
Dynamic Routing Protocols (RIP and OSPF)

What you will learn in this lab:

- How the dynamic routing protocol Routing Information Protocol (RIP) exchanges messages.
- How RIP reconfigures the routing tables after a change in the network topology.
- How the link state routing protocol Open Shortest Path First (OSPF) works.
- Convergence problems in RIP without split-horizon and triggered updates.

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Prelab 5

1. Refresh your knowledge of link state and distance vector routing protocols. Review the count-to-infinity problem and the split-horizon heuristic in distance vector routing protocols. What are the key differences between distance vector routing algorithms and link state algorithms?
2. Review Lab 3 to find answers to the following questions:
 - 2.1. On a Redhat 6.2 system, which files contain the information on the IP addresses of the system?
 - 2.2. On a Redhat 6.2 system, which file contains the information if the system is an IP router?
 - 2.3. Which lines do you need to set in the file given in 2.2 to setup a Linux PC, such that it performs IP forwarding (i.e., acts as an IP router) ?
3. What are the key differences between distance vector routing algorithms and link state algorithms?
4. Go to the website of gated at <http://www.gated.org/gated-web/code/doc/manuals/quickstart/whatisgated.html> and read about **gated**. Also read how to configure gated to run RIP, at http://www.gated.org/gated-web/code/doc/manuals/config_guide/samp_host.html.
 - 4.1. What are the different routing protocols supported by gated?
 - 4.2. Explain the statement "running RIP in passive mode". You can find information at http://www.gated.org/gated-web/code/doc/manuals/config_guide/rip_stmt.html.
 - 4.3. Provide the configuration file, which forces gated to run RIP in passive mode on a specific network interface.
(Hint: Check the sample configuration file at http://www.gated.org/gated-web/code/doc/manuals/config_guide/samp_host.html)
5. Read the manpage of **gdc** at http://www.gated.org/gated-web/code/doc/manuals/operation_guide/gdc.html. The gdc program is used to start, stop, and reconfigure the gated daemon.
 - 5.1. Provide the syntax of gdc for checking whether gated is running.
 - 5.2. Provide the syntax of gdc for forcing gated to reread its configuration file.
6. Read the manpage of **ospf_monitor** at http://www.gated.org/gated-web/code/doc/manuals/operation_guide/ospf_monitor.html.
 - 6.1. Provide the syntax of an entry in the *mon_db_file*, which queries the OSPF routing daemon on the machine vintpc1 with IP address 10.0.10.1.
 - 6.2. How does one save all the output from ospf_monitor into a file?
 - 6.3. How does one query a router to display its link state database?
 - 6.4. How do you display the router link advertisements originating from a router with the router id 10.0.12.1 and area id 0.0.0.1 (assume you are running ospf_monitor on your PC and the index of the configured router is 1)?

7. At URL <http://www.freebsd.org/cgi/man.cgi>, select "Redhat Linux/i386 6.2" and read the man pages of the commands **rsh** and **netstat**. Answer the following questions:
 - 7.1. Provide the syntax of the command, which continuously reports any changes to the routing table on the local host.
 - 7.2. Provide the syntax of the command, which displays the routing table of a remote host.
8. Read Appendix A of this Lab manual.
 - 8.1. What happens at the router if the hold-down of RIP is set to X seconds (for a Cisco 7000 router)?
 - 8.2. Explain the meaning of the flash-update-threshold in RIP (for a Cisco 7000 router).

Deliverables: Answer all problems and turn the answers in at the beginning of the lab.

Lab 5

For Parts 1, 2, 3, 4, 5 you will setup the PCs in a ring configuration.



Figure 1: Network Topology in Lab 5 (Parts 1 – 5).

Setup for Lab 5

- Parts 1- 5 only involves the six PCs. The machines will be configured in a ring configuration as shown in Figure 1.
- The goal of this lab is to observe how the dynamic routing protocols RIP and OSPF work.
- First, you will setup the PCs as RIP routers.
 - You will observe how the routing tables are dynamically modified, and eventually find the shortest path to all machines.
 - Then you will “break” the ring topology and observe how the routing tables adapt to this change.
- After this, you will run the same experiments with the OSPF routing protocol.
 - You will configure the machines as OSPF routers.
 - You will observe how the OSPF protocol floods the link state information of each router across the whole network.
 - You will observe the modification in the link state database of the routers when there is a break in the ring topology.
- Finally, we include an experiment which lets you observe the count-to-infinity problem when using the RIP protocol. You will observe how triggered updates solve the count-to-infinity problem of a RIP router, which uses split-horizon only. In this last experiment, you work with the configuration shown in Figure 2.

