CS 2600 Network Simulation Lab

Riverbed Modeler Lab Exercise 2: Small Internetworks

Approximate time required: 2 hours

This Riverbed Modeler lab exercise was adapted from "Small Networks Tutorial" provided by Riverbed. It has been modified for compatibility with Riverbed Modeler Academic Edition v17.5.A.

Small Internetworks

In this lab exercise, you will see how Riverbed Modeler can do organizational scaling to solve a typical "what if" problem. You will learn how to use the Project Editor and other Modeler features to build and analyze network models. Unlike Lab 1, we will construct a model "from scratch", rather than using a pre-built model.

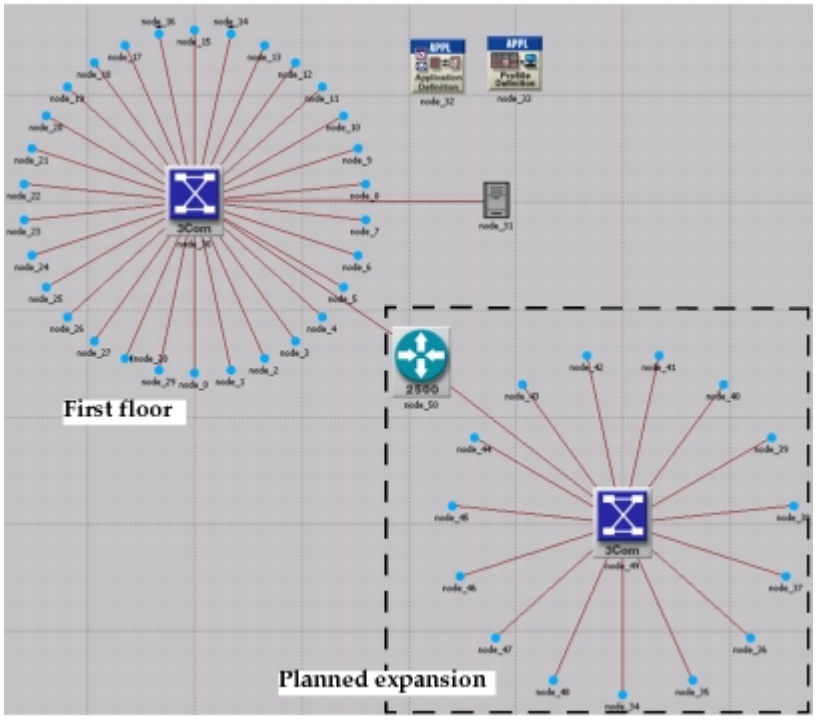
In this tutorial, you will

- Build a network
- Collect statistics about network performance
- Analyze these statistics

Key Concept – You will use the Project Editor to build a topology of a small internetwork, choose statistics to collect, run a simulation, and analyze the results.

In this lab exercise, you plan for the expansion of a small company's intranet (internal network). Currently, the company has a star topology network on the first floor of its office building and plans to add an additional star topology network on another floor (see figure 1). You will build and test this "what-if" scenario to ensure that the load added by the second network will not have a significant negative impact on network performance.

Figure 1 The Final Network



Getting Started

When creating a new network model, you must first create a new **project** and **scenario**. A project is a group of related scenarios that each explore a different aspect of the network.

After creating a new project, use the Startup Wizard to set up a new scenario.

The options in the Wizard let you

- Define the initial topology of the network
- Define the scale and size of the network
- Select a background map for the network
- Associate an object palette with the scenario

Key Concept – The Startup Wizard automatically appears each time you create a new project. The Startup Wizard lets you define certain aspects of the network environment.

The following procedure describes how to use the Startup Wizard to set up a new scenario.

Procedure 1 Setting Up a New Scenario

1. Start Riverbed Modeler (using Administrator privileges).
2. Select **File > New**…
3. Select **Project** from the pull-down menu and click **OK**.
4. Name the project and scenario, without embedded blanks, as follows:
   a. Name the project **<initials>_Sm_Int**. Include your initials in the project name to distinguish it from other versions of this project.
   b. Name the scenario **first_floor**.
   c. Click **OK**.
      - The Startup Wizard opens.
5. Enter the values shown in the following table in the dialog boxes of the Startup Wizard.

Table 1 Values to Enter in the Startup Wizard

Dialog Box Name	Value
1. Initial Topology	Select the default value: **Create empty scenario.**
2. Choose Network Scale	Select **Office**. Select the **Use metric units** checkbox below.
3. Specify Size	Select the default size: **100 m x 100 meters**
4. Select Technologies	Include the **Sm_Int_Model_List** model family.
5. Review	Verify values, then click **Finish**.

- A workspace of the size you specified is created. The object palette you specified opens in a separate window.

  If “Validating Node Self-Description Database…” gets stuck in a loop, make sure that you are running Modeler with Administrator rights.

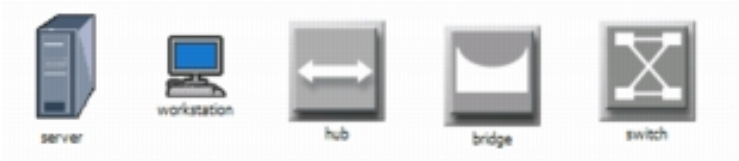
End of Procedure 1

Creating the Network

Key Concept – Network models are created in the Project Editor using **nodes** and **links** from the **object palette**.

Node – A representation of a real-world network object that can transmit and receive information.

Figure 2 Nodes



Link – A communication medium that connects nodes to one another. Links represent physical connectivity (e.g., electrical or fiber optic cables).

Figure 3 A Link

These objects are found in the **object palette**, a dialog box that contains graphical representations of node and link models.

If it is still open, close the object palette.

