Network Simulation Tools - OPNET

Advanced Topics In OPNET

Configuration and Analysis of Routing Behavior in IP Networks

Outline of Presentation

- RIP Deployment and Analysis
  - No_Failure Scenario
  - Failure Sccenario
- OSPF Configuration and Analysis
  - No_Area
  - Area
  - Balanced

Objectives

- Routing protocols deployment and configuration in OPNET
  - Configure and analyze the performance of the Routing Information Protocol (RIP) model
  - Routing behavior analysis in networks configure and analyze the performance of the Open Shortest Path First (OSPF) routing protocol

RIP: Routing Information Protocol

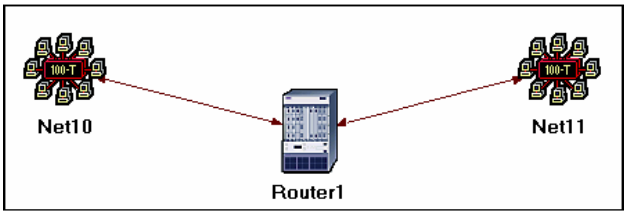
A Routing Protocol Based on the Distance-Vector Algorithm

Creating a New Project

- Open OPNET Modeler ➔ Choose **New** from the **File** menu
- Select **Project** and click **OK**
  - Name the project **Routing_RIP**
  - The scenario **NO_Failure** ➔ Click OK.
- 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

Creating and Configuring the Network

- Go to **Object Palette ➔ internet_toolbox**
  - Add to the project workspace one **ethernet4_slip8_gtwy** router and two **100BaseT_LAN** objects
- Close the Object Palette dialog box
- Save your project

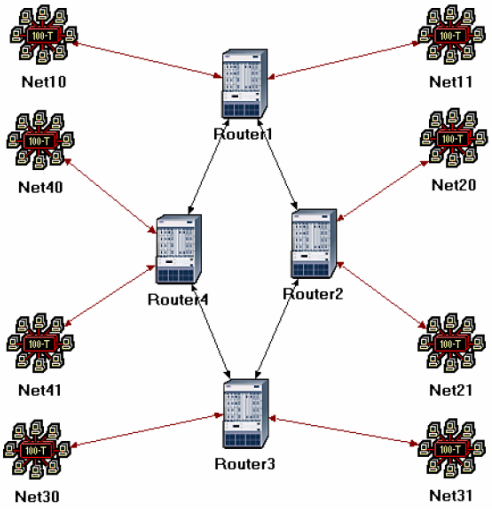


… Creating and Configuring the Network

- Connect the router and the LANs with a **100BaseT**
- RClick on Router1 ➔ **Edit Attributes**
  - Expand the **IP Routing Parameters** hierarchy and set the following:
    - **Routing Table Export = Once at End of Simulation**
- Click OK and then save your project

… Creating and Configuring the Network

- Select all the objects in the network
  - Router, 2 LANs and interconnection
- Make three more copies and make sure that your network look like this
- Use **PPP_DS3** links to interconnect the routers



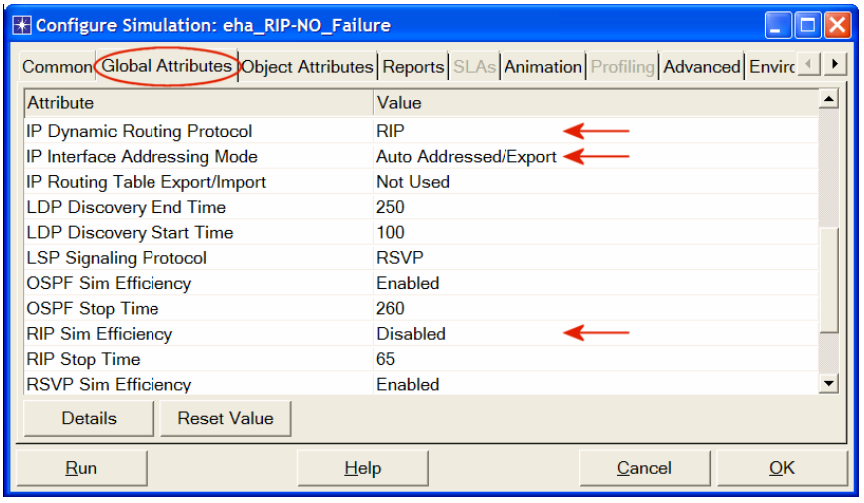
Choosing the Statistics

- RClick anywhere in the project workspace and select **Choose Individual Statistics** from the pop-up menu
- In the **Choose Results** dialog box, check the following statistics:
  - Global Statistics ➔ RIP ➔ Traffic Sent (bits/sec)
  - Global Statistics ➔ RIP ➔ Traffic Received (bits/sec)
  - Nodes Statistics ➔ Route Table ➔ Total Number of Updates
- Click OK and then save your project

