Laboratory

6

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 **Riverbed Modeler 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 **Finish**.

Create and Configure the Network

Initialize the Network:

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.

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.

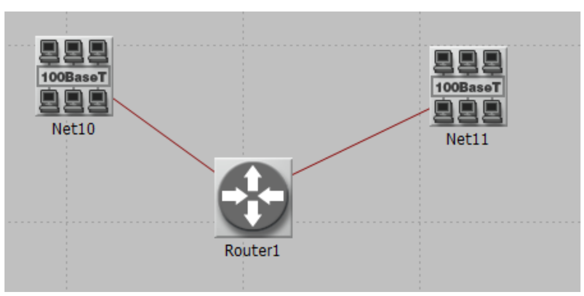
2. Add to the project workspace the following objects from the palette: one **ethernet4_slip8_gtwy** router and two **100BaseT_LAN** objects.

   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.



Configure the Router:

1. Right-click on **Router1** ⇒ **Edit Attributes** ⇒ Expand the **Reports** hierarchy ⇒ Expand the **RIP Routing Table** hierarchy and set the following:
   i. **Export Time(s) Specification** = **Once at End of Simulation**. This asks the router to export its routing table at the end of the simulation to the *simulation log*.
   ii. **Status** = **Enable**.

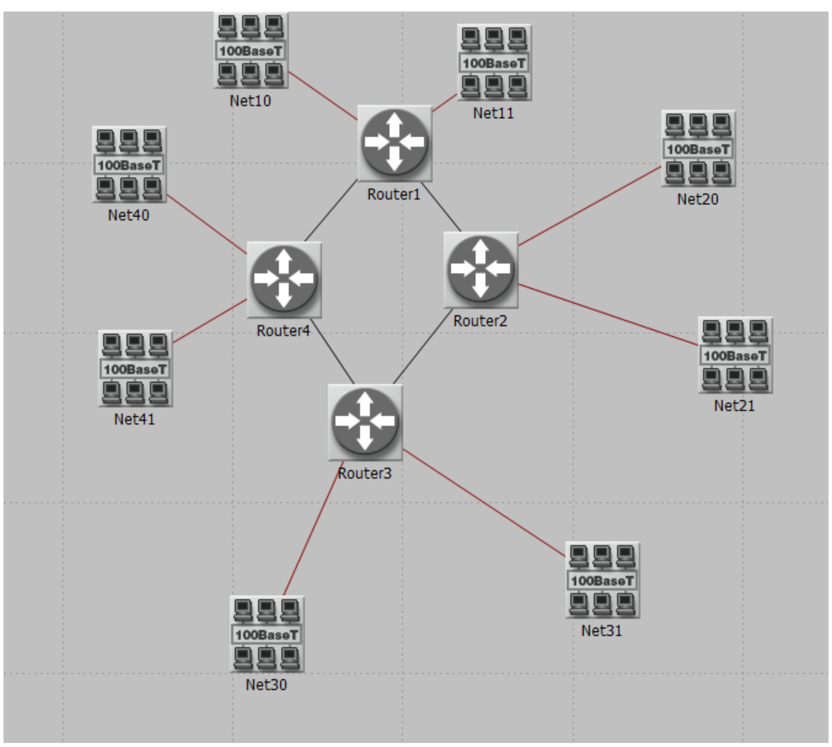
2. Expand the **IP** hierarchy ⇒ Expand the **IP Routing Parameters** hierarchy ⇒ Expand the **Loopback Interfaces** hierarchy ⇒ set the **Number of Rows** to **1**.

3. 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:

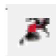
1. Right-click anywhere in the project workspace and select **Choose Individual Statistics** from the pop-up menu.

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 and Run 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:

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.