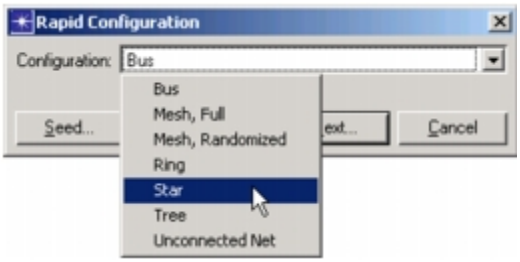
Key Concept – Use any of three methods to create a network topology, or a combination of all three. One method is to import the topology (as we did in Lab 1). Another is to place individual nodes from the object palette into the workspace. The third method is to use **Rapid Configuration**.

Rapid Configuration creates a network in one action after you select a network configuration, the types of nodes within the network, and the types of links that connect the nodes.

Procedure 2 Creating the First-floor Network with Rapid Configuration

1. In the **Project:** dialog box, select **Topology > Rapid Configuration…**
2. Select **Star** from the pull-down menu of available configurations, as shown in figure 4 below, then click **Next…**

Figure 4 Available Configurations Pull-Down Menu



You will use this dialog box to specify the node models and link models in the network. Models follow this naming scheme:

Generic Devices:
<protocol*n*>_..._<protocol*n*>_<function>_<mod>

Vendor Devices:
<Vendor>_<Chassis/Make>_<protocol*n*>

where:

- **<protocol*n*>** specifies a specific protocol supported by the model and the number of ports using that protocol
- **<function>** is an abbreviation of the general function of the model
- **<mod>** indicates the level of derivation of the model

For example:

ethernet2_bridge_int

specifies the intermediate (**int**) derivation of a 2-port Ethernet (**ethernet2**) bridge (**bridge**).

Vendor models have an additional prefix that specifies the vendor and the vendor product number for that particular network object.

For example, the 3Com switch used in this tutorial is named:

3C_SSII_1100_3300_4s_ae52_e48_ge3

This node is a stack of two 3Com SuperStack II 1100 and two SuperStack II 3300 chassis (**3C_SSII_1100_3300**) with four slots (**4s**), 52 auto-sensing Ethernet ports (**ae52**), 48 Ethernet ports (**e48**), and 3 Gigabit Ethernet ports (**ge3**).

End of Procedure 2

Procedure 3 Specifying the Nodes and Links to Use to Build the Network

1. In the **Rapid Configuration:** dialog box (figure 5 below), set the **Center Node Model** to **3C_SSII_1100_3300_4s_ae52_e48_ge3** (the 3Com switch).

2. Set the **Periphery Node Model** to **Sm_Int_wkstn**, and change the **Number** of periphery nodes to **30**. This sets 30 workstations with Ethernet adapters as the peripheral nodes.

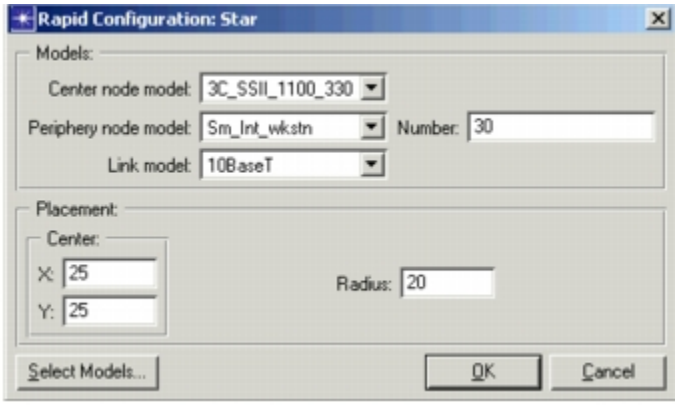
3. Set the **Link Model** to **10BaseT** (10Mbps Ethernet), and leave the Rapid Configuration dialog box open.

End of Procedure 3

Procedure 4 Specifying Where the Network Will Be Placed

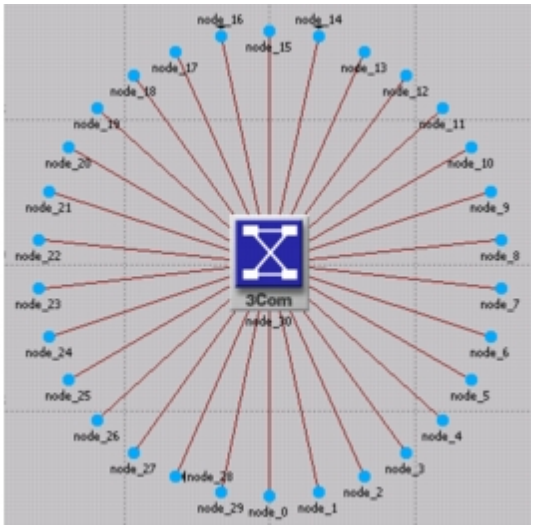
1. Set the **X center** and **Y center** to **25**.
2. Set the **Radius** to **20**.

Figure 5 Rapid Configuration Dialog Box



3. Click **OK**.
   - The network is drawn in the Project Editor as shown in figure 6 below. To expand it, choose **View > Zoom > To All.**

Figure 6 The First Floor Network



End of Procedure 4

Now that the general network topology has been built, you will add a server. Here, you will use the second method of creating network objects: dragging them from the object palette onto the workspace.

Procedure 5 Creating Network Objects

1. Open the object palette by clicking on the **Object Palette** tool button.

2. Select the **Sm_Int_server** (small Internet server) object in the palette and drag the corresponding object icon into the workspace.

3. By default, you can create additional instances of the same object by left-clicking after the initial “drag-and-drop” from the palette.

   Because you do not need additional copies of this object, *right-click to turn off node creation.*

4. To connect the server to the star network, locate the **10BaseT Duplex Link** in the palette and double-click on it.

5. Move the mouse from the object palette to the project workspace and note the blue link symbol currently attached to the mouse pointer. Click on the server object to draw one endpoint of your link, then click on the switch object in the center of the star to complete the link.