Configuring the Simulation

- Set the duration to be 10.0 minutes
- Click on the **Global Attributes** tab and change the following attributes:
  - **IP Dynamic Routing Protocol = RIP**
    - This sets the RIP protocol to be the routing protocol of all routers in the network
  - **IP Interface Addressing Mode = Auto Addressed/Export**
  - **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)
- Click OK and then save the project

… Configuring the Simulation



Link Failure 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

… Link Failure Scenario

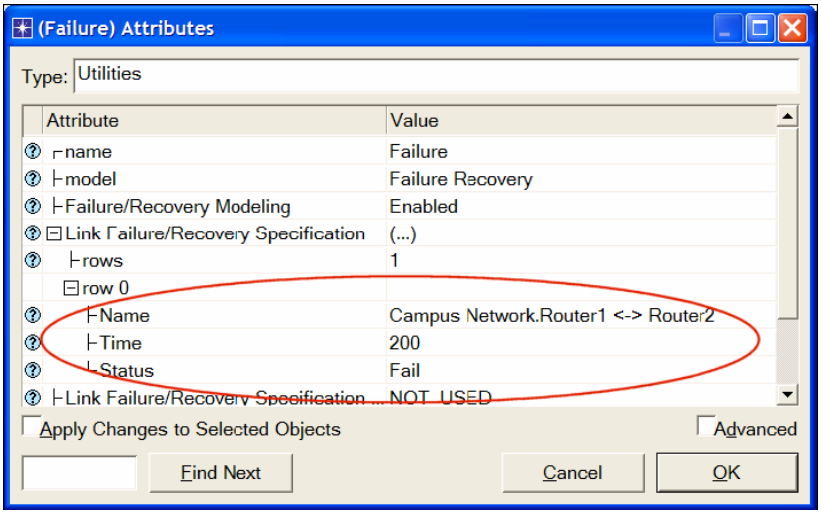
- Duplicate the first scenario from the **Scenarios** menu and name it **Failure** ➔ Click OK.
- Open the Object Palette and select the **Utilities** palette from the dropdown menu
- Add a Failure Recovery object to your workspace and name it Failure

Failure

… Link Failure Scenario

- RClick 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 shown in the next figure
  - This will "fail" the link between Router1 and Router2 200 seconds into the simulation
- Click OK and then save the project

… Link Failure Scenario

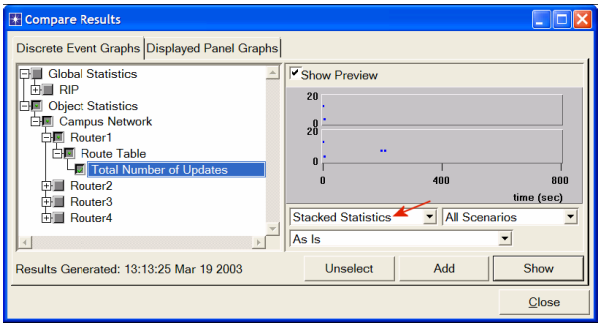


Running the Simulation

- To run the simulation for both scenarios simultaneously:
  - Go to the Scenarios menu ➔ Select **Manage Scenarios**
  - Change the values under the **Results** column to <collect> (or <recollect>) for both scenarios
- Click OK to run the two simulations
- After the two simulation runs complete, one for each scenario, click Close
- Make sure to save your project

Viewing the Results

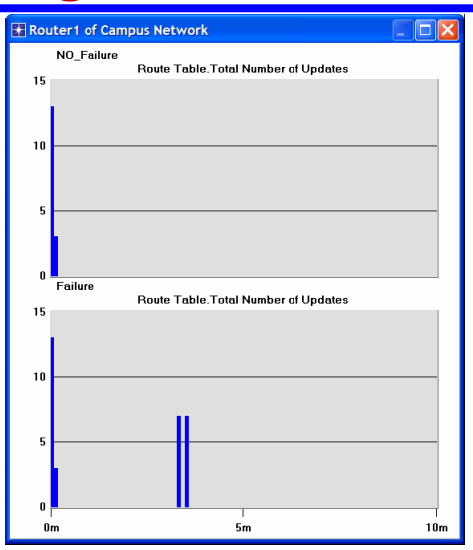
- Select **Compare Results** from the **Results** menu
- Change the drop-down menu in the right-lower part of the **Compare Results** dialog box to Stacked Statistics as shown



