

# RIP: Routing Information Protocol

## A Routing Protocol Based on the Distance-Vector Algorithm

### Objective

The objective of this lab is to configure and analyze the performance of the Routing Information Protocol (RIP) model.

### Overview

A router in the network needs to be able to look at a packet's destination address and then determine which of the output ports is the best choice to get the packet to that address. The router makes this decision by consulting a forwarding table. The fundamental problem of routing is: How do routers acquire the information in their forwarding tables?

Routing algorithms are required to build the routing tables and hence forwarding tables. The basic problem of routing is to find the lowest-cost path between any two nodes, where the cost of a path equals the sum of the costs of all the edges that make up the path. Routing is achieved in most practical networks by running routing protocols among the nodes. The protocols provide a distributed, dynamic way to solve the problem of finding the lowest-cost path in the presence of link and node failures and changing edge costs.

One of the main classes of routing algorithms is the distance-vector algorithm. Each node constructs a vector containing the distances (costs) to all other nodes and distributes that vector to its immediate neighbors. RIP is the canonical example of a routing protocol built on the distance-vector algorithm. Routers running RIP send their advertisements regularly (e.g., every 30 seconds). A router also sends an update message whenever a triggered update from another router causes it to change its routing table.

In this lab you will set up a network that utilizes RIP as its routing protocol. You will analyze the routing tables generated in the routers, and you will observe how RIP is affected by link failures.


## Procedure

### Create a New Project

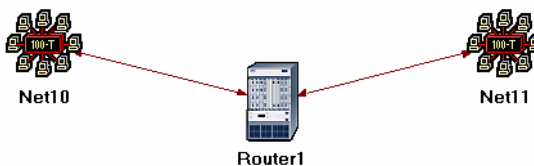
1. Start **OPNET IT Guru Academic Edition** ⇒ Choose **New** from the **File** menu.
2. Select **Project** and click **OK** ⇒ Name the project **<your initials>\_RIP**, and the scenario **NO\_Failure** ⇒ Click **OK**.
3. In the *Startup Wizard: Initial Topology* dialog box, make sure that **Create Empty Scenario** is selected ⇒ Click **Next** ⇒ Select **Campus** from the *Network Scale* list ⇒ Click **Next** three times ⇒ Click **OK**.

### Create and Configure the Network

#### Initialize the Network:

1. The *Object Palette* dialog box should now be on top of your project workspace. If it is not there, open it by clicking . Make sure that the **internet\_toolbox** is selected from the pull-down menu on the object palette.
2. Add to the project workspace the following objects from the palette: one **ethernet4\_slip8\_gtwy** router and two **100BaseT\_LAN** objects.
  - a. To add an object from a palette, click its icon in the object palette ⇒ Move your mouse to the workspace ⇒ Click to place the object ⇒ Right-click to stop creating objects of that type.
3. Use bidirectional **100BaseT** links to connect the objects you just added as in the following figure. Also, rename the objects as shown (right-click on the node ⇒ **Set Name**).
4. Close the *Object Palette* dialog box.
5. Save your project.

The **ethernet4\_slip8\_gtwy** node model represents an IP-based gateway supporting four Ethernet hub interfaces and eight serial line interfaces. IP packets arriving on any interface are routed to the appropriate output interface based on their destination IP address. The Routing Information Protocol (RIP) or the Open Shortest Path First (OSPF) protocol may be used to dynamically and automatically create the gateway's routing tables and select routes in an adaptive manner.