   Right-click on the workspace to turn off link creation.

   This creates a 10BaseT link connecting the two objects.

6. Finally, you need to add configuration objects to specify the application traffic that will exist on the network. For this lab, preconfigured application definition and profile definition objects have been included in the object palette:

   - the application definition object contains default configurations for the standard applications, and

   - the profile definition object contains a profile that models light database access

   To model the traffic caused by workstations accessing a database at a low rate, you will need to add one instance of each object to your workspace

7. Select the **Sm_Application_Config** object in the palette and drag that object into the workspace

8. Right-click to turn off object creation.

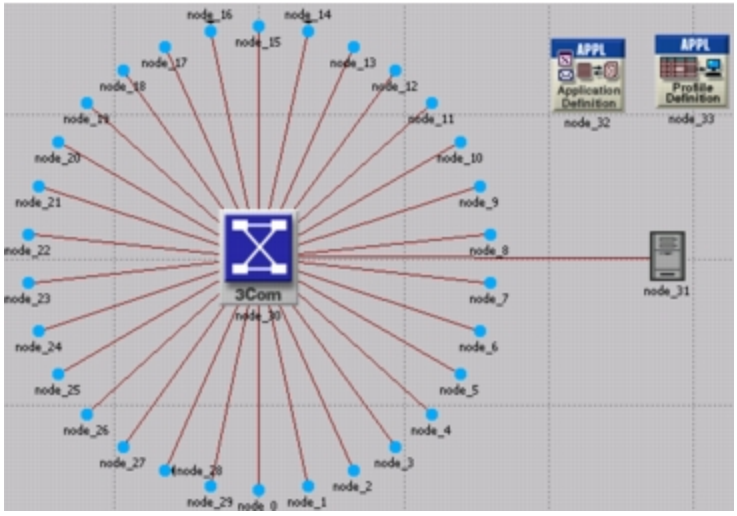
9. Select the **Sm_Profile_Config** object in the palette, drag it into the workspace, and right-click.

10. Close the object palette.

End of Procedure 5

The network is now built and should look similar to figure 7.

Figure 7 The Finished First Floor Network



Collecting Statistics

Key Concept – You can collect statistics from individual nodes in your network (object statistics), or from the entire network (global statistics).

Now that you have created the network, you should determine which statistics are needed to answer the questions presented earlier:

- Will the server be able to handle the additional load of the second network?
- Will the total delay across the network be acceptable once the second network is installed?

To answer these questions, you need a snapshot of the current performance for comparison. To get this baseline, you will collect one object (node) statistic, **Server Load**, and one global statistic, **Ethernet Delay**.

Server load is a key statistic that reflects the performance of the entire network.

Procedure 6 Collecting Object Statistics

1. Right-click on the server node (**node_31**) and select **Choose Individual DES Statistics** from the server object pop-up menu.

   ➢ The Choose Results dialog box for node_31 appears.

The Choose Results dialog box hierarchically organizes the statistics you may collect.

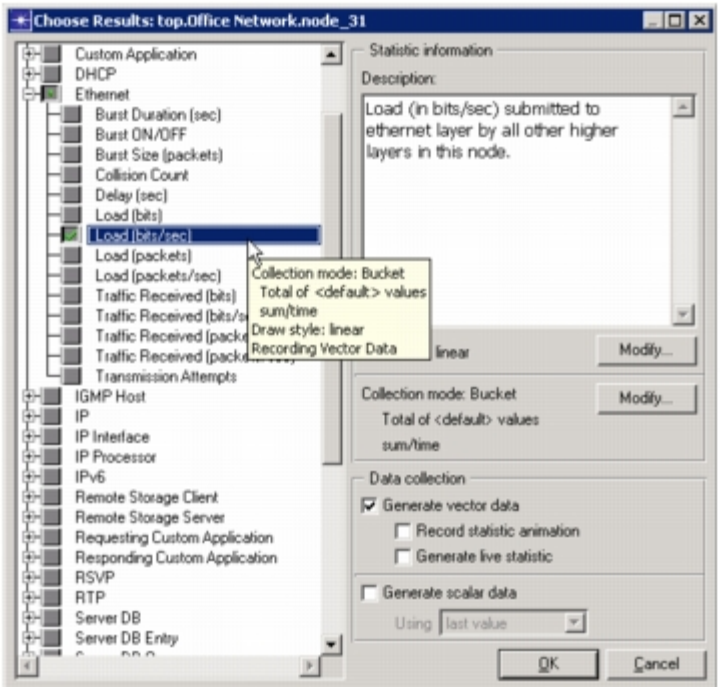
2. To collect the Ethernet load on the server:

   a. In the **Choose Results** dialog box (shown in figure 8 below), expand the treeview node for **Node Statistics**, and then **Ethernet** to see the Ethernet statistics hierarchy.

   b. Click the checkbox next to **Load (bits/sec)** to enable collection for that statistic.

   c. Read the description of the Load (bits/sec) statistic at the upper right. Note that this describes the overall Ethernet load generated by the server node.

Figure 8 Choose Results Dialog Box



   d. Click **OK** to close the dialog box.