… Viewing the Results

- Select the **Total Number of Updates** statistic for Router1 and click Show
- You should get two graphs, one for each scenario. RClick on each graph and select **Draw Style → Bar**
- 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

… Viewing the Results



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

… Obtain the IP Addresses of the Interface

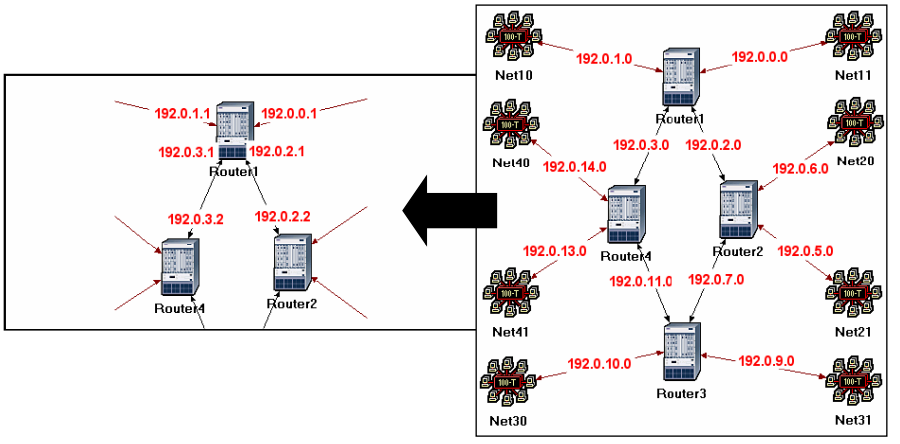
- From the **File** menu choose **Model Files → Refresh Model Directories**
- From the **File** menu choose **Open**
  - From the drop-down menu choose **Generic Data File →** Select the **Routing_RIP-NO_Failure-ip_addresses** file
    - The other file created from the **Failure** scenario should contain the same information
- Click OK

… Obtain the IP Addresses of the Interface

- The following is a part of the gdf file content. It shows the IP addresses assigned to the interfaces of Router1 in our network
- The interface of Router1 that is connected to Net11 has the IP address 192.0.0.1
  - 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
  - Logical AND of the interface IP address and the subnet mask

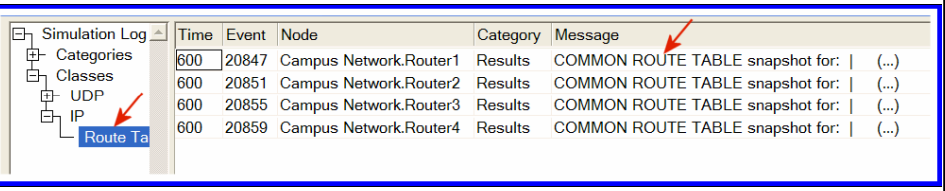
```
Node Name: Campus Network.Router1
 Iface Name          Iface Index   IP Address       Subnet Mask      Connected Link
 ----------          -----------   --------------   --------------   ----------------
 IF0                    0          192.0.0.1        255.255.255.0    Campus Network.Net11 <-> 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.
```

… Obtain the IP Addresses of the Interface



Comparing the Routing Tables Content

- Go to the **Results** menu ➔ **Open Simulation Log**
  - Expand the hierarchy on the left as shown below ➔ Click on the field **COMMON ROUTE TABLE**



  - **Carry out the previous step for both scenarios**

Routing table of Router1 (NO_Failure scenario)

- The following are partial contents of Router1's routing table for both scenarios
  - Your results may vary due to different nodes placement

```
  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
```