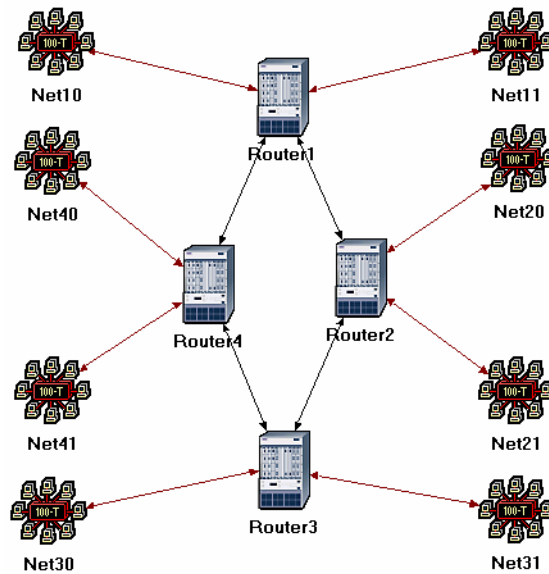
### Configure the Router:

1. Right-click on **Router1** ⇒ **Edit Attributes** ⇒ Expand the **IP Routing Parameters** hierarchy and set the following:
  - i. **Routing Table Export = Once at End of Simulation.** This asks the router to export its routing table at the end of the simulation to the *simulation log*.
2. Click **OK** and then save your project.

### Add the Remaining LANs:

1. Highlight or select simultaneously (using shift and left-click) all five objects that you currently have in the project workspace (one router, two LANs, and two links). You can click-and-drag a box around the objects to do this.
2. Press **Ctrl+C** to copy the selected objects and then press **Ctrl+V** to paste them.
3. Repeat step 2 three times to generate three new copies of the objects and arrange them in a way similar to the following figure. Rename all objects as shown.
4. Connect routers, as shown, using **PPP\_DS3** links.

The **PPP\_DS3** link has a data rate of 44.736 Mbps.



### Choose the Statistics

**RIP traffic** is the total amount of RIP update traffic (in bits) sent/received per second by all the nodes using RIP as the routing protocol in the IP interfaces in the node.


**Total Number of Updates** is the number of times the routing table at this node gets updated (e.g., due to a new route addition, an existing route deletion, and/or a next hop update).

To test the performance of the RIP protocol, we will collect the following statistics:

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, check the following statistics:
  - a. **Global Statistics** ⇒ **RIP** ⇒ **Traffic Sent (bits/sec).**
  - b. **Global Statistics** ⇒ **RIP** ⇒ **Traffic Received (bits/sec).**
  - c. **Nodes Statistics** ⇒ **Route Table** ⇒ **Total Number of Updates.**
3. Click **OK** and then save your project.

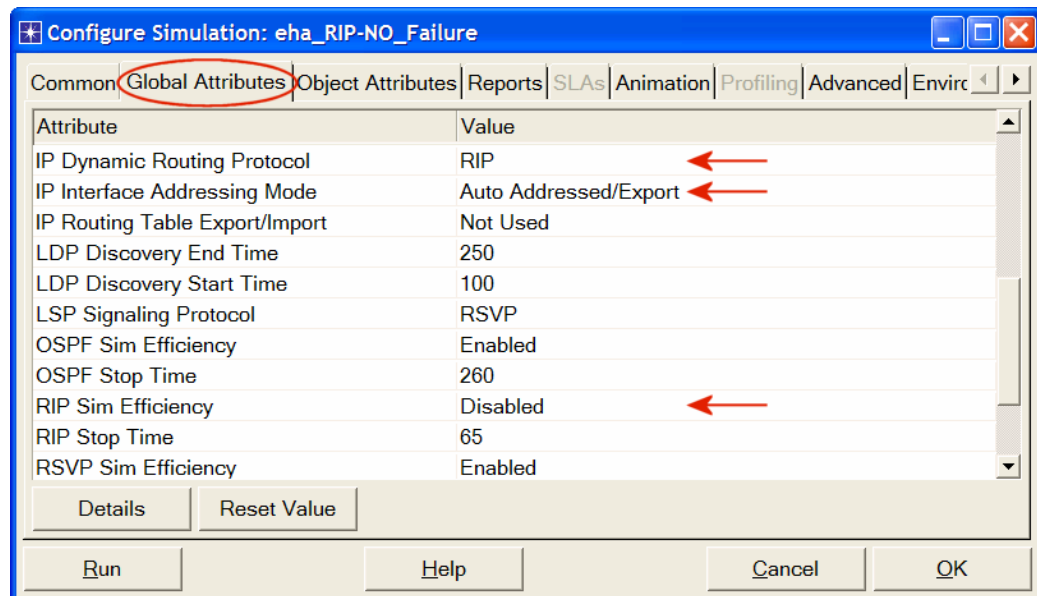
## Configure the Simulation

Here we need to configure some of the simulation parameters:

1. Click on  and the *Configure Simulation* window should appear.
2. Set the duration to be **10.0 minutes**.
3. Click on the **Global Attributes** tab and change the following attributes:
  - a. **IP Dynamic Routing Protocol = RIP**. This sets the RIP protocol to be the routing protocol of all routers in the network.
  - b. **IP Interface Addressing Mode = Auto Addressed/Export**.
  - c. **RIP Sim Efficiency = Disabled**. If this attribute is enabled, RIP will stop after the "RIP Stop Time." But we need the RIP to keep updating the routing table in case there is any change in the network (as we will see in the second scenario).
4. Click **OK** and then save the project.


**Auto Addressed** means that all IP interfaces are assigned IP addresses automatically during simulation. The class of address (e.g., A, B, or C) is determined based on the number of hosts in the designed network. Subnet masks assigned to these interfaces are the default subnet masks for that class.

**Export** causes the auto-assigned IP interface to be exported to a file (name of the file is <net\_name>-ip\_addresses.gdf and gets saved in the primary model directory).

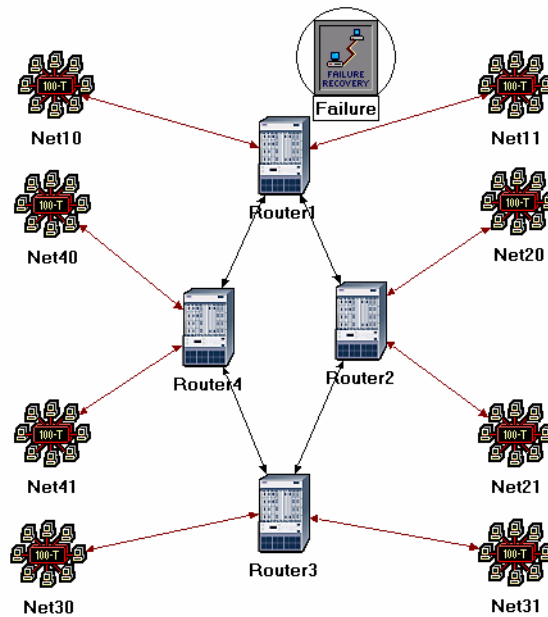


## Duplicate the Scenario

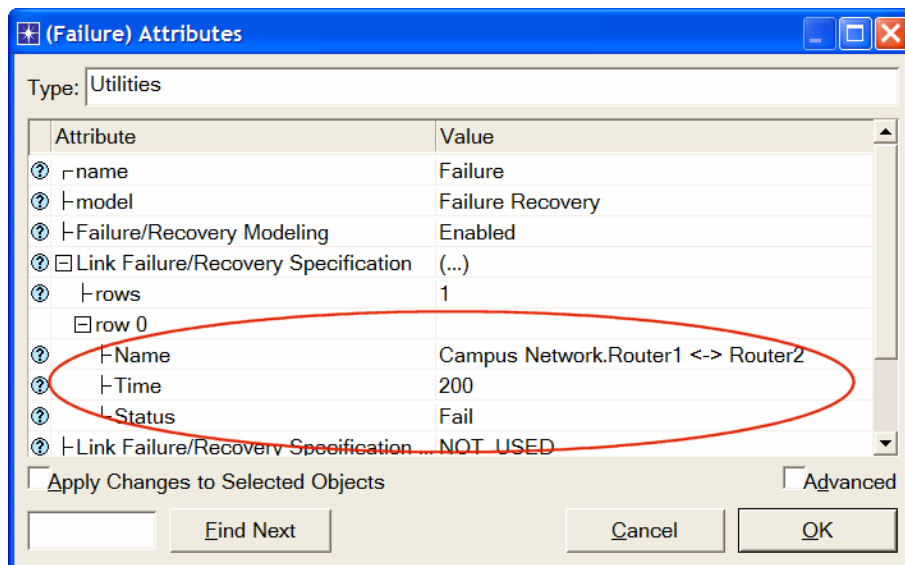
In the network we just created, the routers will build their routing tables, and then they will not need to update them further because we didn't simulate any node or link failures. In this scenario we will simulate failures so that we can compare the behavior of the routers in both cases.

