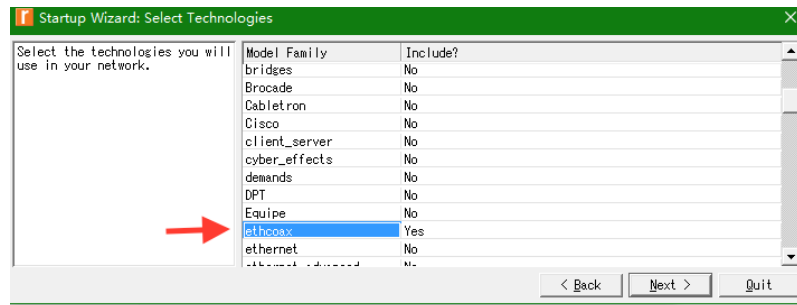### Create a New Project

To create a new project for the Ethernet network:

1. Start **Riverbed Modeler Academic Edition** ⇒ Choose **New** from the **File** menu.
2. Select **Project** ⇒ Click **OK** ⇒ Name the project **<your initials>_Ethernet**, and the scenario **Coax_2** ⇒ Make sure that the Use Startup Wizard is checked ⇒ Click **OK**.

Local area networks (LANs) are designed to span distances of up to a few thousand meters.

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** ⇒ Assign **200** to **X Span** and keep **Y Span** as **100** ⇒ Click **Next** ⇒ Choose ethcoax model like the above fig ⇒ Click Next ⇒ Click **Finish**.

4. Close the *Object Tree* dialog box.

Create the Network

To create our coaxial Ethernet network:

1. To create the network configuration, select **Topology** ⇒ **Rapid Configuration**. From the drop-down menu choose **Bus** and click **Next**.

2. Click the **Select Models** button in the *Rapid Configuration* dialog box. From the *Model List* drop-down menu choose **ethcoax_station** and click **OK**.
3. In the *Rapid Configuration* dialog box, set the following eight values and click **OK**.

The **eth_tap** is an Ethernet bus tap that connects a node with the bus.

The **eth_coax** is an Ethernet bus that can connect nodes with bus receivers and transmitters via taps.
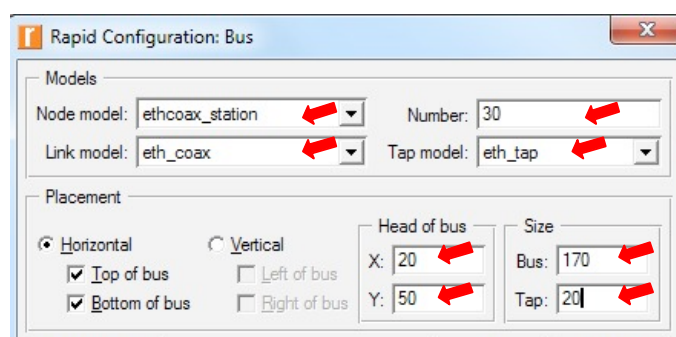
4. To configure the coaxial bus, right-click on the horizontal link ⇒ Select **Edit Attributes (Advanced)** from the menu:

a. Click on the value of the **model** attribute ⇒ Select **Edit** from the drop-down menu ⇒ Choose the **eth_coax_adv** model. Check the advanced at right down corner.

b. Assign the value **0.05** to the **delay** attribute (propagation delay in sec/m).

c. Assign **5** to the **thickness** attribute.

d. Click **OK**.

5. Now you have created the network. It should look like the illustration below.

6. Make sure to save your project.

A higher delay is used here as an alternative to generating higher traffic which would require much longer simulation time.