End of Procedure 6

Global statistics can be used to gather information about the network as a whole. For example, you can find out the delay for the entire network by collecting the global **Delay** statistic:

Procedure 7 Collecting Global Statistics

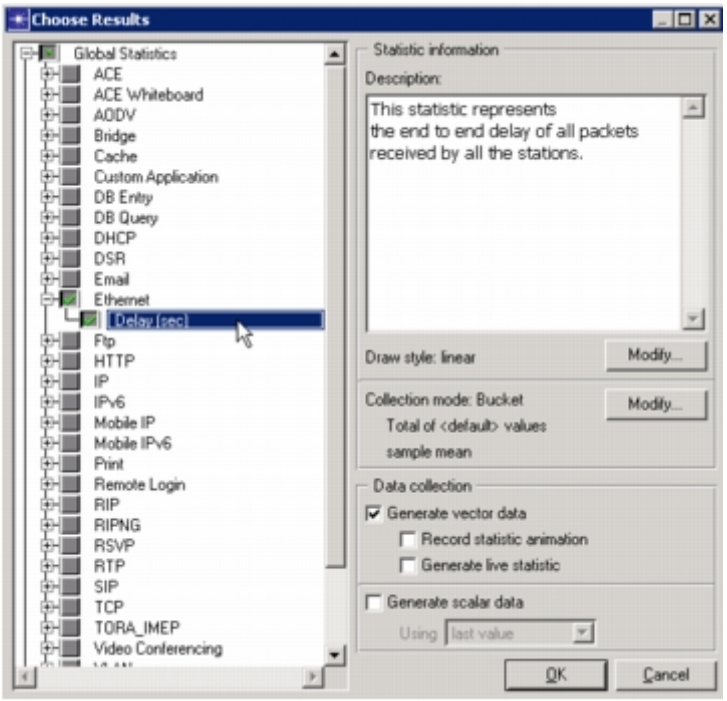
1. Right-click in the workspace (but not on an object) and select **Choose Individual DES Statistics** from the workspace pop-up menu.

2. Expand the **Global Statistics** node.

3. Expand the **Ethernet** node.

4. Click the checkbox next to **Delay (sec)** to enable data collection. Read the description of that statistic.

Figure 9 Global Statistic Chosen



5. Click **OK** to close the Choose Results dialog box.

6. It is good to get into the habit of saving your project every so often. Choose **File > Save**. (This may be preferable to using the automatic project backup function.)

End of Procedure 7

Now that you have specified the statistics to collect and saved the project, you are almost ready to run your simulation. First, though, verify that your **Network Simulation Repositories** preference is set appropriately.

Procedure 8 Verifying the Repositories Preference

1. Choose **Edit > Preferences**.

2. Type **network sim** in the **Search for:** field and click the **Find** button.

3. If the **Value** field for the **Network Simulation Repositories** preference does not contain "**(stdmod)**", click on the field.

    a. The **Network Simulation Repositories** dialog box opens.

    b. Click on the current value (such as "<empty>"), then click the **Insert** button.

    c. Type **stdmod**, press Enter and click **OK**.

4. Click **OK** to close the **Network Simulation Repositories and Preferences** dialog boxes.

End of Procedure 8

The Academic Edition of Riverbed Modeler requires an additional procedure to generate traffic when the simulation runs.

Procedure 9 Enabling Traffic Generation in the Application Definition

1. Right click on the **Application Definition** object and choose **Edit Attributes**.

2. Locate **Application Definitions** and change the **Value** column from **None** to **Default**.

3. Click **OK** to close the Attributes dialog box.

End of Procedure 9

The following procedure describes how to run the simulation.

Procedure 10 Running a Simulation

1. Select **DES > Configure/Run Discrete Event Simulation…**

   You can also open the Configure/Run DES dialog box by clicking on the **Configure/Run Discrete Event Simulation (DES)** tool button. 

2. In the **Configure/Run DES** dialog box, set **Duration:** to 0.5 to simulate one-half hour of network activity.

3. Click the **Run** button to begin the simulation.

   While the simulation runs, a dialog box appears showing the simulation's progress.

4. When the simulation finishes, click the **Close** button on the **Simulation Execution:** dialog box.

   If your simulation does not complete, if no results were collected, or if the results vary significantly from those shown, you will have to troubleshoot your simulation.

End of Procedure 10

Viewing Results

After your simulation has executed, you will want to see the information collected for each statistic. There are several ways to view results; in this lab exercise you will use the View Results option in the individual object, or workspace pop-up menu.

Procedure 11 Viewing the Server Ethernet Load for the Simulation

1. Right-click on the server node (**node_31**) and choose View Results from the server's object pop-up menu.

   - The Results Browser opens.

2. If necessary, select the **DES Graphs** tab.

3. In the lower pane, expand the **Object Statistics > Office Network > node_31 > Ethernet** hierarchy.

4. Click on the checkbox next to **Load (bits/sec)** to indicate that you want to view that result.

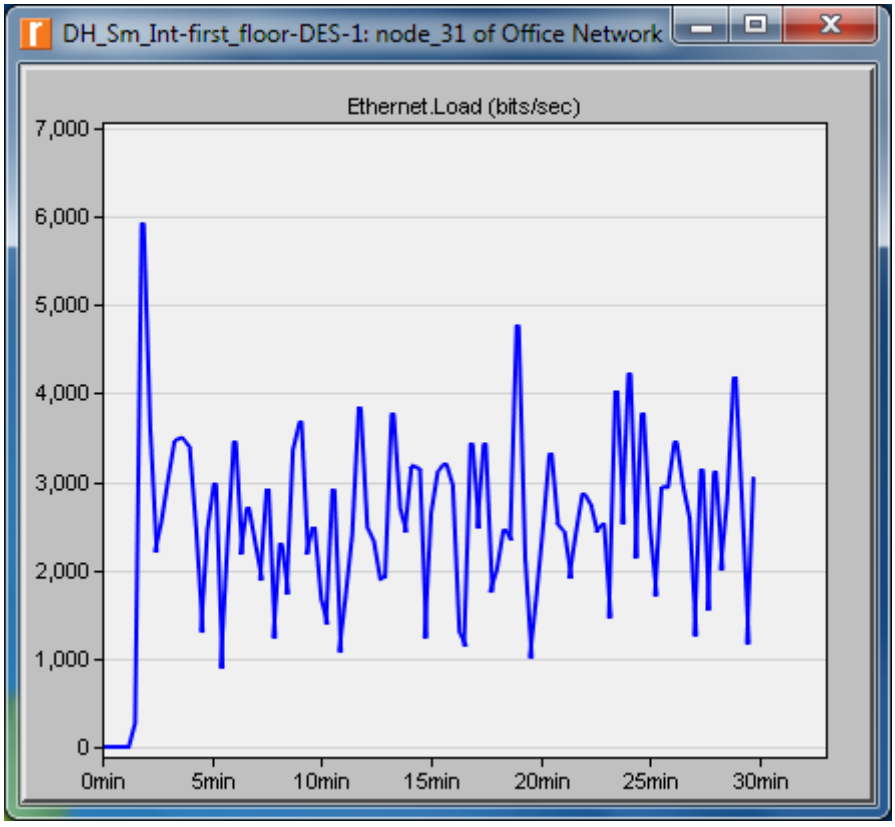
5. Click the **Show** button in the Results Browser.