Part 1. Setting up the configuration

All PCs are equipped with two 100BaseT Ethernet cards. We refer to one card as the “first Ethernet card” and the other one as the “second Ethernet card”.

Set up the network in the configuration as shown in Figure 1. You can connect two Ethernet cards with an Ethernet hub, or directly with a crossover cables. Ask your lab instructor what to do.

Connect the first Ethernet card of one machine to the second Ethernet card of another machine according to the following table.

First Ethernet card of		Second Ethernet card of
Vintpc1		Vintpc2
Vintpc2		Vintpc3
Vintpc3 connects to....	Vintpc6
Vintpc4		Vintpc1
Vintpc5		Vintpc4
Vintpc6		Vintpc5

Exercise 1-1.

Once the physical connectivity is established you will configure the IP addresses of the two Ethernet interfaces on your machine (with names eth1 and eth0). Use the `ifconfig` command to setup the interfaces as follows:

Machine	Top Ethernet card (eth1)	Bottom Ethernet card (eth0)
Vintpc1	10.0.12.2	10.0.14.1
Vintpc2	10.0.23.2	10.0.12.1
Vintpc3	10.0.36.2	10.0.23.1
Vintpc4	10.0.14.2	10.0.45.1
Vintpc5	10.0.45.2	10.0.56.1
Vintpc6	10.0.56.2	10.0.36.1

At the end of this exercise, you should be able to “ping” your neighboring machines.

Get a check-off when you are done with this exercise.



Part 2 Setting up RIP routing

In this exercise, you will set up your PC as a RIP router. This is done by editing the following configuration files.

- **`/etc/sysconfig/network-scripts/ifcfg-eth0`**
`/etc/sysconfig/network-scripts/ifcfg-eth1`

To change the IP address permanently, edit the above files. The IP addresses in the files are assigned whenever the machine is rebooted.

- **`/etc/sysconfig/network`**

This file needs to be edited for enabling IP forwarding. If IP forwarding is enabled, a machine boots up as a router.

Note: From Lab 3 (Static Routing), you know that a host/router can have IP forwarding enabled, but not execute a dynamic routing protocol. To execute a dynamic routing protocol, a routing daemon (routed or gated), which is a user-level process, should be started. In this Lab, we will use the `gated` routing daemon which is able to run several routing protocols.

- **`/etc/gated.conf`**

If the `gated` daemon is started, it reads the configuration file `/etc/gated.conf` by default. The file `/etc/gated.conf` has information on the routing protocol to be run.

Exercise 2-1. File Configuration and Preparation

- In the directory `/etc` we have stored a sample configuration file `/etc/gated.conf.rip`. The configuration information in this file sets parameters and starts the RIP routing protocol.
- Copy the file `/etc/gated.conf.rip` to `/etc/gated.conf`. View the `/etc/gated.conf` file to convince yourself that `gated` has been configured to run RIP.
- Configure the IP addresses in the files `/etc/sysconfig/network-scripts/ifcfg-eth0` and `/etc/sysconfig/network-scripts/ifcfg-eth1` according to the table in Part 1.
- Edit `/etc/sysconfig/network` and enable IP forwarding.
- Reboot your machine. If your machine boots up, your machine will be configured to perform IP forwarding and the interface address will be configured properly.

Exercise 2-2. Start RIP and measure RIP traffic

Start `ethereal` on both Ethernet interfaces of your machine, and then start the `gated` daemon. Recall that `/etc/gated.conf` has been configured to run RIP routing protocol. Your objective is to capture all RIP packets.

- From the prelab you know that the `gdc` command is used to set the operation of the `gated` daemon. Verify that `gated` is not already running, by issuing the command:

```
gdc running
```

- Wait until all groups have completed the previous exercises. If some groups are behind, coordinate and help each other.
- Launch a number of windows (xterm's) and start measurement tools to measure the exchange of routing information.
 - Monitor RIP traffic (UDP port 520) on the interfaces with `ethereal`.
 - Monitor changes to the local routing table (`netstat -crn`).