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
```

OSPF: Open Shortest Path First

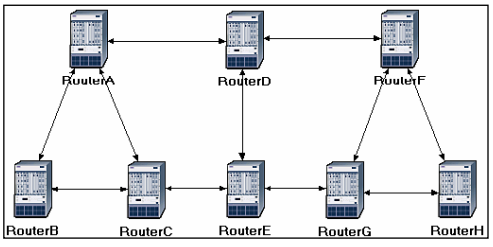
A Routing Protocol Based on the Link-State Algorithm

Creating a New Project

- Start OPNET Modeler ➔ Choose **New** from the **File** menu
- Select Project and click OK ➔ Name the project Routing_OSPF, and the scenario No_Areas ➔ Click OK
- 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.

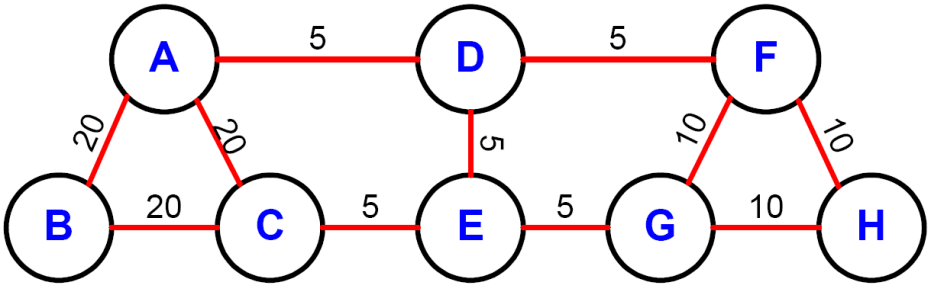
Creating and Configuring the Network

- Go to **Object Palette → routers**
  - Add to the project workspace eight **slip8_gtwy** routers
- Switch the **Object Palette** to **links**
  - Use **PPP_DS3** links to connect the routers



- Save your work and move on

Configuring the Link Costs



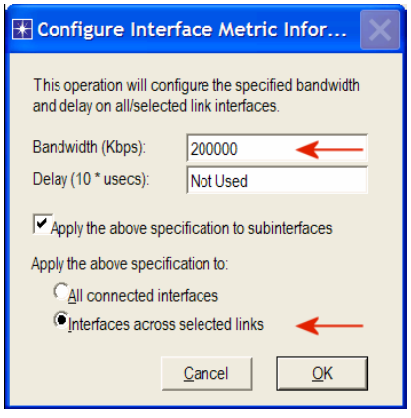
- OPNET router models support a parameter called a reference bandwidth to calculate the actual cost
- Cost = (Reference bandwidth) / (Link bandwidth)
  - The default value of the reference bandwidth is 1,000,000 Kbps.

… Configuring the Link Costs

- To assign the costs to the links of our network, do the following:
  - Select all links in your network that correspond to the links with a cost of 5 in the above graph
  - Select the **Protocols** menu ➔ **IP** ➔ **Routing** ➔ **Configure Interface Metric Information**
  - Assign 200,000 to the Bandwidth (Kbps) field ➔ Check the **Interfaces across selected links** radio button, as shown ➔ Click OK.

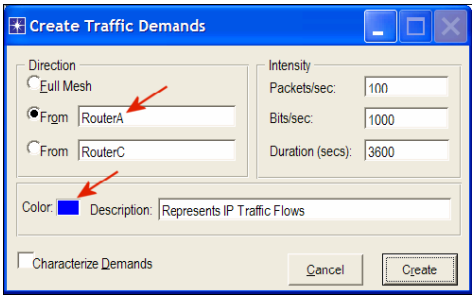
… Configuring the Link Costs

- Repeat these configurations for all links with a cost of 10 but assign 100,000 Kbps to the Bandwidth (Kbps) field
- Repeat these configurations for all links with a cost of 20 but assign 50,000 Kbps to the Bandwidth (Kbps) field
- Remember to Save your project



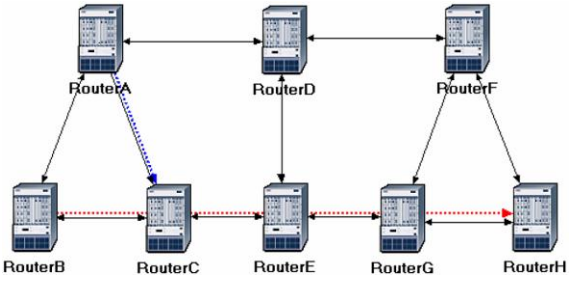
Configuring the Traffic Demands

- Select both RouterA and RouterC
- Select the **Protocols** menu ➔ **IP** ➔ **Demands** ➔ **Create Traffic Demands**
  - Check the From RouterA radio button as shown ➔ Keep the color as blue ➔ Click Create
  - Now you should see a blue-dotted line representing the traffic demand between RouterA and RouterC



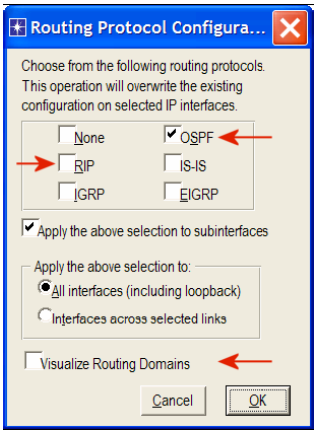
… Configuring the Traffic Demands

- Create a new traffic demand from RouterB to RouterH