   ➢ The graph of the server load appears in the Project Editor, as shown in figure 10 below.

End of Procedure 11

The graph of the server load should resemble the following graph. Your results may differ slightly due to differences in node placement and link length, but the general trends should be consistent.

Figure 10 Server Load Graph



Bits/second, the unit of measure on this axis, is shown in the statistic on the Choose Results dialog box.

Simulation time, in minutes

Note: At its peak, the load on the server is about 6,000 bits/second (6Kbps). You will need this baseline for comparison after you add the second network.

When you finish viewing the server load graph, close this dialog box and the Results Browser. (If the system prompts you, choose to delete the graph panel.)

Key Concept – The **View Results** option from the workspace pop-up menu allows you to obtain global statistics and individual object statistics from one treeview.

You also should look at the Global Ethernet Delay on the network. To view this statistic:

Procedure 12 Viewing the Global Ethernet Delay Statistic

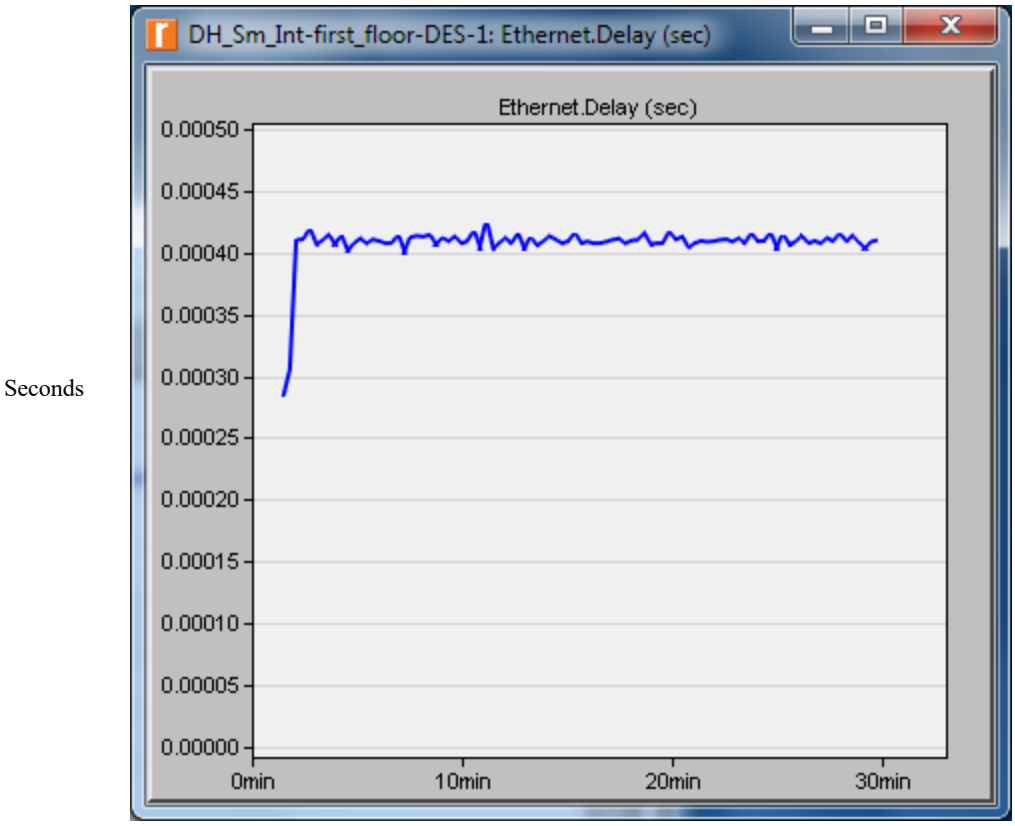
1. Right-click in the workspace, then select **View Results** from the pop-up menu.

2. Check the box next to **Global Statistics > Ethernet > Delay (sec)**.

3. Click the Show button to view the Ethernet delay for the whole network.

   The Ethernet delay graph appears in the Project Editor. The graph should resemble figure 11 below.

Figure 11 Ethernet Delay Graph



End of Procedure 12

Note that after the network reaches steady state, the maximum delay is around 0.4 milliseconds.

When you finish viewing the graph, close the graph and the Results Browser.

Expanding the Network

You have created a baseline network and gathered statistics about it. Now you are ready to expand the network and verify that it still operates sufficiently well with the additional load.

When performing a “what-if” comparison, it is convenient to store the baseline network as one scenario and create the experimental test network as a different scenario. You will duplicate the existing scenario and make changes to it, instead of building the new topology from scratch.

Procedure 13 Duplicating a Scenario

1. Choose **Scenarios > Duplicate Scenario…**
2. Enter **expansion** as the name for the new scenario.
3. Click **OK**.
   - ➢ The scenario, with all the nodes, links, statistics, and the simulation configuration, is duplicated and named expansion.