Thickness specifies the thickness of the line used to "draw" the bus link.
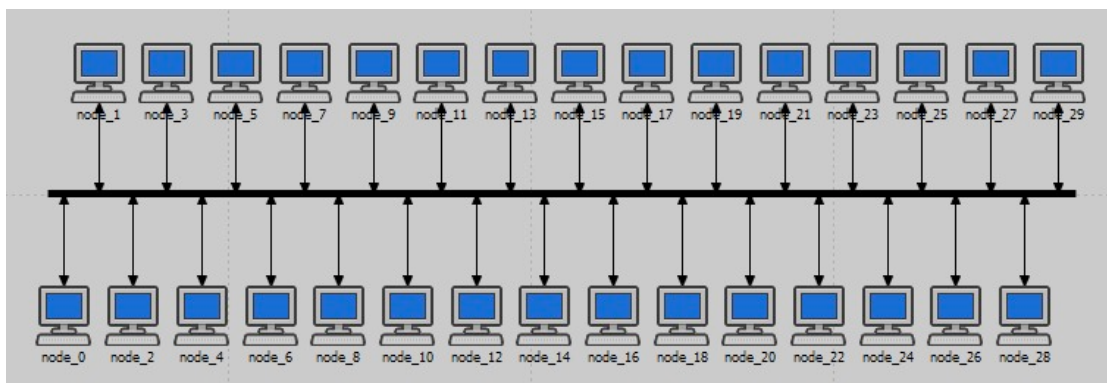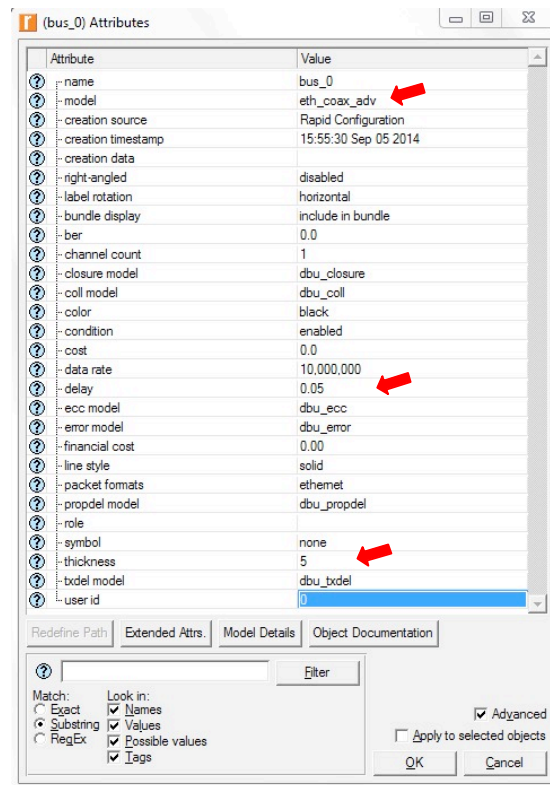
Configure the Network Nodes

To configure the traffic generated by the nodes:

1. Right-click on any of the 30 nodes ⇒ **Select Similar Nodes**. Now all nodes in the network are selected.

2. Right-click on any of the 30 nodes ⇒ **Edit Attributes**.
3. Check the **Apply Changes to Selected Objects** check box. This is important to avoid reconfiguring each node individually.
4. Expand the **Traffic Generation Parameters** hierarchy:

   a. Change the value of the **ON State Time** to **exponential(100)** ⇒ Change the value of the **OFF State Time** to **exponential(0.00001)**. (*Note:* Packets are generated only in the "ON" state.)

5. Expand the **Packet Generation Arguments** hierarchy:

   a. Change the value of the **Packet Size** attribute to **constant(1024)** ⇒ Change the value of the **Interarrival Time** attribute to **exponential(2)**.

*The argument of the **exponential** distribution is the mean of the interval between successive events. In the exponential distribution the probability of occurrence of the next event by a given time is not at all dependent upon the time of occurrence of the last event or the elapsed time since that event.*

