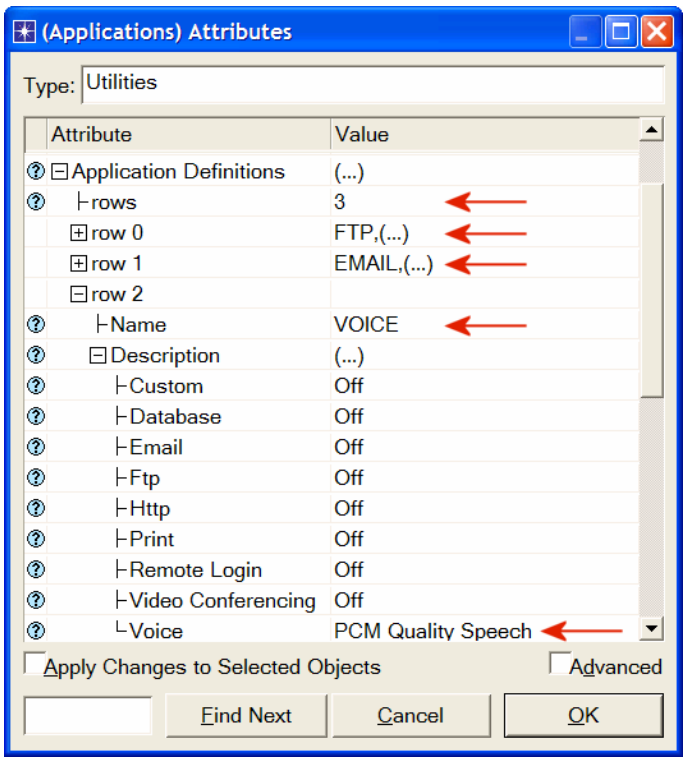
3. Close the *Object Palette* dialog box and rename (right-click on the node ⇒ **Set Name**) the objects you added as shown and then save your project:



Configure the Applications:

1. Right-click on the **Applications** node ⇒ **Edit Attributes** ⇒ Expand the **Application Definitions** attribute and set **rows** to 3 ⇒ Name the rows: **FTP**, **EMAIL**, and **VOICE**.
   i. Go to the **FTP** row ⇒ Expand the **Description** hierarchy ⇒ Assign **High Load** to FTP.
   ii. Go to the **EMAIL** row ⇒ Expand the **Description** hierarchy ⇒ Assign **High Load** to Email.
   iii. Go to the **VOICE** row ⇒ Expand the **Description** hierarchy ⇒ Assign **PCM Quality Speech** to Voice.

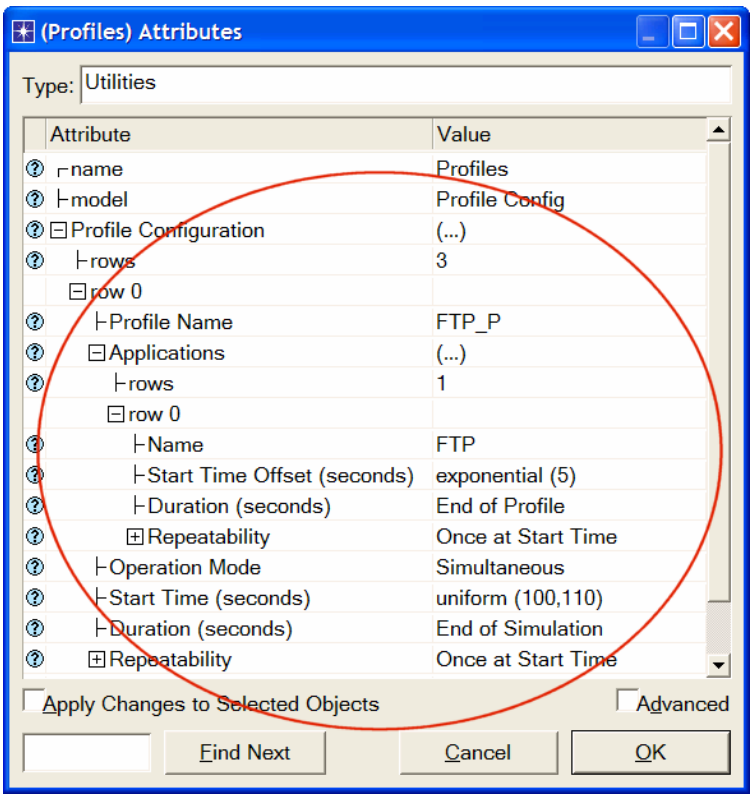
PCM stands for Pulse Code Modulation. It is a procedure used to digitize speech before transmitting it over the network.