For the postlab report, you need to save your measurements. Make sure that you establish the time correlation between the measurements taken in each window. Save the measurement data into files. While saving the data captured by `ethereal` into a plain text file, remember to select "Print hex data" in the "Ethereal: Print" window.

Your task is to observe how the local and remote routing tables converge to the shortest paths. Pay attention to the frequency at which messages are transmitted. Observe the speed of convergence. How can you tell that the routing tables have converged?

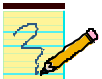
- Wait until all groups have completed the previous exercises, before you start `gated`. This experiment assumes that all machines start the routing daemon at approximately the same time.

- Start `gated` daemon with the command `gdc start`.

- Query the remote routing tables with the command:

```
rsh <remote IP address> netstat -rn
```

- Capture the routes to all machines with the command `traceroute`.



Lab Report: Include the measurements in your report and provide a detailed description of the convergence of the routing tables. Select one (!) RIP message captured with `ethereal` and provide an explanation of all fields of this message. Do not include the listing of all captured routing messages in your report.



Get a check-off when you are done with this exercise.

Part 3 Reconfiguring the Topology (RIP)

In this experiment, one of the links in Figure 1 will be disconnected. You will observe how the routing tables reorganize themselves after this change of the topology.

Exercise 3-1.

- Verify that all groups are done with the previous exercise. If not, wait until all groups are ready.
- Now, the groups working on vintpc3 and vintpc6 disconnect the link between vintpc3 and vintpc6.
- Perform the same measurements as in the previous exercise, using `ethereal`, `netstat -cr,rsh` and `traceroute`.
- Record the measurements until all routing tables have converged.

The experiment is completed when all routing tables have converged.



Lab Report: Provide an explanation how the routes have changed. Include the final routing table.



Get a check-off when you are done.

Part 4. Setting up OSPF Routing

In this exercise, you will work with the link state routing protocol OSPF. Link state routers have an identical and complete picture of the network. This is achieved by flooding the link state information of each router over the whole network. In addition, unlike distance vector routing protocols, link state protocols do not have convergence problems.

In this experiment you will learn:

- To configure a router with OSPF.
- The different types of packets used by the OSPF protocol.
- How does each router (running OSPF) in the network learn the state of the interfaces of the other routers?
- The fields contained in a link state advertisement.
- Flooding of an advertisement by a router to its neighbors.

- The identical link state database maintained by each router.

You will use `ospf_monitor` to query the gated daemon for the link state database, link state advertisements from all the routers in the network

`ethereal` will be used to capture the different types of OSPF packets and to analyze the payload of the captured packets in details.

Exercise 4-1.

In the following exercise, you configure the gated daemon to run OSPF. The directory `/etc` contains a sample file `gated.conf.ospf` which is used to configure gated to run ospf.

- Stop the gated daemon on your machine using `gdc stop`.
- View the file `/etc/gated.conf.ospf` and note the commands used to configure the PC as an OSPF router.
- Copy the file `/etc/gated.conf.ospf` to `/etc/gated.conf`. Now, when you start the gated daemon, the daemon will run the OSPF routing protocol.

Exercise 4-2.

In the following exercise, you will start OSPF routing. Before that, you need to start `ethereal` to capture the packets being transmitted by OSPF when it gets started. As mentioned previously you will capture the raw packets into a file using `ethereal` so that you can use both `ethereal` and `tcpdump` to parse the raw packets later.



- Start ethereal measurement on both interfaces

```
ethereal -i interfacename
```

You will analyze the captured OSPF packets using `ethereal`. Make sure that you save the data on floppy.

- Start the gated daemon with the `gdc` command. Gated will now run OSPF since the `/etc/gated.conf` file has been modified:

```
gdc start
```

All groups should start the OSPF protocol at about the same time.

- Use `netstat -cr` to observe the routing table changes.
- When the routing table has stabilized (How can you tell?), run the `ospf_monitor`:

```
ospf_monitor /labdata/mon_db
```

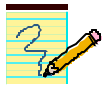
The `mon_db` file contains an entry for your local machine.