  - Now you can see the lines representing the traffic demands as shown
- To hide these lines: Select the **View** menu ➔ Select **Demand Objects** ➔ Select **Hide All**
- Save your project



Configuring the Routing Protocol

- Select the **Protocols** menu ➔ **IP** ➔ **Routing** ➔ **Configure Routing Protocols**
- Check the **OSPF** check box ➔ Uncheck the **RIP** check box ➔ Uncheck the **Visualize Routing Domains** check box
- Click OK.
- Select RouterA and RouterB only
  - Select the **Protocols** menu ➔ **IP** ➔ **Routing** ➔ Select **Export Routing Table for Selected Routers** ➔ Click **OK** on the Status Confirm dialog box



Addresses Configuration

- Select the **Protocols** menu ➔ **IP** ➔ **Addressing** ➔ Select **Auto-Assign IP Addresses**
- Save your project and move on

Simulation Configuration

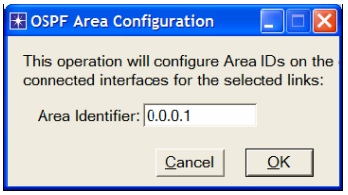
- Click on  and the *Configure Simulation window* should appear.
- Set the duration to be 10.0 minutes.
- Click OK and then save your project.

Areas & Load Balancing

- In the network we just created, all routers belong to one level of hierarchy (i.e., one area)
- Also, there is no load balancing enforcement for any routes
- Two new scenarios will be created.
  - The first new scenario will define two new areas in addition to the backbone area
  - The second one will be configured to balance the load for the traffic demands between RouterB and RouterH

The Area Scenario

- Select **Duplicate Scenario** from the **Scenarios** menu and give it the name Areas ➔ Click OK.
- Area 0.0.0.1
  - Select the three links that connect RouterA, RouterB, and RouterC
  - Select the **Protocols** menu ➔ **OSPF** ➔ **Configure Areas**
    - Assign the value 0.0.0.1 to the Area Identifier ➔ Click OK

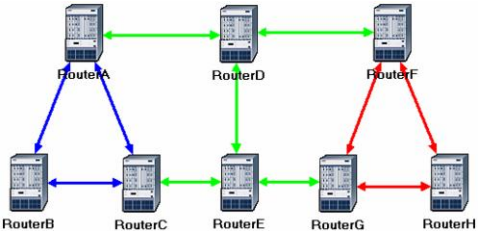


The Area Scenario

- RClick on **RouterC ➔ Edit Attributes**
  - Expand the **OSPF Parameters**
  - Expand the **Loopback Interfaces**
  - Expand the **row0**
  - Assign **0.0.0.1** to the value of the **Area ID** attribute
  - Click **OK**
- Area 0.0.0.2
  - Select the three links that connect RouterF, RouterG, and RouterH
  - Select the **Protocols** menu ➔ **OSPF** ➔ **Configure Areas**
    - Assign the value 0.0.0.2 to the Area Identifier ➔ Click OK

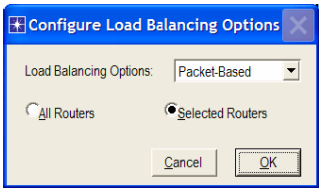
The Area Scenario

- To visualize the areas we just created, select the Protocols menu ➔ OSPF ➔ Visualize Areas ➔ Click OK