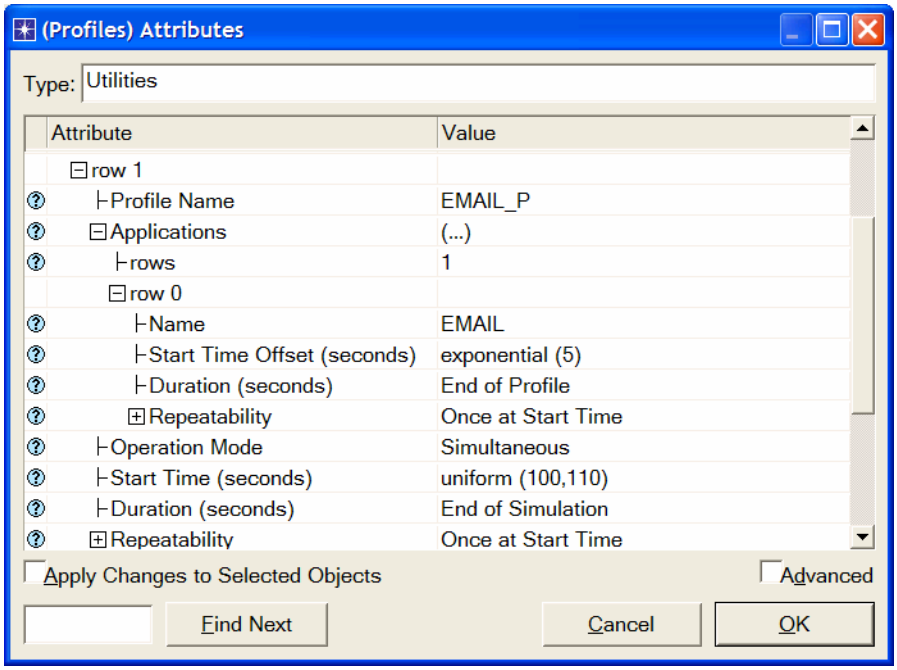
2. Click **OK** and then save your project.

Configure the Profiles:

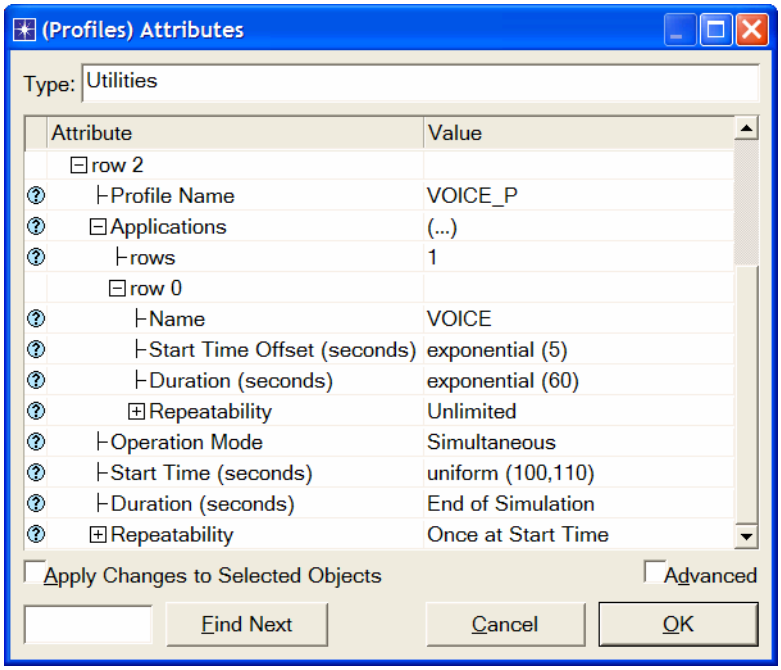
1. Right-click on the **Profiles** node ⇒ **Edit Attributes** ⇒ Expand the **Profile Configuration** attribute and set **rows** to 3.
   i. Name and set the attributes of row 0 as shown:



   ii. Name and set the attributes of row 1 as shown:



iii. Name and set the attributes of row 2 as shown. (*Note:* To set the **Duration** to **exponential(60)**, you will need to assign "**Not Used**" to the "**Special Value**") ⇒ Close the *Object Palette* dialog box.