1. Select **Duplicate Scenario** from the **Scenarios** menu and name it **Failure** ⇒ Click **OK**.
2. Open *Object Palette* by clicking . Select the **Utilities** palette from the drop-down menu.

3. Add a **Failure Recovery** object to your workspace and name it **Failure** as shown  
 ⇒ Close the *Object Palette* dialog box.



4. Right-click on the **Failure** object ⇒ **Edit Attributes** ⇒ Expand the **Link Failure/Recovery Specification** hierarchy ⇒ Set **rows** to 1 ⇒ Set the attributes of the added row, **row 0**, as follows:



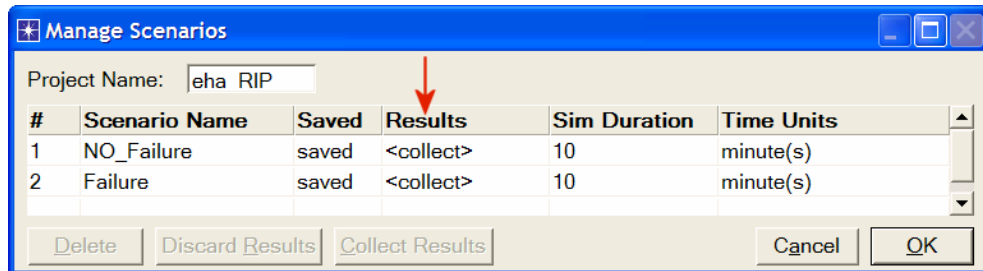
This will “fail” the link between **Router1** and **Router2** 200 seconds into the simulation.

5. Click **OK** and then save the project.

## 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.

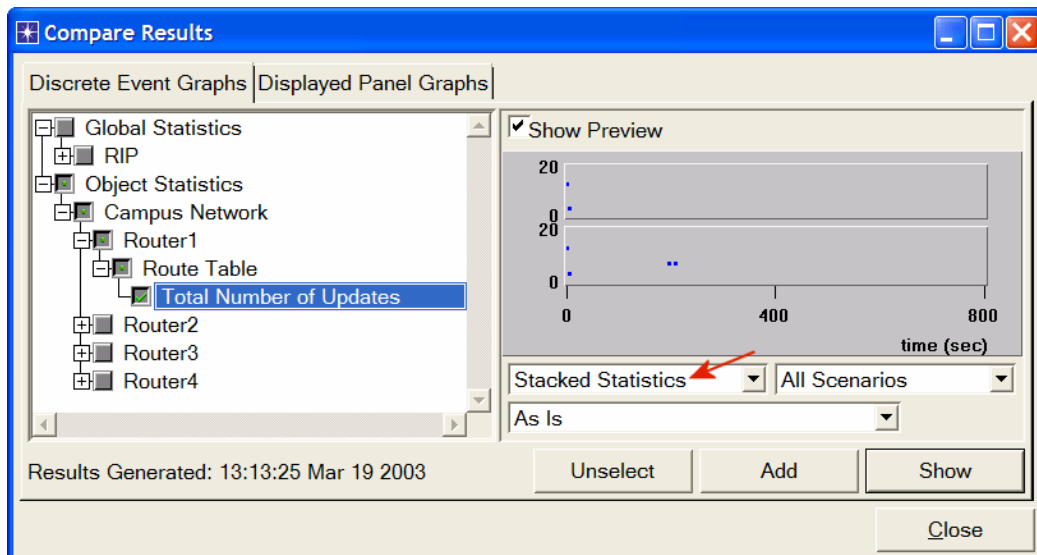


3. Click **OK** to run the two simulations. Depending on the speed of your processor, this may take several seconds to complete.
4. After the two simulation runs complete, one for each scenario, click **Close** ⇒ Save your project.