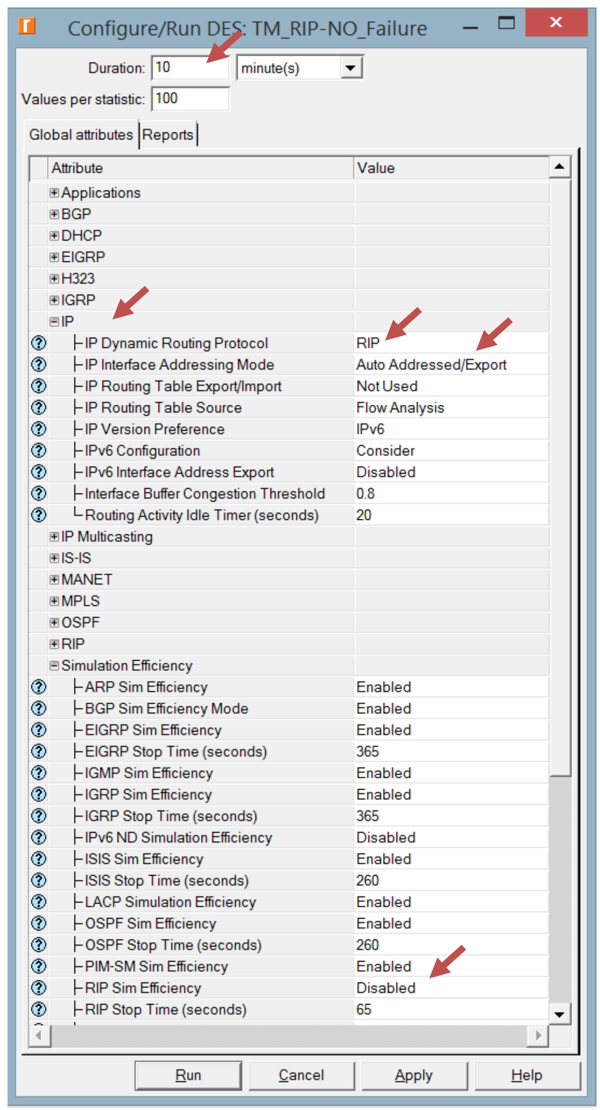
Export causes the auto-assigned IP interface to be exported to a file (name of the file is <net_name>-ip_addresses.gdf and gets saved in the primary model directory).

   a. Expand the **IP** hierarchy ⇒ **IP Dynamic Routing Protocol** = **RIP**. This sets the RIP protocol to be the routing protocol of all routers in the network.

   b. Expand the **IP** hierarchy ⇒ **IP Interface Addressing Mode** = **Auto Addressed/Export**.

   c. Expand the **Simulation Efficiency** hierarchy ⇒ **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.

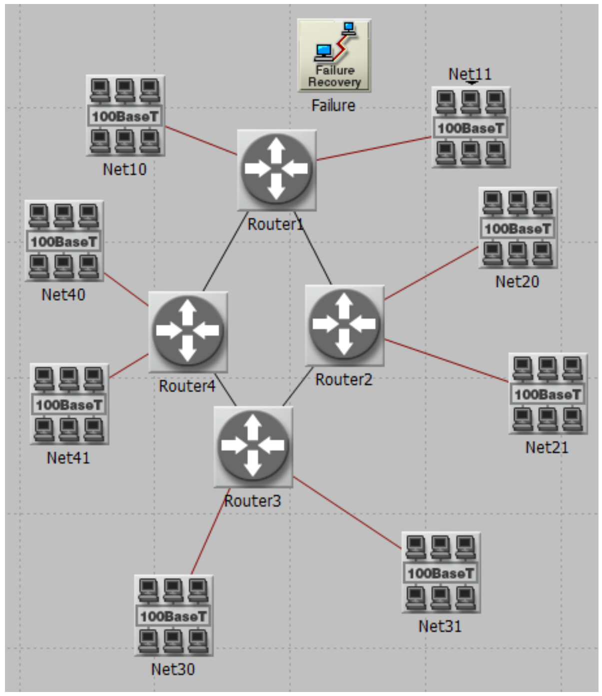


Duplicate the Scenario

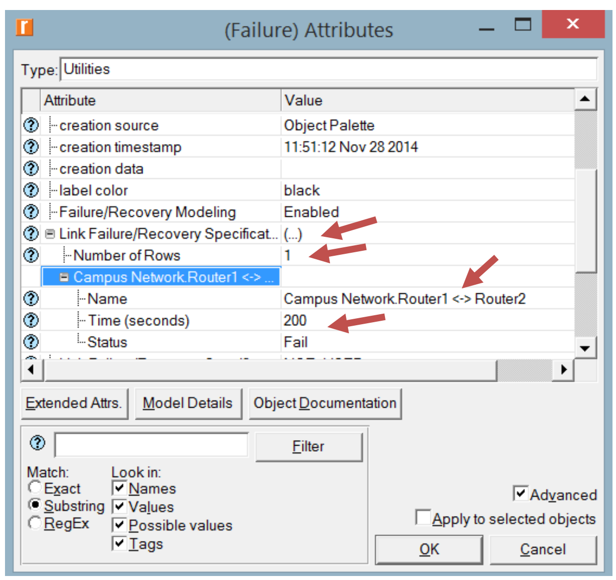
In the network we just created, the routers will build their routing tables, and then they will not need to update them further because we didn't simulate any node or link failures. In this scenario we will simulate failures so that we can compare the behavior of the routers in both cases.