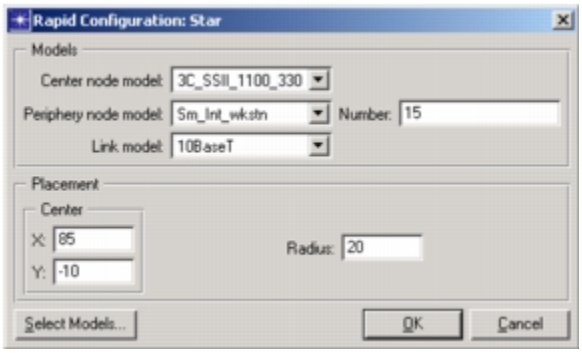
End of Procedure 13

The second-floor segment will resemble the first-floor segment, but will not have a server of its own.

Procedure 14 Building a New Segment

1. Select **Topology > Rapid Configuration**.
2. Choose **Star** for the topology and click **Next…**
3. Complete the Rapid Configuration dialog box with these values:
   - Center Node Model: **3C_SSII_1100_3300_4s_ae52_e48_ge3**
   - Periphery Node Model: **Sm_Int_wkstn**
   - Number: **15** (half as many as first_floor)
   - Link model: **10BaseT**
   - X: **85**, Y: **-10**, Radius: **20**

Figure 12 Rapid Configuration Dialog Box



4. Click **OK** to create the network.

5. Resize your workspace as needed to view both network segments.

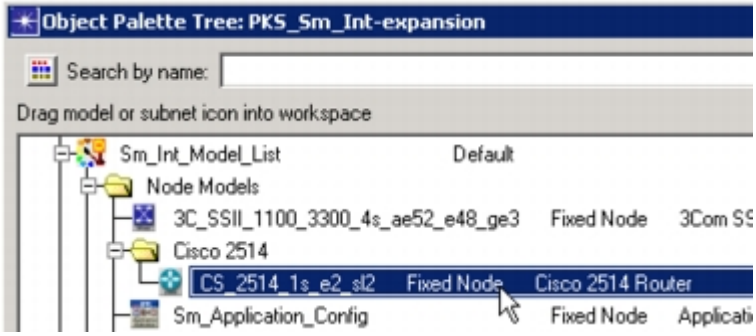
End of Procedure 14

Next, you will join the two networks.

Procedure 15 Joining Two Networks

1. If it is not already open, click the tool button to open the object palette.

2. Expand the Cisco 2514 folder.



3. Select **CS_2514_1s_e2_sl2** and drag the **Cisco 2514** router icon into the workspace between the two networks. Right-click to turn off node creation.

4. Expand the **Link Models** treeview, select 10BaseT Duplex Link…, and click on the **10BaseT** link icon in the object palette.

5. Create **10BaseT** links between the Cisco router (**node_50**) and the 3Com switches at the center of each star.

6. Right-click to turn off link creation.

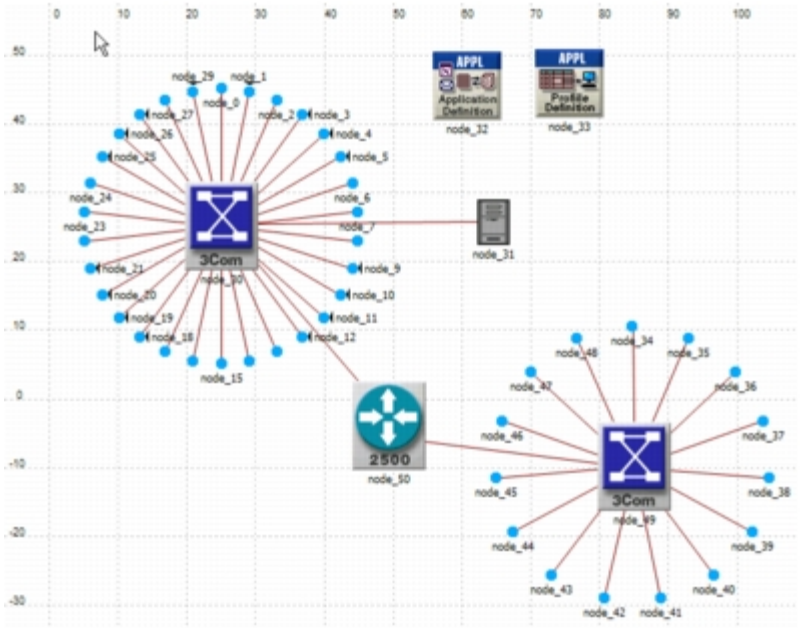
7. Close the object palette.

8. Select **File > Save**.

End of Procedure 15

The final network should resemble figure 13.

Figure 13 The Final Network



Next, run the simulation of the new expansion scenario.

Procedure 16 Running the Expansion Scenario

1. Select **DES > Configure/Run Discrete Event Simulation…**

2. Verify that the **Duration** is set to 0.5 hours.

3. Click the **Run** button to begin the simulation.

4. When the simulation is done, close the **Simulation Execution** dialog box.

End of Procedure 16

Comparing Results

To answer the questions posed about the addition of a second network to the existing LAN, you will need to compare the simulation results from both scenarios.

You will use the **View Results** menu item in the object and workspace pop-up menus to combine statistics from different scenarios in the same graph. When comparing results, choosing a statistic in one scenario produces a graph showing the value of that statistic in all scenarios.