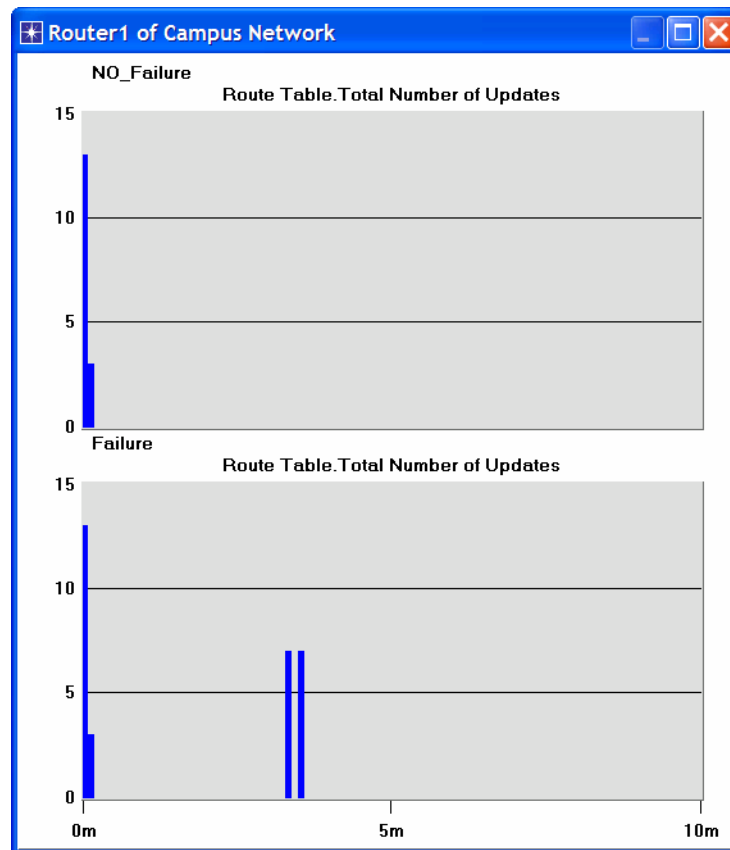
## View the Results

Compare the Number of Updates:

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 to **Stacked Statistics** as shown.



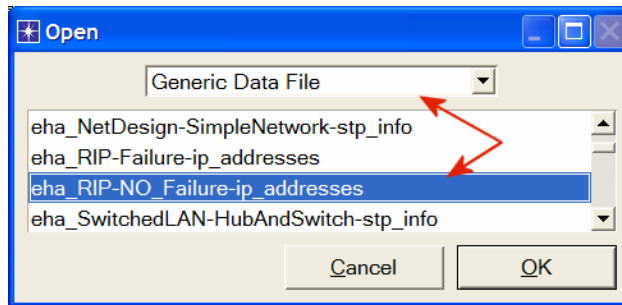
3. Select the **Total Number of Updates** statistic for **Router1** and click **Show**.
4. You should get two graphs, one for each scenario. Right-click on each graph and select **Draw Style** ⇒ **Bar**.
5. The resulting graphs should resemble the following (you can zoom in on the graphs by clicking-and-dragging a box over the region of interest):



*Obtain the IP Addresses of the Interface:*

Before checking the contents of the routing tables, we need to determine the IP address information for all interfaces in the current network. Recall that these IP addresses are assigned automatically during simulation, and we set the global attribute **IP Interface Addressing Mode** to export this information to a file.

1. From the **File** menu choose **Model Files** ⇒ **Refresh Model Directories**. This causes OPNET IT Guru to search the model directories and update its list of files.
2. From the **File** menu choose **Open** ⇒ From the drop-down menu choose **Generic Data File** ⇒ Select the **<your initials>\_RIP-NO\_Failure-ip\_addresses** file (the other file created from the **Failure** scenario should contain the same information) ⇒ Click **OK**.