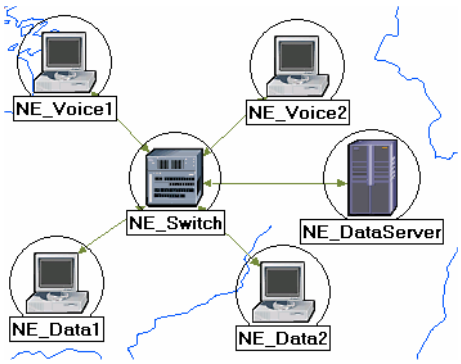


Configure the NorthEast Subnet:

1. Double-click on the **NorthEast** subnet node. You get an empty workspace, indicating that the subnet contains no objects.

2. Open the object palette  and make sure that **atm_advanced** is selected from the pull-down menu on the object palette..

3. Add the following items to the subnet workspace: one **atm8_crossconn_adv** switch, one **atm_uni_server_adv**, four **atm_uni_client_adv**, and connect them with bidirectional **atm_adv** links ⇒ Close the palette ⇒ Rename the objects as shown.



4. Change the **data rate** attribute for all links to **DS1**.

Hint: To edit the attributes of multiple nodes in a single operation, select all nodes simultaneously using shift and left-click; then **Edit Attributes** of one of the nodes, and select **Apply Changes to Selected Objects**.

5. For both **NE_Voice1** and **NE_Voice2**, set the following attributes:

   i. Set **ATM Application Parameters** to **CBR only.**

   ii. Expand the **ATM Parameters** hierarchy ⇒ Set **Queue Configuration** to **CBR only.**

   iii. Expand the **Application: Supported Profiles** hierarchy ⇒ Set **rows** to 1 ⇒ Expand the **row 0** hierarchy ⇒ Set **Profile Name** to **VOICE_P.**

   iv. **Application: Supported Services** ⇒ Edit its value ⇒ Set **rows** to **1** ⇒ Set **Name** of the added row to **VOICE** ⇒ Click **OK**.

   v. Expand the **Application: Transport Protocol** hierarchy ⇒ **Voice Transport = AAL2.**

Client Address is the Transport Adaptation Layer (TPAL) address of the node. This value must be unique for each node.
The **TPAL** model suite presents a basic, uniform interface between applications and transport layer models. All interactions with a remote application through TPAL are organized into sessions. A session is a single conversation between two applications through a transport protocol.

6. For **NE_Voice1**, select **Edit Attributes** ⇒ Edit the value of the **Client Address** attribute and write down **NE_Voice1**.

7. For **NE_Voice2**, select **Edit Attributes** ⇒ Edit the value of the **Client Address** attribute and write down **NE_Voice2**.

8. Configure the **NE_DataServer** as follows:

   i. **Application: Supported Services** ⇒ **Edit** its value ⇒ Set **rows** to 2 ⇒ Set **Name** of the added rows to**: EMAIL** and **FTP** ⇒ Click **OK.**

   ii. Expand the **Application: Transport Protocol Specification** hierarchy ⇒ **Voice Transport = AAL2.**

   iii. Edit the value of the **Server Address** attribute and write down **NE_DataServer**.

9. For both **NE_Data1** and **NE_Data2**, set the following attributes:

   i. Expand the **ATM Parameters** hierarchy ⇒ Set **Queue Configuration** to **UBR.**

   ii. Expand the **Application: Supported Profiles** hierarchy ⇒ Set **rows** to 2 ⇒ Set **Profile Name** to **FTP_P** (for **row 0**) and to **EMAIL_P** (for **row 1**)**.**

The **queue configuration** specifies a one-to-one mapping between output port queues and the QoS that they support. A specific queue may be configured to support a specific QoS.

10. For **NE_Data1**, select **Edit Attributes** ⇒ Edit the value of the **Client Address** attribute and write down **NE_Data1**.

11. For **NE_Data2**, select **Edit Attributes** ⇒ Edit the value of the **Client Address** attribute and write down **NE_Data2**.