- Use the `ospf_monitor` to view the link state database of your local machine.

Hint: If you type **d** at the prompt of the `ospf_monitor` you obtain the index of the configured routers. Then you can use **@index l** to display the link state database.

- Add an entry for your neighbor in `mon_db`. (You know the syntax of the entry in the file from the prelab.) Use `ospf_monitor` to view the link state database of your neighbor.
- Save the link state database to a file.
- Stop capturing packets. Use `ethereal` to analyze the OSPF packets. Note the fields in the Link State Update packets.
- Use `ospf_monitor` to view and save the link state advertisements from all routers in the network.

Hint: Use the command **@index a 0.0.0.1 1 ls_id router_id**. You can find the link state id (`ls_id`) and the router id (`router_id`) with `ethereal`.



Lab Report: Answer the questions in the exercise.

1. Include the `ethereal` measurement in your report showing the different types of OSPF packets. Only include one packet from each type. Do not include all packets that you have captured!
2. Answer the following questions:
 - a. Which type of packets is used for flooding the link state information?
 - b. What is the area-id of the network in the experiment?
 - c. Explain the fields in the link state advertisements.
 - d. Explain the fields in the link-state database?
 - e. Does OSPF use TCP or UDP to transmit packets?
 - f. Use `ethereal` to describe the fields of a particular link state update packet.
 - g. Use `ethereal` to describe the fields in a particular link state advertisement.



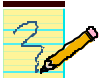
Get a check-off when you are done.

Part 5. Convergence of OSPF

This part is similar to Part 3. In this experiment, one of the links will be disconnected. You will observe how the change in the link state information of the routers involved is reflected in all the routers in the network.

Exercise 5-1.

- Verify that all groups are done with the previous part of the lab. If not, wait until all groups are ready.
- Now, the groups working on vintpc3 and vintpc6 disconnect the link between vintpc3 and vintpc6.
- Perform the same measurements as Part 3, using `ethereal`, `ospf_monitor`, `netstat -cr`, and `traceroute`.
- Record the measurements until all routing tables have converged.



The experiment is complete when all routing tables have converged.

Lab Report: Discuss some the differences that you observed in comparison to Part 3.



Get a check-off when you are done.

Part 6. Count-to-Infinity in RIP

In this experiment, you will observe the convergence problems in RIP. The network configuration for this experiment is shown in Figure 2.

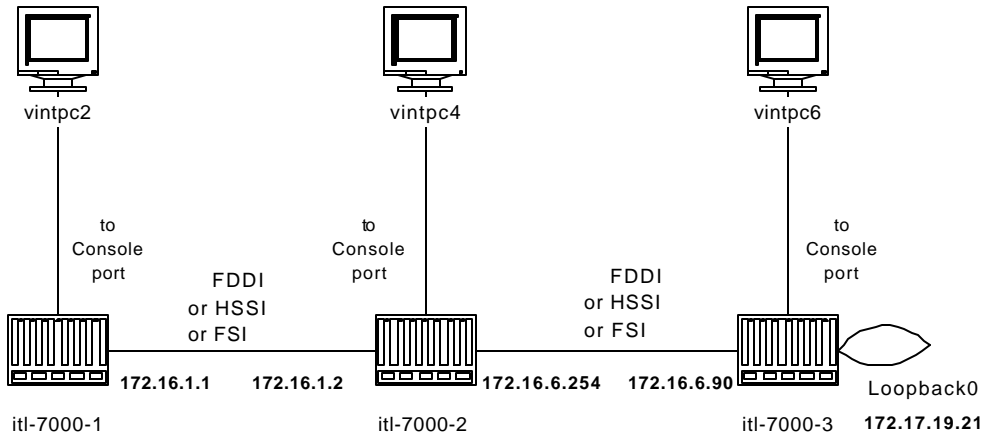


Figure 2: Configuration to observe count-to-infinity in RIP.

Exercise 6-1.

The Cisco 7000 routers (itl-7000-1, itl-7000-2, itl-7000-3) are configured as follows:

- All routers run RIP with split-horizon disabled on all their interfaces.
- Triggered update is disabled on the routers.
- The hold-down timer, explained in Appendix A, is set to zero.