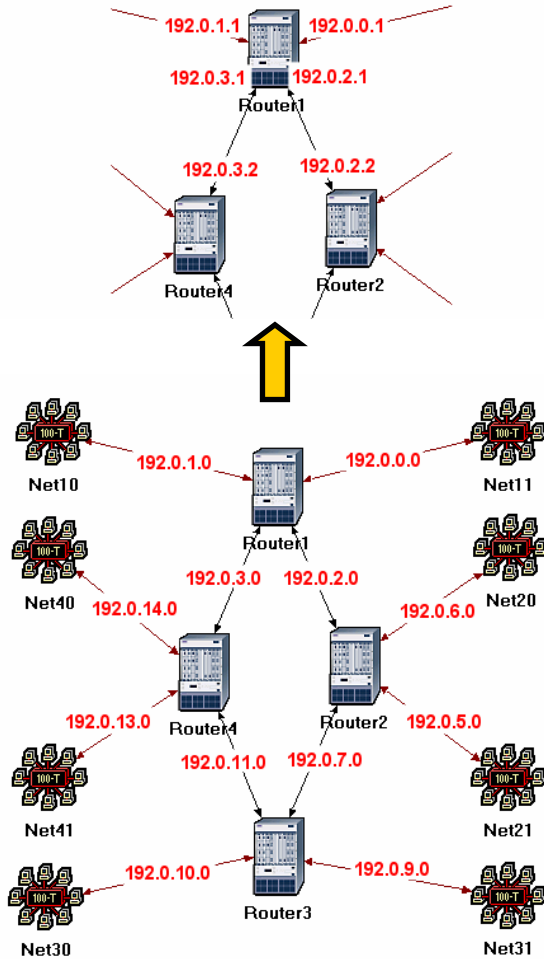


3. The following is a part of the **gdf** file content. It shows the IP addresses assigned to the interfaces of **Router1** in our network. For example the interface of **Router1** that is connected to **Net11** has the IP address **192.0.0.1** (*Note: Your result may vary due to different nodes placement.*) The **Subnet Mask** associated with that interface indicates that the address of the subnetwork, to which the interface is connected, is **192.0.0.0** (i.e., the logical AND of the interface IP address and the subnet mask).

Node Name: Campus Network.Router1	Iface Name	Iface Index	IP Address	Subnet Mask	Connected Link
	IF0	0	192.0.0.1	255.255.255.0	Campus Network.Net11 <-> Router1
	IF1	1	192.0.1.1	255.255.255.0	Campus Network.Net10 <-> Router1
	IF10	10	192.0.2.1	255.255.255.0	Campus Network.Router1 <-> Router2
	IF11	11	192.0.3.1	255.255.255.0	Campus Network.Router4 <-> Router1
	Loopback	12	192.0.4.1	255.255.255.0	Not connected to any link.



4. Print out the layout of the network you implemented in this lab. On this layout, from the information included in the **gdf** file, write down the IP addresses associated with **Router1** as well as the addresses assigned to each subnetwork as shown in the following two figures (*Note: Your IP addresses may vary due to different nodes placement.*)



*Compare the Routing Tables Content:*

1. To check the content of the routing tables in **Router1** for both scenarios:
  - i. Go to the **Results** menu ⇒ **Open Simulation Log** ⇒ Expand the hierarchy on the left as shown below ⇒ Click on the field **COMMON ROUTE TABLE**.

Time	Event	Node	Category	Message
600	20847	Campus Network.Router1	Results	COMMON ROUTE TABLE snapshot for:   (...)
600	20851	Campus Network.Router2	Results	COMMON ROUTE TABLE snapshot for:   (...)
600	20855	Campus Network.Router3	Results	COMMON ROUTE TABLE snapshot for:   (...)
600	20859	Campus Network.Router4	Results	COMMON ROUTE TABLE snapshot for:   (...)