12. Save your project.

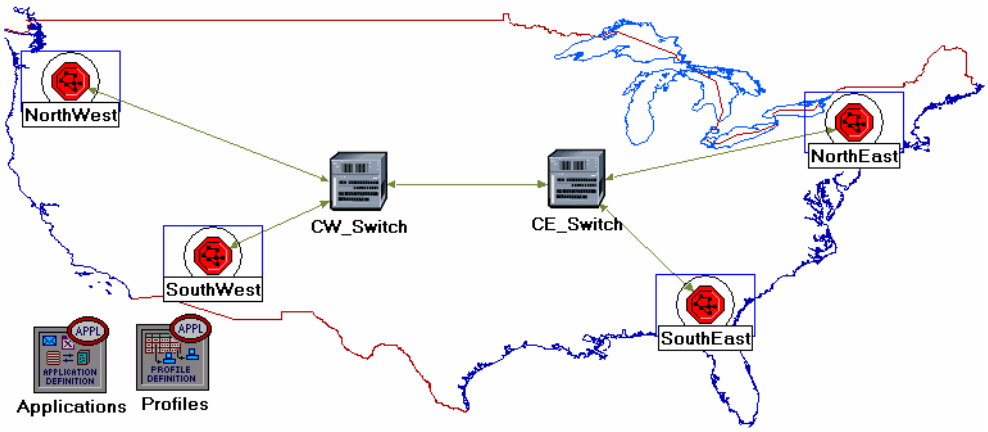
Add Remaining Subnets:

1. Now you completed the configuration of the *NorthEast* subnet. To go back to the project space, click the **Go to the higher level**  button.

The subnets of the other regions should be similar to the *NorthEast* one except for the names and client addresses.

2. Make three copies of the subnet we just created.

3. Rename (right-click on the node ⇒ **Set Name**) the subnets and connect them to the switches with bidirectional **atm_adv** links as shown. (*Note:* You will be asked to pick the node inside the subnet to be connected to the link. Make sure to choose the "switch" inside each subnet to be connected.)



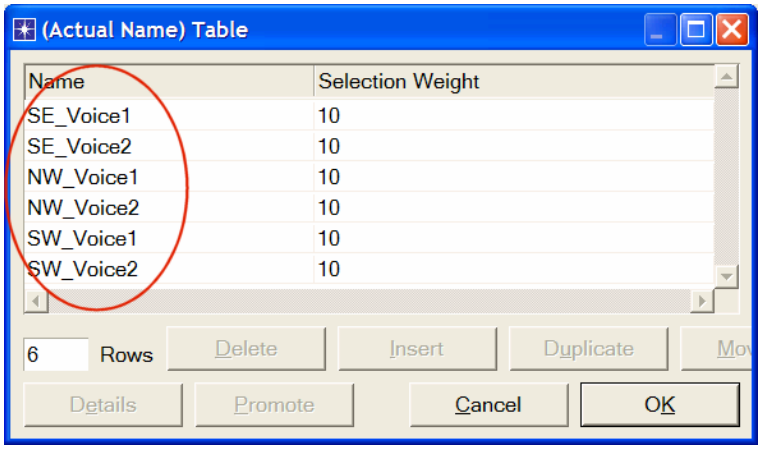
4. Change the **data rate** for all links to **DS1**.

5. Select and double-click *each* of the new subnets (total four subnets) and change the **names**, **client address**, and **server address** of the nodes inside these subnets as appropriate (e.g., replace NE with SW for the *SouthWest* subnet).

Hint: To do step 6, you can right-click on any **voice** station and choose **Edit Similar Nodes**. This brings up a table in which each node occupies one row and attributes are shown in the columns. Follow the same procedure with similar steps in this lab.

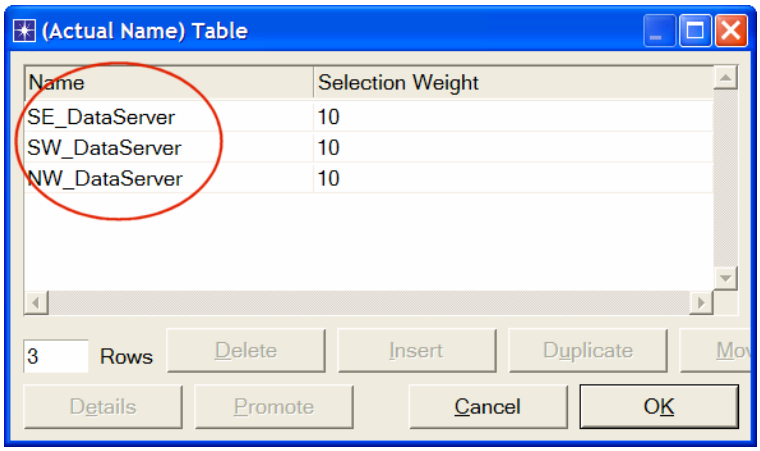
6. For all **voice** stations in all subnets (total of eight stations), edit the value of the **Application: Destination Preferences** attribute as follows:

   i. Set **rows** to 1 ⇒ Set **Symbolic Name** to **Voice Destination** ⇒ Click on **(…)** under the **Actual Name** column ⇒ Set **rows** to 6 ⇒ For each row choose a voice station that is not in the current subnet. The following figure shows the actual names for one of the voice stations in the *NorthEast* subnet:



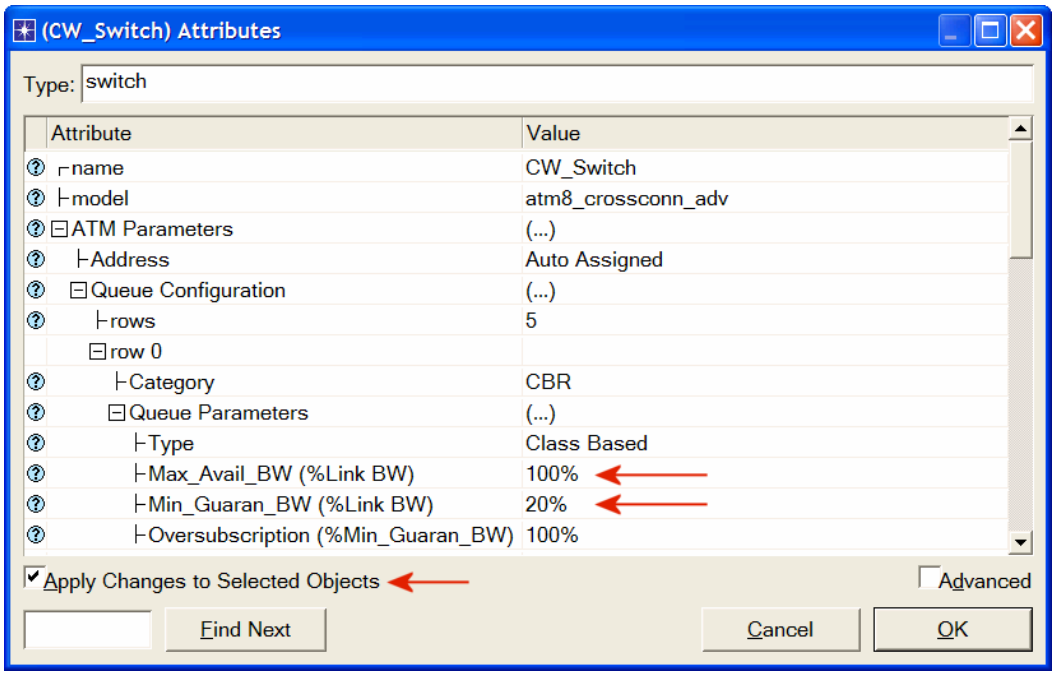
7. For all **data** stations in all subnets (total of eight stations), configure the **Application: Destination Preferences** attribute as follows:

   i. Set **rows** to 2 ⇒ Set **Symbolic Name** to **FTP Server** for the one row and **Email Server** for the other row ⇒ For each symbolic name (i.e., FTP Server and Email Server), click on **(…)** under the **Actual Name** column ⇒ Set **rows** to 3 ⇒ For each row choose a data server that is not in the current subnet. The following figure shows the actual names for one of the data stations in the *NorthEast* subnet:



Hint: To do step 8 in a single operation, you can use the right-click menu on any switch to **Select Similar Nodes**; then **Edit Attributes**, and check **Apply Changes to Selected Objects**. This feature does work, even across objects in different subnets.

8. For all **switches** in the network (total of six switches), configure the **Max_Avail_BW** of the CBR queue to be 100%, as shown below, and the **Min_Guaran_BW** to be 20%.



Max_Avail_BW is the maximum bandwidth allocated to this queue. Calls will be admitted into this queue only if they are within the maximum available bandwidth requirement.