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

1. Click on  and the *Configure Simulation* window should appear.

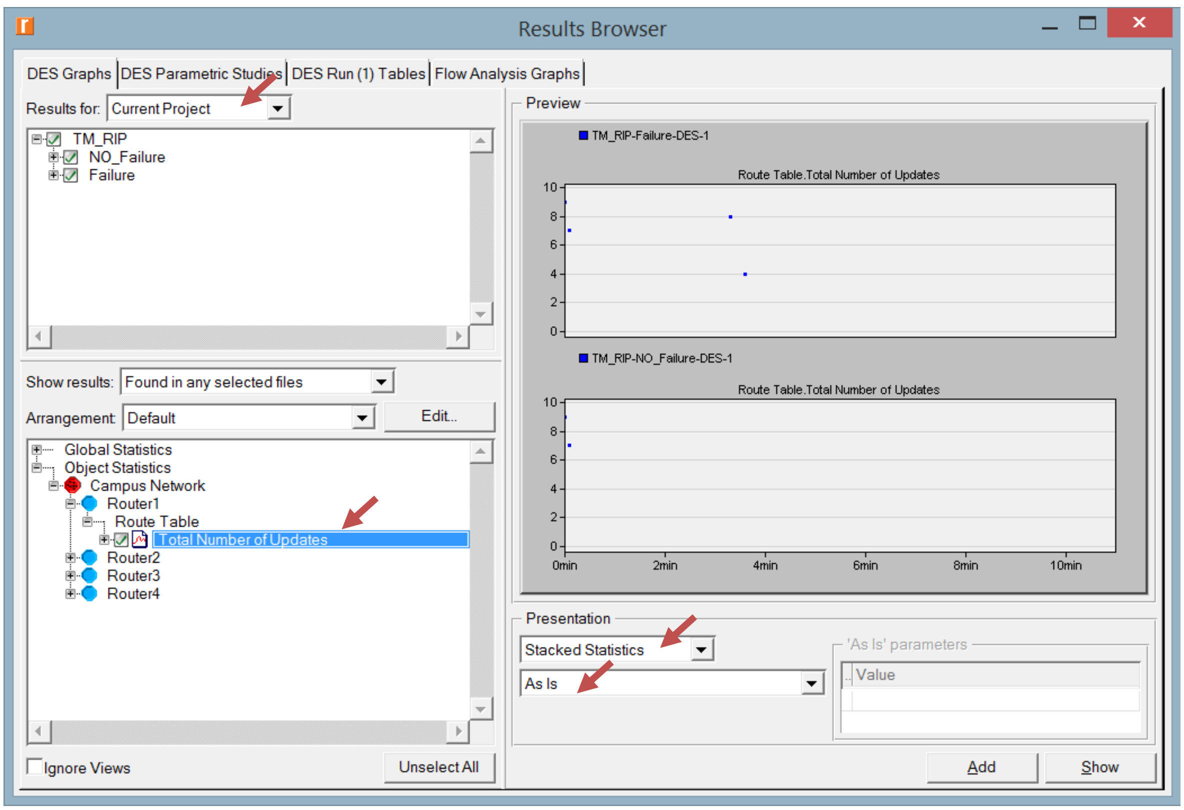
2. Check that all the configuration are as was configured previously and click **Run**.

View the Results

Compare the Number of Updates:

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

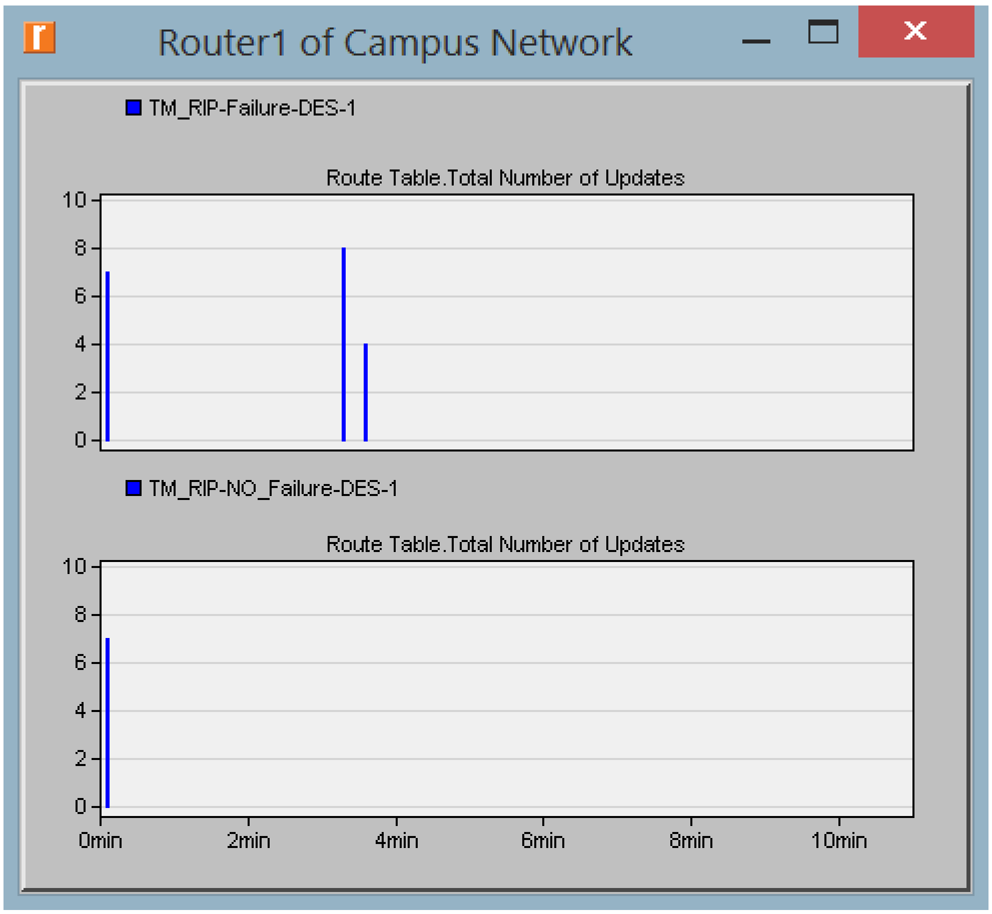
2. Change the drop-down menu in the right-lower part of the *Compare Results* dialog box to **Stacked Statistics** as shown.



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 Chart**.

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:

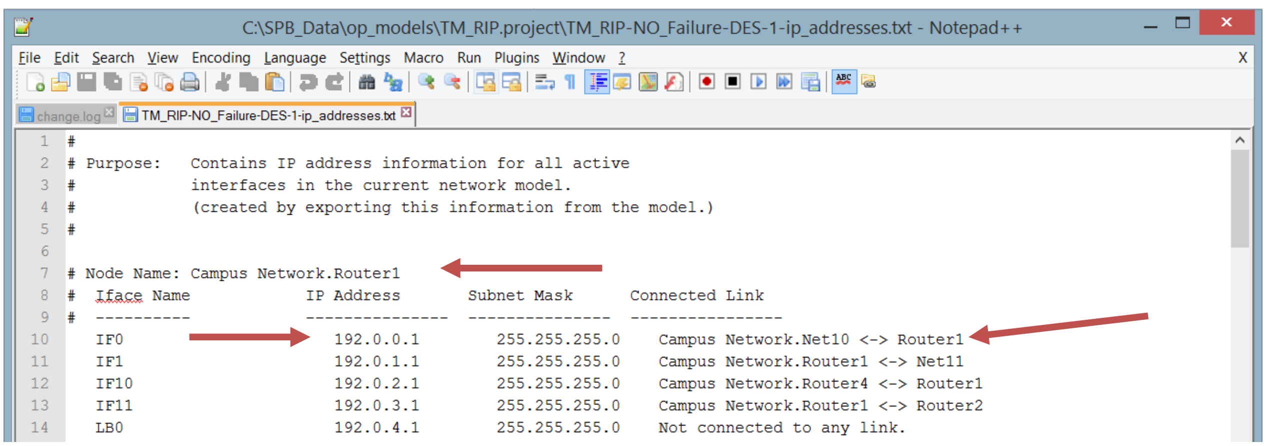
Before checking the contents of the routing tables, we need to determine the IP address information for all interfaces in the current network. Recall that these IP addresses are assigned automatically during simulation, and we set the global attribute **IP Interface Addressing Mode** to export this information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

1. From your favorite file explorer, find the directory in which your project is saved.

2. Locate the **<your initials>_RIP-NO_Failure-ip_addresses.gdf** file (the other file created from the **Failure** scenario should contain the same information) ⇒ Make a copy of this file and change the file type to **.txt** (meaning to **<your initials>_RIP-NO_Failure-ip_addresses.txt**).