*The **interarrival time** is the time between successive packet generations in the "ON" state.*
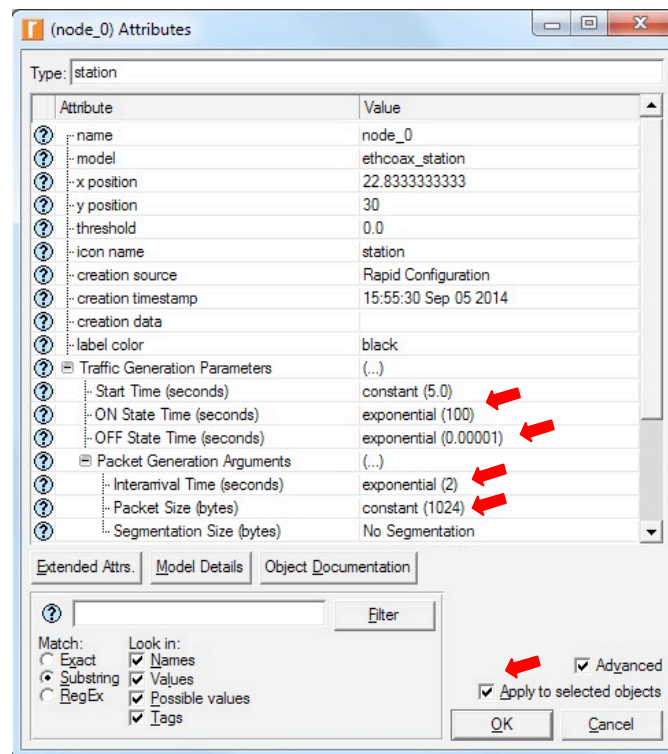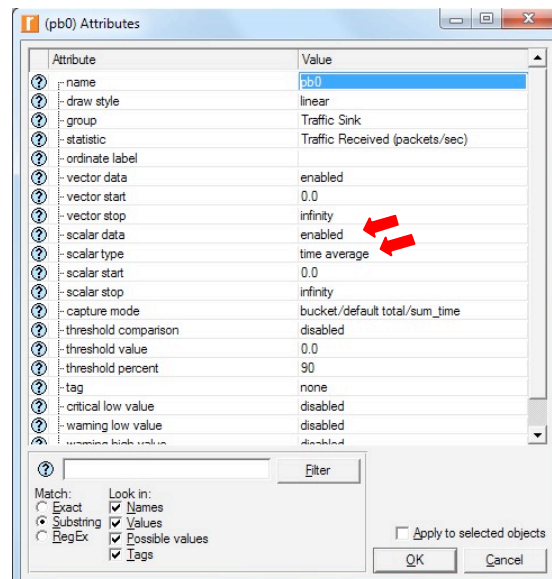

6. Click **OK** to return back to the *Project Editor*.

7. Make sure to save your project.

Choose the Statistics

To choose the statistics to be collected during the simulation:

1. Right-click anywhere in the project workspace (but not on one of the nodes or links) and select **Choose Individual DES Statistics** from the pop-up menu ⇒ Expand the **Global Statistics** hierarchy.

   a. Expand the **Traffic Sink** hierarchy ⇒ Click the check box next to **Traffic Received (packets/sec)** (make sure you select the statistic with units of packets/sec),

   b. Expand the **Traffic Source** hierarchy ⇒ Click the check box next to **Traffic Sent (packets/sec).**

   c. Click **OK**.

2. Now to collect the average of the above statistics as a scalar value by the end of each simulation run:

   a. Select **Choose Statistics (Advanced)** from the *DES* menu.

   A **probe** represents a request by the user to collect a particular piece of data about a simulation.

   b. The **Traffic Sent** and **Traffic Received** probes should appear under the **Global Statistic Probes**.

   c. Right-click on **Traffic Received** probe ⇒ **Edit Attributes**. Set the **scalar data** attribute to **enabled** ⇒ Set the **scalar type** attribute to **time average** ⇒ Compare to the following figure and click **OK**.

   d. Repeat the previous step with the **Traffic Sent** probe.

   e. Select save from the **File** menu in the *Probe Model* window and then close that window.

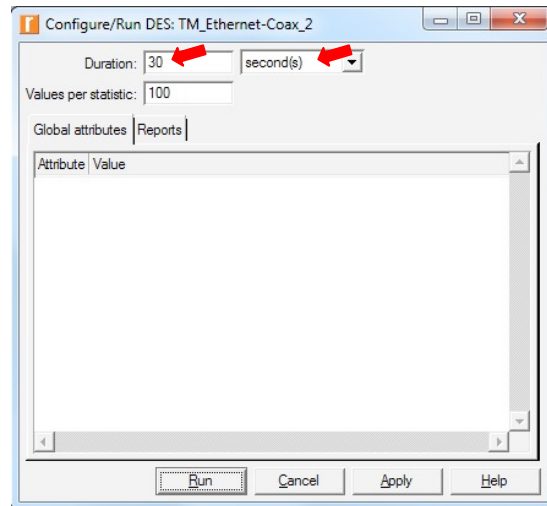   f. Now you are back to the *Project Editor*. Make sure to save your project.