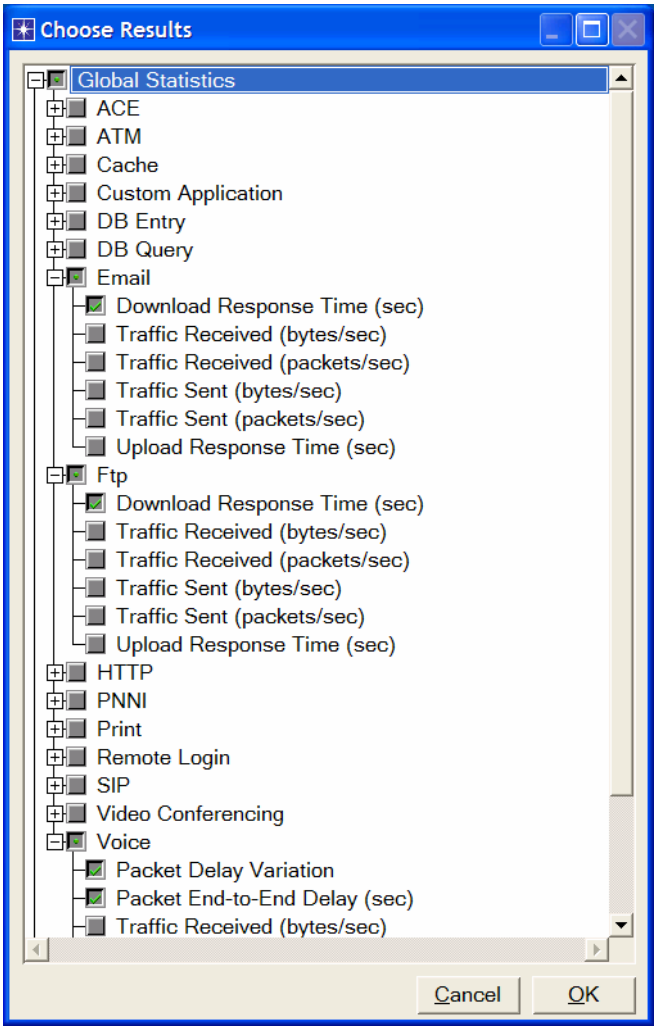
9. Save your project.

Choose the Statistics

To test the performance of the applications defined in the network, we will collect one of the many available statistics as follows:

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 following 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 be **10.0 minutes**.
3. Click **OK**. We will be running the simulation later.