3. Use your favorite **advanced text editor** (If you don't have one installed, or if the one you have does not perform well, you may use **Notepad++** which can be downloaded for free from: http://notepad-plus-plus.org/).

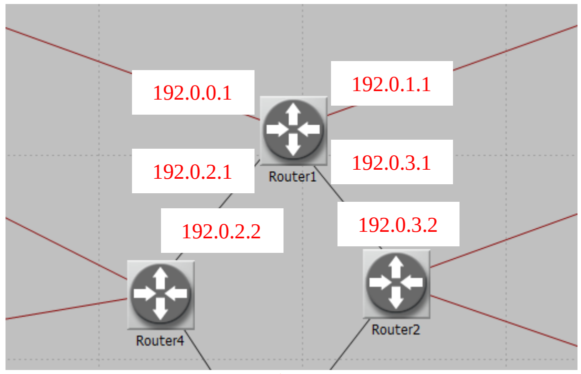
4. The following is a part of the **gdf** file content. It shows the IP addresses assigned to the interfaces of **Router1** in our network. For example the interface of **Router1** that is connected to **Net10** has the IP address `192.0.0.1` (*Note:* Your result may vary due to different nodes placement.) 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).

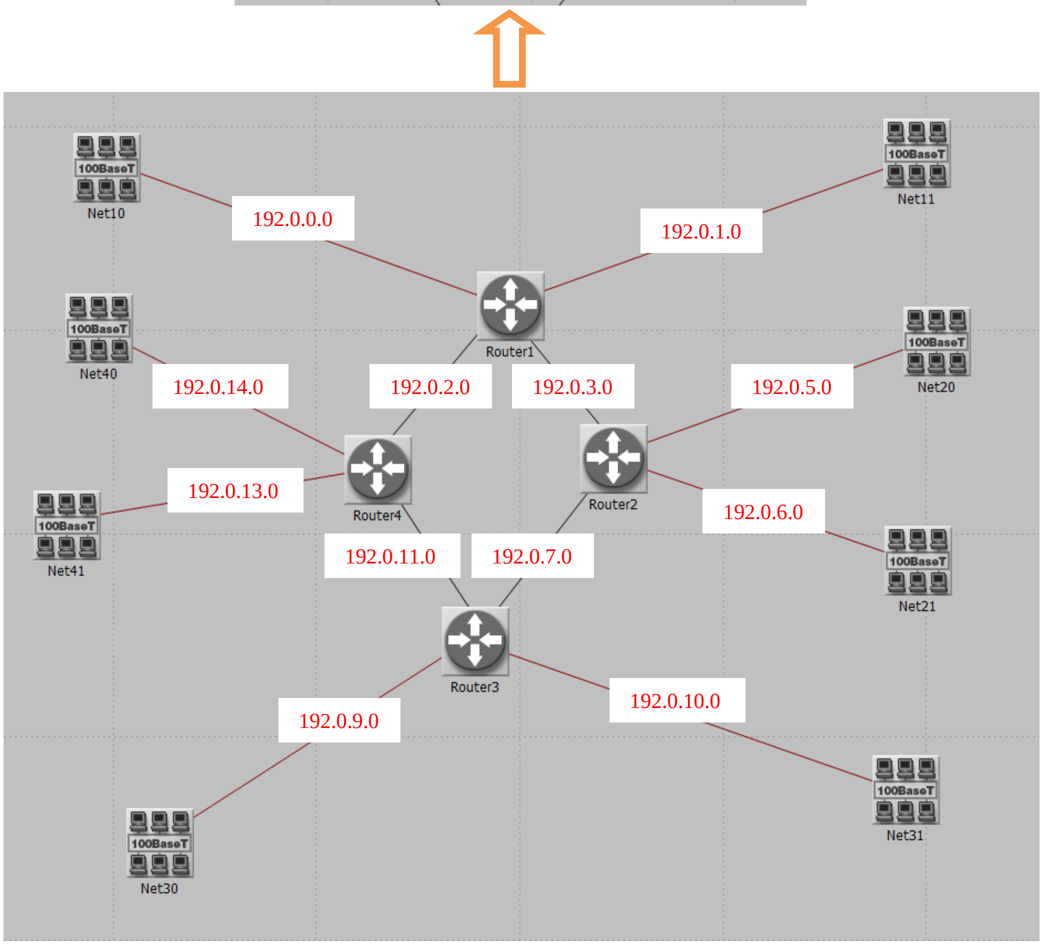



```
#
# Purpose:   Contains IP address information for all active
#            interfaces in the current network model.
#            (created by exporting this information from the model.)
#

# Node Name: Campus Network.Router1
#  Iface Name            IP Address        Subnet Mask       Connected Link
#  ----------            ---------------   ---------------   ----------------
   IF0                     192.0.0.1         255.255.255.0     Campus Network.Net10 <-> Router1
   IF1                     192.0.1.1         255.255.255.0     Campus Network.Router1 <-> Net11
   IF10                    192.0.2.1         255.255.255.0     Campus Network.Router4 <-> Router1
   IF11                    192.0.3.1         255.255.255.0     Campus Network.Router1 <-> Router2
   LB0                     192.0.4.1         255.255.255.0     Not connected to any link.
```