To view the server load from both scenarios at once:

Procedure 17 Viewing the Server Load from Both Scenarios

1. Right-click on the server node (**node_31**) to display the pop-up menu and choose **View Results**.

2. If necessary, select the **DES Graphs** tab.

3. Select **Current Project** from the **Results for:** pull-down menu.

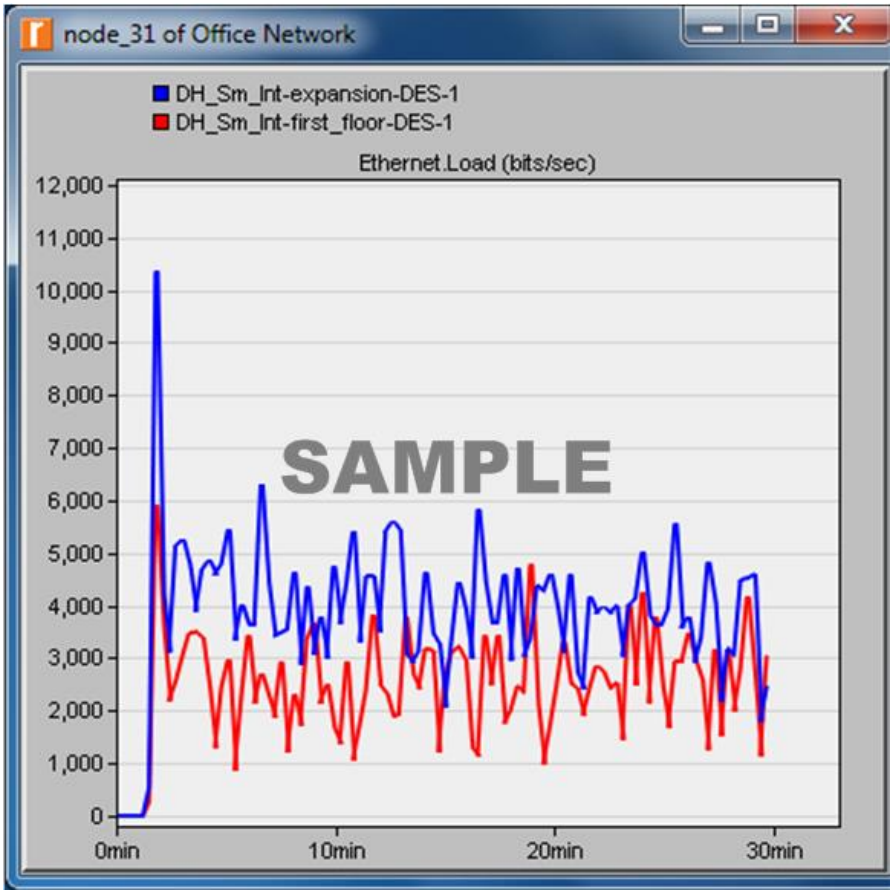
4. In the upper pane, expand **<your initials>_Sm_int** if necessary, and check the boxes next to both scenarios.

5. In the Presentation area at the lower right, select **Overlaid Statistics** from the upper pull-down menu.

6. Under **Arrangement:**, select the **Object Statistics > Office Network > node_31 > Ethernet > Load (bits/sec)** statistic, and click the **Show** button. Your results should resemble those in the figure 14 below (but may not be identical):

   Note: If your results differ greatly from those shown in the following figures, you will need to troubleshoot your simulation.

Figure 14 Ethernet Loads Compared



Bits/second

Simulation time, in minutes

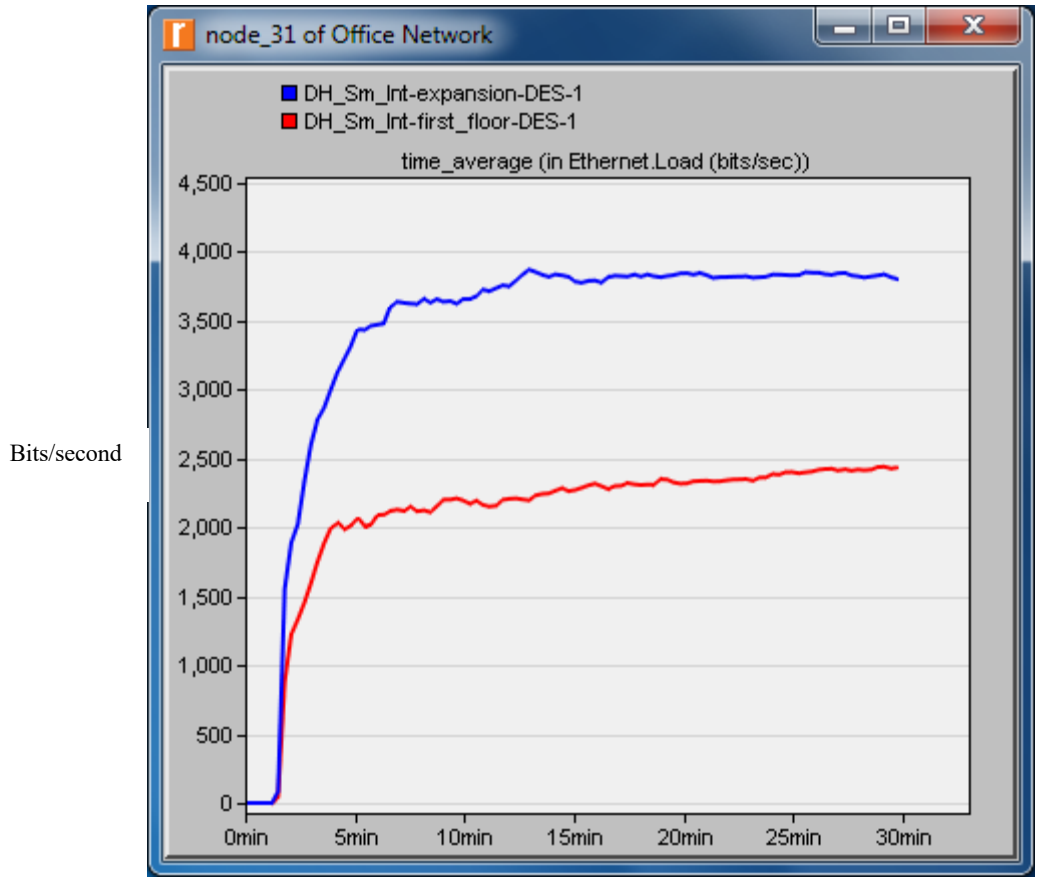
7. *Include this Ethernet Loads Compared graph in your lab repor*t.