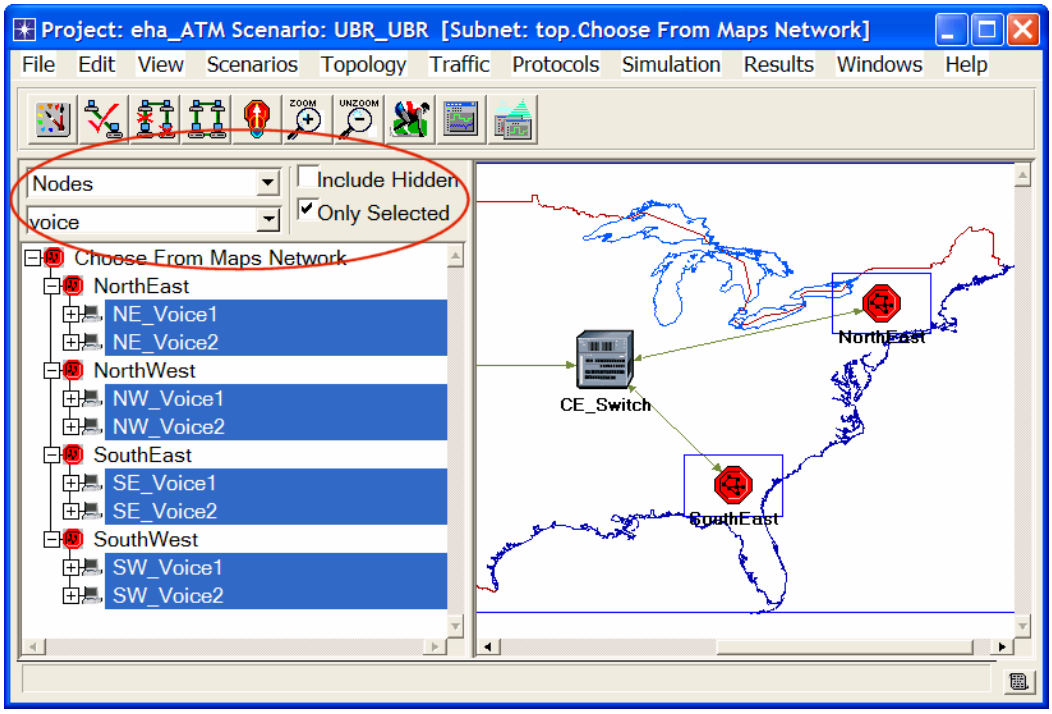
Duplicate the Scenario

In the network we just created, we used the CBR service class for the Voice application and the UBR service class for the FTP and Email applications. To analyze the effect of such different classes of services, we will create another scenario that is similar to the CBR_UBR scenario we just created but it uses only one class of service, UBR, for all applications. In addition, to test the effect of the ATM adaptation layer, in the new scenario we will use AAL5 for the Voice application rather than AAL2.

1. Select **Duplicate Scenario** from the **Scenarios** menu and give it the name **UBR_UBR** ⇒ Click **OK**.
2. For all voice stations in all subnets, reconfigure them as follows. (Check the note below for a faster way to carry out this step.)
   i. Set **ATM Application Parameters** to **UBR only.**
   ii. **ATM Parameters** ⇒ Set **Queue Configuration** to **UBR.**
   iii. **Application: Transport Protocol** ⇒ Set **Voice Transport** to **AAL5.**
3. Save your project.

Note: One easy way to carry out step 2 above is through the network browser as follows:

- Select **Show Network Browser** from the **View** menu.
- Select **Nodes** from the drop-down menu, and check the **Only Selected** check box as shown in the following figure.
- Write **voice** in the find field and click **Enter.**
- In the network browser you should see a list of all voice stations selected.
- Right-click on any of the voice stations in the list, select **Edit Attributes**, and check **Apply Changes to Selected Objects**.
- Carry out the configuration changes in step 2 above.
- To hide the network browser, deselect **Show Network Browser** from the **View** menu.

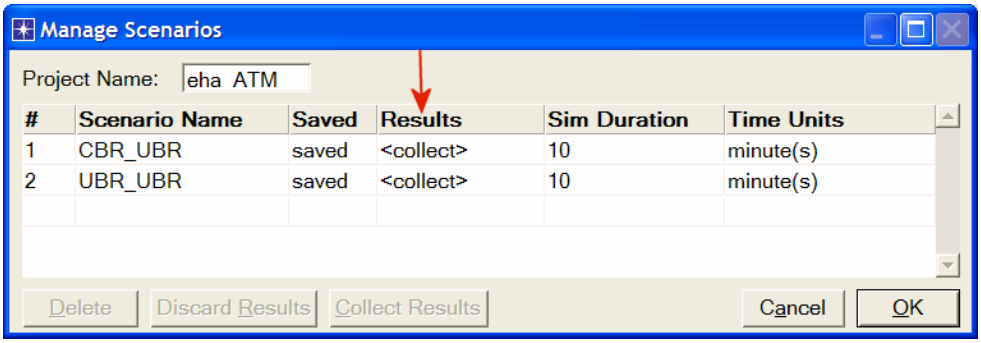


Run the Simulation

To run the simulation for both scenarios simultaneously:

1. Go to the **Scenarios** menu ⇒ Select **Manage Scenarios**.

2. Change the values under the **Results** column to **<collect>** (or **<recollect>**) for both scenarios. Compare to 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**.

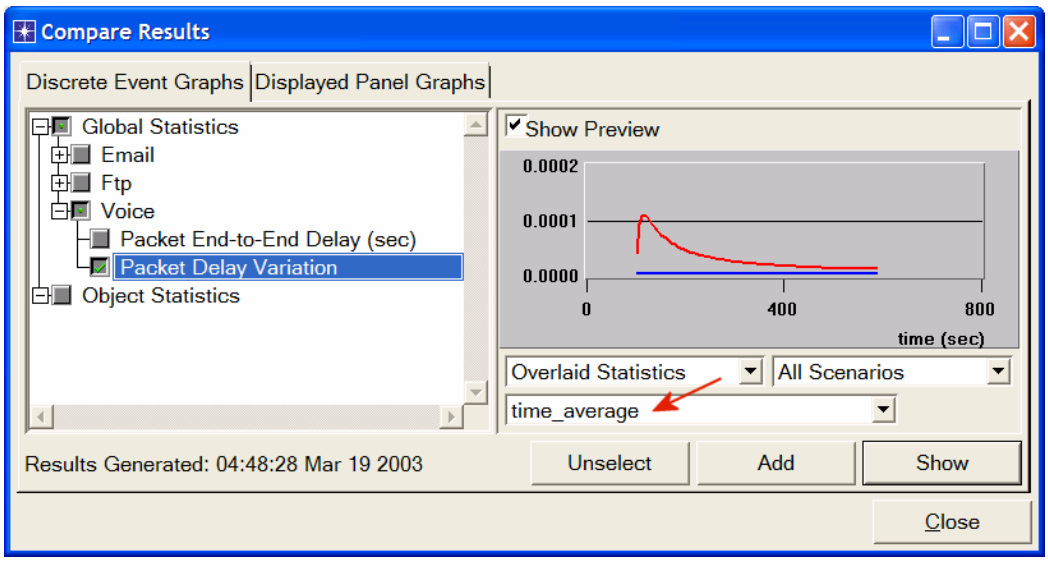
5. Save your project.