- Carry out the previous step for both scenarios. The following are partial contents of Router1's routing table for both scenarios (*Note: Your results may vary due to different nodes placement*):

Routing table of Router1 (**NO\_Failure** scenario):

```

Router name: Campus Network.Router1
at time: 600.00 seconds
ROUTE TABLE contents:

```

Dest. Address	Subnet Mask	Next Hop	Interface Name	Metric	Protocol
192.0.0.0	255.255.255.0	192.0.0.1	IF0	0	Direct
192.0.1.0	255.255.255.0	192.0.1.1	IF1	0	Direct
192.0.2.0	255.255.255.0	192.0.2.1	IF10	0	Direct
192.0.3.0	255.255.255.0	192.0.3.1	IF11	0	Direct
192.0.4.0	255.255.255.0	192.0.4.1	Loopback	0	Direct
192.0.5.0	255.255.255.0	192.0.2.2	IF10	1	RIP
192.0.6.0	255.255.255.0	192.0.2.2	IF10	1	RIP
192.0.7.0	255.255.255.0	192.0.2.2	IF10	1	RIP
192.0.8.0	255.255.255.0	192.0.2.2	IF10	1	RIP
192.0.11.0	255.255.255.0	192.0.3.2	IF11	1	RIP
192.0.13.0	255.255.255.0	192.0.3.2	IF11	1	RIP
192.0.14.0	255.255.255.0	192.0.3.2	IF11	1	RIP
192.0.15.0	255.255.255.0	192.0.3.2	IF11	1	RIP
192.0.9.0	255.255.255.0	192.0.2.2	IF10	2	RIP
192.0.10.0	255.255.255.0	192.0.2.2	IF10	2	RIP
192.0.12.0	255.255.255.0	192.0.2.2	IF10	2	RIP

**Loopback interface** allows a client and a server on the same host to communicate with each other using TCP/IP.

Routing table of Router1 (**Failure** scenario):

```

Router name: Campus Network.Router1
at time: 600.00 seconds
ROUTE TABLE contents:

```

Dest. Address	Subnet Mask	Next Hop	Interface Name	Metric	Protocol
192.0.0.0	255.255.255.0	192.0.0.1	IF0	0	Direct
192.0.1.0	255.255.255.0	192.0.1.1	IF1	0	Direct
192.0.2.0	255.255.255.0	192.0.2.1	IF10	0	Direct
192.0.3.0	255.255.255.0	192.0.3.1	IF11	0	Direct
192.0.4.0	255.255.255.0	192.0.4.1	Loopback	0	Direct
192.0.11.0	255.255.255.0	192.0.3.2	IF11	1	RIP
192.0.13.0	255.255.255.0	192.0.3.2	IF11	1	RIP
192.0.14.0	255.255.255.0	192.0.3.2	IF11	1	RIP
192.0.15.0	255.255.255.0	192.0.3.2	IF11	1	RIP
192.0.5.0	255.255.255.0	192.0.3.2	IF11	3	RIP
192.0.6.0	255.255.255.0	192.0.3.2	IF11	3	RIP
192.0.7.0	255.255.255.0	192.0.3.2	IF11	2	RIP
192.0.8.0	255.255.255.0	192.0.3.2	IF11	3	RIP
192.0.9.0	255.255.255.0	192.0.3.2	IF11	2	RIP
192.0.10.0	255.255.255.0	192.0.3.2	IF11	2	RIP
192.0.12.0	255.255.255.0	192.0.3.2	IF11	2	RIP

## Further Readings

- RIP: IETF RFC number 2453 ([www.ietf.org/rfc.html](http://www.ietf.org/rfc.html)).

## Questions

- 1) Obtain and analyze the graphs that compare the sent RIP traffic for both scenarios. Make sure to change the draw style for the graphs to **Bar**.
- 2) Describe and explain the effect of the failure of the link connecting **Router1** to **Router2** on the routing tables.
- 3) Create another scenario as a duplicate of the **Failure** scenario. Name the new scenario **Q3\_Recover**. In this new scenario have the link connecting **Router1** to **Router2** recover after 400 seconds. Generate and analyze the graph that shows the effect of this recovery on the **Total Number of Updates** in the routing table of **Router1**. Check the contents of **Router1**'s routing table. Compare this table with the corresponding routing tables generated in the **NO\_Failure** and **Failure** scenarios.

## 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.