- The network should look like the following one with different colors assigned to each area
  - you may get different colors though
- Note that the area you did not configure is the backbone area and its Area Identifier = 0.0.0.0



The Balanced Scenario

- Under the **Scenarios** menu, **Switch to Scenario** ➔ Select No_Areas.
- Select **Duplicate Scenario** from the **Scenarios** menu, and give it the name Balanced ➔ Click OK
- In the new scenario, select both RouterB and RouterH
- Select the **Protocols** menu ➔ **IP** ➔ **Routing** ➔ **Configure Load Balancing Options** ➔ Make sure that the option is **Packet-Based** and the radio button **Selected Routers** is selected ➔ Click OK
- Save your project

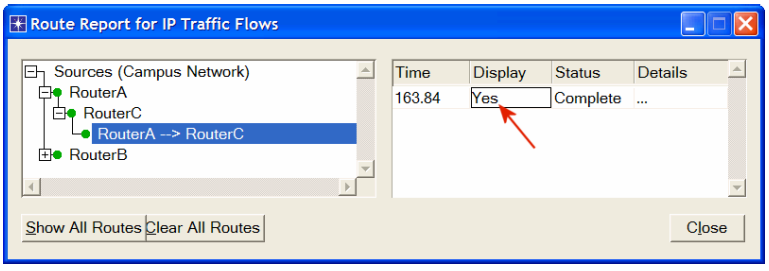


Running the Simulation

- To run the simulation for the three scenarios simultaneously:
  - Go to the **Scenarios** menu ➔ Select **Manage Scenarios**
  - Click on the row of each scenario and click the Collect Results button.
  - This should change the values under the Results column to <collect>
  - Click OK to run the three simulations
  - After the three simulation runs complete, one for each scenario, click Close
  - Save your project

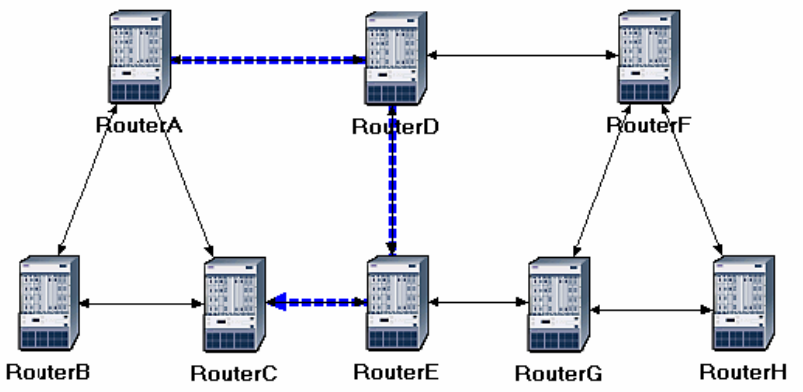
Viewing the Results : No_Area

- Go back to the No_Areas scenario
- To display the route for the traffic demand between RouterA and RouterC
- Select the Protocols menu ➔ IP ➔ Demands ➔ Display Routes for Configured Demands
  - Expand the hierarchies as shown and select RouterA→RouterC
  - Go to the Display column and pick Yes ➔ Click Close



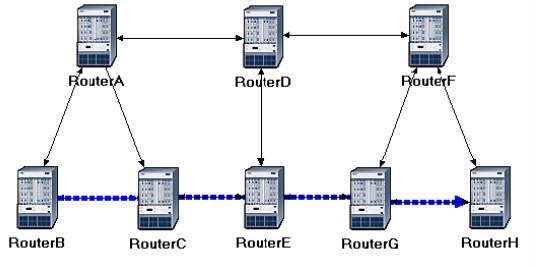
Viewing the Results : No_Area

- The resulting route will appear on the network



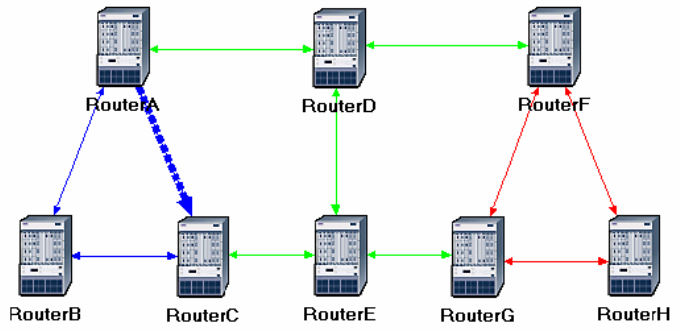
Viewing the Results : No_Area

- Repeat the previous step to show the route for the traffic demand between RouterB and RouterH.
  - Depending on the order in which you created the network topology, the other "equal-cost" path can be used, that is, the RouterB-RouterA-RouterD-RouterF-RouterH path



Viewing the Results : Areas

- Go to scenario Areas.
- Display the route for the traffic demand between RouterA and RouterC



Viewing the Results : Balanced

- Go to scenario Balanced
- Display the route for the traffic demand between RouterB and RouterH