View the Results

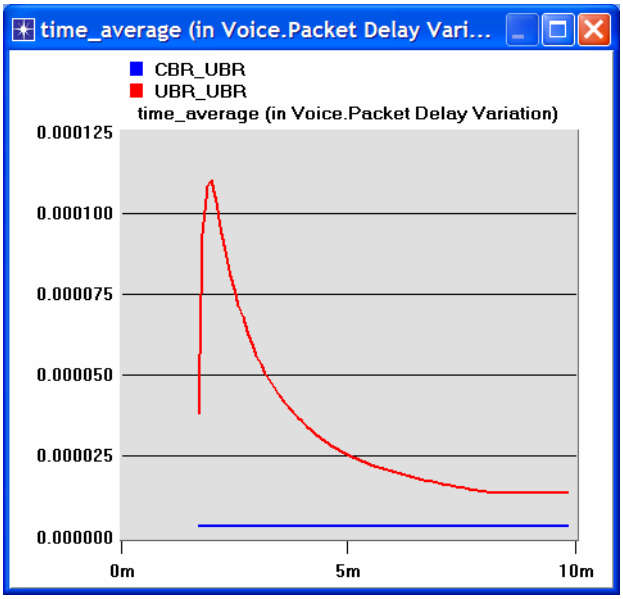
To view and analyze the results:

1. Select **Compare Results** from the **Results** menu.

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



3. Select the voice **Packet Delay Variation** statistic and click **Show**. The resulting graph should resemble the one below. (*Note:* Result may vary slightly due to different node placement.)



Further Readings

- OPNET ATM Model Description: From the **Protocols** menu, select **ATM** ⇒ **Model Usage Guide**.

Questions

1) Analyze the result we obtained regarding the voice **Packet Delay Variation** time. Obtain the graphs that compare the **Voice packet end-to-end delay**, the **Email download response time**, and the **FTP download response time** for both scenarios. Comment on the results.

2) Create another scenario as a duplicate of the **CBR_UBR** scenario. Name the new scenario **Q2_CBR_ABR**. In the new scenario you should use the **ABR** class of service for data, i.e., the FTP and Email applications in the data stations. Compare the performance of the **CBR_ABR** scenario with that of the **CBR_UBR** scenario.

Hints:
- To set ABR class of service to a node, assign **ABR Only** to its **ATM Application Parameters** attribute and **ABR only (Per VC Queue)** to its **Queue Configuration** (one of the **ATM Parameters**).
- For all **switches** in the network (total of 6 switches), configure the **Max_Avail_BW** of the **ABR** queue to be 100% and the **Min_Guaran_BW** to be 20%.

3) Edit the **FTP** application defined in the **Applications** node so that its **File Size** is twice the current size (i.e., make it 100000 bytes instead of 50000 bytes). Edit the **EMAIL** application defined in the **Applications** node so that its **File Size** is five times the current size (i.e., make it 10000 bytes instead of 2000 bytes). Study how this affects the voice application performance in both the **CBR_UBR** and **UBR_UBR** scenarios. (*Hint:* to answer this question, you might need to create duplicates of the **CBR_UBR** and **UBR_UBR** scenarios. Name the new scenarios **Q3_CBR_UBR** and **Q3_UBR_UBR** respectively)

Lab Report

Prepare a report that follows the guidelines explained in Lab 0. The report should include the answers to the above questions 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.