   To do that, verify that the graph is selected ("on top" in Windows) after you press the **Show** button. Then use ALT+PRINT SCREEN to copy the graph to the Windows Clipboard. Paste it into your lab report using CTRL+V.

8. Delete your Ethernet Loads Compared graph.

9. Back in the Results Browser **Presentation:** area, change **As Is** to **time_average**, and click **Show**. **time_average** displays a continuous running average. Your results should resemble those in figure 15 below (but may not be identical):

Figure 15 Time-Averaged Server Loads Compared



Although the average load for the expansion scenario is higher (as expected), the load as a whole appears to be leveling off (that is, not monotonically increasing), indicating a stable network.

Next, we will see how network *delay* is affected by adding a second floor. To compare Ethernet delay for the two scenarios:

10. Close the graph and the Results Browser for the server.

11. Right-click in the workspace to display the pop-up menu and choose **View Results**.

12. As before, select **Current Project** from the **Results for:** pull-down menu, then check the boxes next to both scenarios.

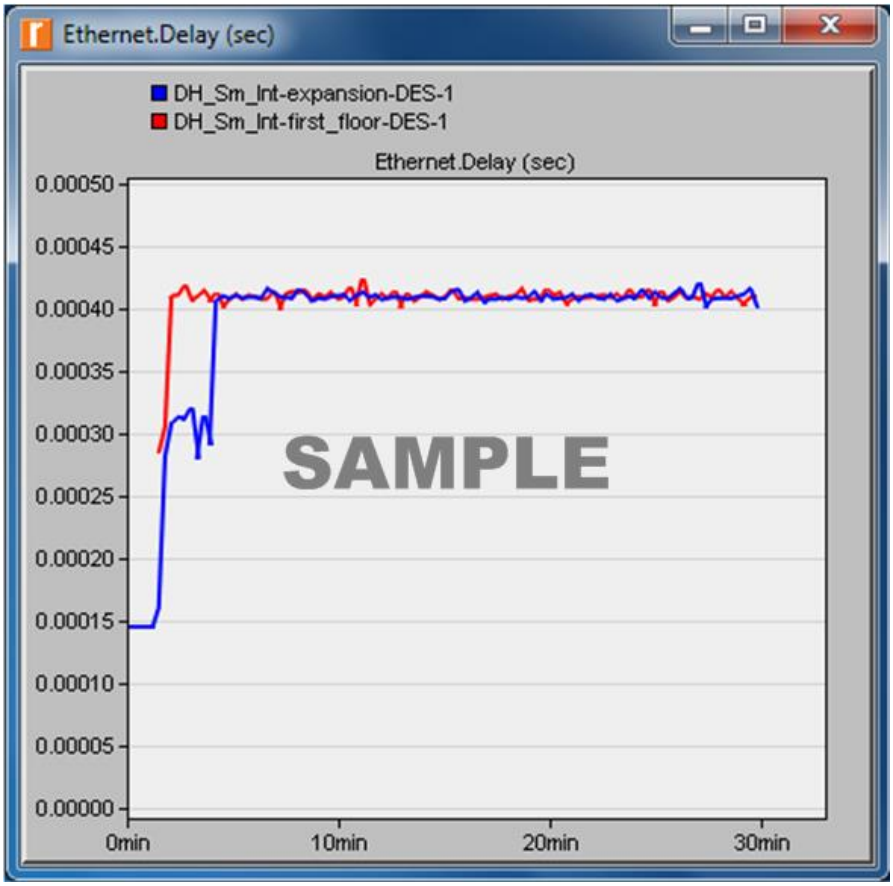
13. Under **Arrangement:**, select **Global Statistics** -> **Ethernet** -> **Delay (sec)**.

14. In the **Presentation:** area, select **Overlaid Statistics** from the pull down menu.

15. Click the **Show** button to display the graph.

16. Your graph of Ethernet delay should resemble the following figure.

Figure 16 Ethernet Delay Compared



17. *Include this Ethernet Delay graph in your lab report.*

18. Close the graph and the Results Browser.

19. Select **File > Close** and save changes before closing.

End of Procedure 17

Questions

1. When you added the second star network in the expansion scenario, the Ethernet load on the shared server peaked at around 10Kbps, and then stabilized at around 4Kbps (see Procedure 17). Explain why that load is or is not a problem. (Note that the y-axis scale on this graph is in the 1 – 12 Kbps range, so most of the available Ethernet data rate range is "off the top" of the scale.)

2. Refer to Figure 16. In this graph, this Ethernet delay measurement is a global statistic that represents the *average propagation delay incurred crossing each individual link*, for of all packets received by all nodes. (It isn't an end to end measurement, and doesn't include router, switch and server queuing delay.)

    a. What effect did adding the second network have on Ethernet delay?

    b. List the elements that influence this statistic. (You might want to refer to the lecture 6 slide titled "Latency = Delay ≈ Propagation Time".)

    c. Speculate on why this behavior was observed.

Summary of Deliverables

- Your "Ethernet Loads Compared" graph generated in Procedure 17 Step 6 (figure 14).
- Your "Ethernet Delay Compared" graph generated in Procedure 17 Step 14 (figure 16).
- Your answers to questions 1 and 2 above.

Submit your Lab Report to Canvas by the due date. If you are working in the lab, save your files (if you wish), log off and shut down your workstation.