5. 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.)


192.0.0.1
192.0.1.1
192.0.2.1
192.0.3.1
Router1
192.0.2.2
192.0.3.2
Router4
Router2


100BaseT
Net10
100BaseT
Net11
192.0.0.0
192.0.1.0
Router1
100BaseT
Net40
100BaseT
Net20
192.0.14.0
192.0.2.0
192.0.3.0
192.0.5.0
192.0.13.0
Router4
Router2
100BaseT
Net41
192.0.6.0
192.0.11.0
192.0.7.0
100BaseT
Net21
Router3
192.0.9.0
192.0.10.0
100BaseT
Net31
100BaseT
Net30

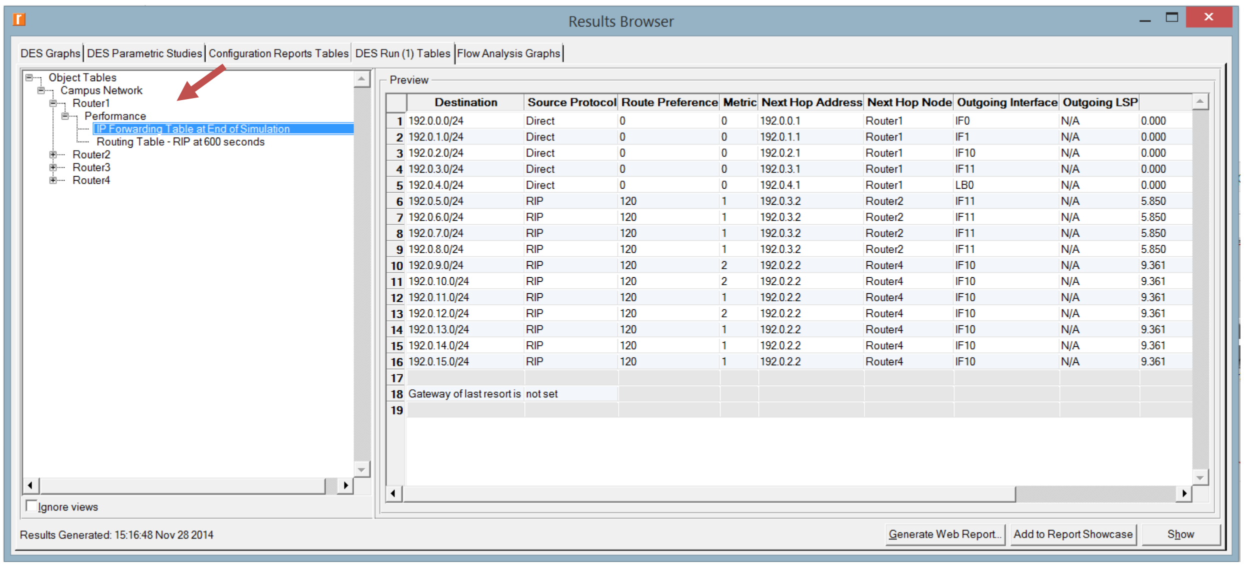
Compare the Routing Tables Content:

1. To check the content of the routing tables in **Router1** for both scenarios:

   i. Select **Router1** by clicking on it ⇒ Go to the **Routing** menu in **IP in the Protocols** menu (Expand the hierarchy on the left as shown below) ⇒ Click on the field **Export Routing Tables….**

   ii. **Run** the simulation.

   iii. Open **View Results** Select **DES Run Tables** tab ⇒ Expand the hierarchy on the left as shown below



	Destination	Source Protocol	Route Preference	Metric	Next Hop Address	Next Hop Node	Outgoing Interface	Outgoing LSP	
1	192.0.0.0/24	Direct	0	0	192.0.0.1	Router1	IF0	N/A	0.000
2	192.0.1.0/24	Direct	0	0	192.0.1.1	Router1	IF1	N/A	0.000
3	192.0.2.0/24	Direct	0	0	192.0.2.1	Router1	IF10	N/A	0.000
4	192.0.3.0/24	Direct	0	0	192.0.3.1	Router1	IF11	N/A	0.000
5	192.0.4.0/24	Direct	0	0	192.0.4.1	Router1	LB0	N/A	0.000
6	192.0.5.0/24	RIP	120	1	192.0.3.2	Router2	IF11	N/A	5.850
7	192.0.6.0/24	RIP	120	1	192.0.3.2	Router2	IF11	N/A	5.850
8	192.0.7.0/24	RIP	120	1	192.0.3.2	Router2	IF11	N/A	5.850
9	192.0.8.0/24	RIP	120	1	192.0.3.2	Router2	IF11	N/A	5.850
10	192.0.9.0/24	RIP	120	2	192.0.2.2	Router4	IF10	N/A	9.361
11	192.0.10.0/24	RIP	120	2	192.0.2.2	Router4	IF10	N/A	9.361
12	192.0.11.0/24	RIP	120	1	192.0.2.2	Router4	IF10	N/A	9.361
13	192.0.12.0/24	RIP	120	2	192.0.2.2	Router4	IF10	N/A	9.361
14	192.0.13.0/24	RIP	120	1	192.0.2.2	Router4	IF10	N/A	9.361
15	192.0.14.0/24	RIP	120	1	192.0.2.2	Router4	IF10	N/A	9.361
16	192.0.15.0/24	RIP	120	1	192.0.2.2	Router4	IF10	N/A	9.361
17									
18	Gateway of last resort is	not set							
19									

2. 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):

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

In the above picture, the routing table of Router1 (**NO_Failure** scenario).

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

Preview

	Destination	Source Protocol	Route Preference	Metric	Next Hop Address	Next Hop Node	Outgoing Interface	Outgoing LSP	Insertion Tir
1	192.0.0.0/24	Direct	0	0	192.0.0.1	Router1	IF0	N/A	0.000
2	192.0.1.0/24	Direct	0	0	192.0.1.1	Router1	IF1	N/A	0.000
3	192.0.2.0/24	Direct	0	0	192.0.2.1	Router1	IF10	N/A	0.000
4	192.0.4.0/24	Direct	0	0	192.0.4.1	Router1	LB0	N/A	0.000
5	192.0.5.0/24	RIP	120	3	192.0.2.2	Router4	IF10	N/A	219.361
6	192.0.6.0/24	RIP	120	3	192.0.2.2	Router4	IF10	N/A	219.361
7	192.0.7.0/24	RIP	120	2	192.0.2.2	Router4	IF10	N/A	219.361
8	192.0.8.0/24	RIP	120	3	192.0.2.2	Router4	IF10	N/A	219.361
9	192.0.9.0/24	RIP	120	2	192.0.2.2	Router4	IF10	N/A	9.361
10	192.0.10.0/24	RIP	120	2	192.0.2.2	Router4	IF10	N/A	9.361
11	192.0.11.0/24	RIP	120	1	192.0.2.2	Router4	IF10	N/A	9.361
12	192.0.12.0/24	RIP	120	2	192.0.2.2	Router4	IF10	N/A	9.361
13	192.0.13.0/24	RIP	120	1	192.0.2.2	Router4	IF10	N/A	9.361
14	192.0.14.0/24	RIP	120	1	192.0.2.2	Router4	IF10	N/A	9.361
15	192.0.15.0/24	RIP	120	1	192.0.2.2	Router4	IF10	N/A	9.361
16									
17	Gateway of last resort is	not set							
18									

Further Readings

- RIP: IETF RFC number 2453 (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 Chart.**

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.