Run the Simulation

To run the simulation:

1. Click on the **Configure/Run Simulation** button: ⚡ ⇒ Assign **30 second(s)** (not hours) to the **Duration** ⇒ Click **Run**. Depending on the speed of your processor, this may take several minutes to complete.


2. After the simulation run is complete, click **Close**.

3. Save your project.

4. Select **Duplicate Scenario** from the *Scenarios* menu.

5. Name the new scenario **Coax_1**.

6. Right-click on any of the 30 nodes ⇒ **Select Similar Nodes**. Now all nodes in the network are selected.

7. Right-click on any of the 30 nodes ⇒ **Edit Attributes**.

8. Check the **Apply Changes to Selected Objects** check box. This is important to avoid reconfiguring each node individually.

9. Expand the **Traffic Generation Parameters** hierarchy ⇒ Expand the **Packet Generation Arguments** hierarchy ⇒ Change the value of the **Interarrival Time** attribute to **exponential(1)**.

10. Go to back to step 1 in this page and repeat the instructions 8 times for the **Interarrival Times** of **exponential(0.5)**, **exponential(0.25)**, **exponential(0.1)**, **exponential(0.05)**, **exponential(0.035)**, **exponential(0.03)**, **exponential(0.025)** and **exponential(0.02)** using the scenarios names: **Coax_05**, **Coax_025**, **Coax_01**, **Coax_005**, **Coax_0035**, **Coax_003**, **Coax_0025** and **Coax_002**. Notice that each time the simulator is completing a run for different traffic generation interarrival time (representing the load into the network) and that each successive run takes longer to complete because the traffic intensity is increasing.

View the Results

To view and analyze the results:

1. Click on the **View Results** button: 🖻 Now the **Results Browser** is open.

2. Select the **DES Parametric Studies** tab.

3. From the *Results for* drop-down menu, select **Current Project**.

4. Uncheck and check again the results for your project in order to check all the results.

5. Uncheck **Coax_0025**

6. Uncheck **Include vectors**.

7. Expand the **Scalar Statistics** ⇒ Expand the **Traffic Sink** and **Traffic Source**.

8. Right click on **Traffic Received** and select **Set as Y-Series**

9. Right click on **Traffic Sent** and select **Set as X-Series**

10. The resulting graph should resemble the one below:
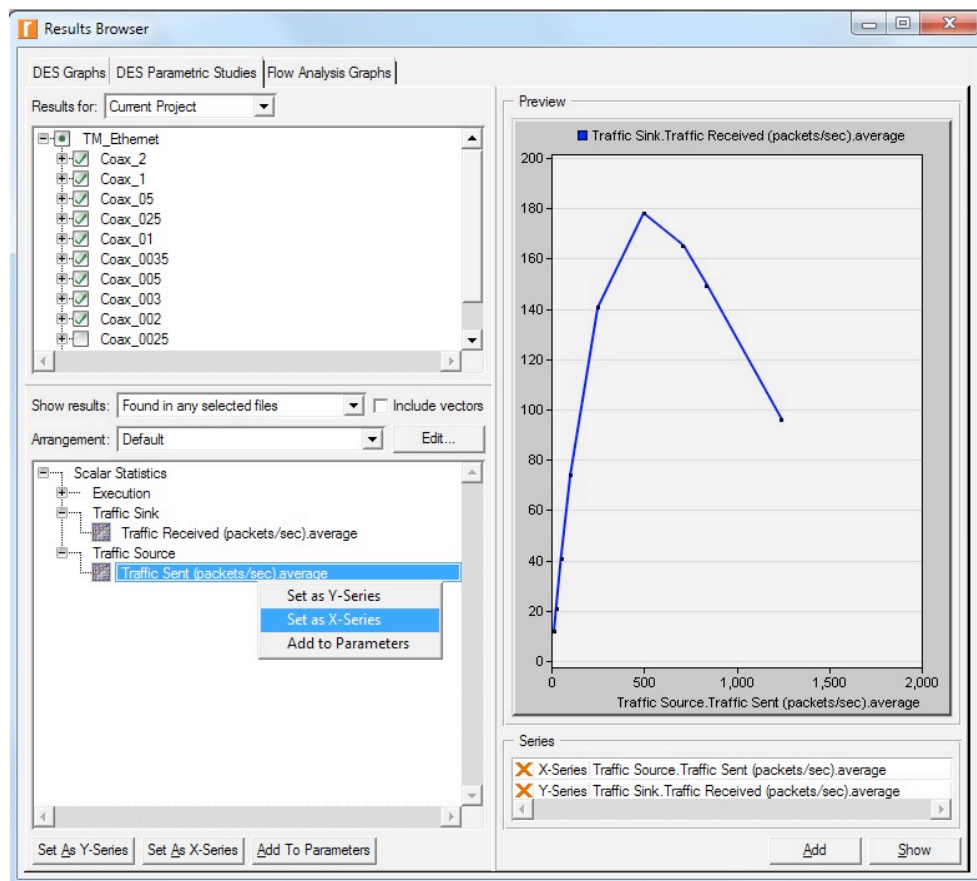
1) Explain the graph we received in the simulation that shows the relationship between the received (throughput) and sent (load) packets. Why does the throughput drop when the load is either very low or very high?

2) Use three duplicates of the simulation scenario implemented in this lab named **Coax_01**, **Coax_005**, and **Coax_0025**. Make sure that the **Interarrival Time** attribute of the *Packet Generation Arguments* for all nodes in the scenarios are as follows:

- **Coax_01** scenario: exponential(0.1)
- **Coax_005** scenario: exponential(0.05)
- **Coax_0025** scenario: exponential(0.025)

Choose the following statistic for node 0: **Node Statistics →Ethcoax →Collision Count**. Make sure that the following global statistic is chosen: **Global Statistics→Traffic Sink→Traffic Received (packet/sec)**. (Refer to the *Choose the Statistics* section in the lab.)

Run the simulation for all three scenarios. Get two graphs: one to compare node 0's collision counts in these three scenarios and the other graph to compare the received traffic from the three scenarios. Explain the graphs and comment on the results. (*Note:* To compare results you need to select **Compare Results** from **Results** in the **DES** menu after the simulation runs is done.)

3) To study the effect of the number of stations on Ethernet segment performance, create a duplicate of the **Coax_0025** scenario. Name the new scenario **Coax_Q3**. In the new scenario, remove the odd- numbered nodes, a total of 15 nodes (node 1, node 3, …, and node 29). Run the simulation for the new scenario. Create a graph that compares node 0's collision counts in scenarios **Coax_0025** and **Coax_Q3**. Explain the graph and comment on the results.

4) In the simulation a packet size of 1024 bytes is used (*Note:* Each Ethernet packet can contain up to 1500 bytes of data). To study the effect of the packet size on the throughput of the created Ethernet network, create a duplicate of the **Coax_0025** scenario. Name the new scenario **Coax_Q4**. In the new scenario use a packet size of 512 bytes (for all nodes). For both **Coax_0025** and **Coax_Q4** scenarios, choose the following global statistic:
Global Statistics→Traffic Sink→Traffic Received (bits/sec). Rerun the

simulation of **Coax_0025** and **Coax_Q4** scenarios. Create a graph that compares the throughput as packets/sec and another graph that compares the throughput as bits/sec in **Coax_0025** and **Coax_Q4** scenarios. Explain the graphs and comment on the results.

Lab Report

The report should include the answers to the above questions as well as the graphs you generated from the simulation scenarios. All the screenshots should contain your name. Discuss the results you obtained and compare these results with your expectations. Mention any anomalies or unexplained behaviors.