Refer to Appendix A for an explanation how to enable/disable split-horizon and triggered updates on the Cisco 7000 routers. The appendix also explains the meaning of the hold-down timer.

In this exercise, you will work in groups of three. The group assignment is as follows:

Machine	Group	Router
vintpc1, vintpc2	Group 1	itl-7000-1
vintpc3, vintpc4	Group 2	itl-7000-2
vintpc5, vintpc6	Group 3	itl-7000-3

Moreover, the following table shows the Cisco 7000 router the PC's are connected to:

Machine	Router
vintpc2	itl-7000-1
vintpc4	itl-7000-2
vintpc6	itl-7000-3

The console port of each Cisco 7000 router is connected to the serial port of a PC. Use `kermit` to access the console port.

```
[/root] C-Kermit>set line /dev/cua0 (or /dev/cua1)
```

```
[/root] C-Kermit>connect
```

The observations in this exercise will be done by **enabling RIP debugging** on the Cisco routers. With RIP debugging enabled, all RIP packets received by Cisco routers will be displayed on the console terminal. Each group will capture the RIP debug output. But only on vintpc2 and vintpc4, the count-to-infinity problem can be observed.

RIP debugging on the Cisco 7000 routers, the command is enabled with the command **debug ip rip** (you must be in privileged EXEC mode to issue this command). To disable RIP debugging, type **no debug ip rip**.

1. Use `kermit` to access the Cisco 7000 router.
2. Enter the enable mode with **enable**. The lab instructor will provide you with the enable password.
3. Save the output of the command **show ip protocols** to a file.
4. Turn on RIP debugging.
5. Wait until the routing tables have converged on the Cisco routers. If the routing tables have not changed after 4 or 5 exchange periods, you can safely assume that the routing tables have converged.
6. The lab instructor will now disconnect the link between itl-7000-2 and itl-7000-3. The groups on vintpc2 and vintpc4 need to capture the RIP debug output (Copy and paste into a file).
7. The experiment is over when the routes have stabilized and the routing tables on the routers vintpc2 and vintpc4 show that 172.17.19.0 is unreachable.

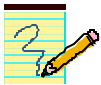
Run RIP until the routing tables have stabilized. Then, the link between itl-7000-2 and itl-7000-3 will be disconnected. You now observe the slow convergence, due to count-to-infinity, of the routing tables.

Exercise 6-2.

Next, we configure the Cisco 7000 routers, such that the count-to-infinity problem does not occur. Configure your Cisco 7000 router as follows:

- **Enable** split-horizon on all interfaces of all routers.
- **Enable** triggered update on all routers.
- Set the hold-down timer to twice the value of the update timer (**show ip protocols** shows the value of the update timer).

Now repeats step 1-7 from the previous exercise. Your goal is to observe that the count-to-infinity problem does not occur. In other words, if the link between itl-7000-2 and itl-7000-3 is removed, the routing tables converge very quickly.



Lab Report:

- Explain the meaning of the timer values in the output of the command **show ip protocol**.
- Use your measurement for an explanation how Split-Horizon solves the count-to-infinity problem?
- What are triggered updates in RIP? How do they work?
- Consider the scenario where Split-horizon is enabled but triggered updates are disabled (Refer to Appendix A). Explain how RIP could still encounter the count-to-infinity problem in the network configuration as shown in Figure 2. **Hint:** Count-to-infinity may occur if RIP packets from all neighbors arrive simultaneously.
- In RIP packets, what is the number used to represent infinity?



Get a check-off when you are done with this part.

Appendix A. Disabling Split-horizon and triggered updates on Cisco 7000

This appendix explains the steps required to enable/disable split-horizon and triggered updates, and to set the holddown timer for RIP routing on Cisco 7000 routers.

Split-horizon is disabled separately for each interface. Triggered updates are disabled on all interfaces (applies globally on the Cisco 7000 RIP process).

To enable or disable split-horizon:

- Enter the enable mode with **enable**.
- Enter the global configuration mode with **configure**.
- Enter the interface configuration mode using **interface if1**.
- Disable split horizon for the interface *if1* with **no ip split-horizon**.
- Enable split horizon for the interface *if1* with **ip split-horizon**.

To disable triggered updates:

- Use **show ip protocols** to find the update timer value
- Enter the enable mode with **enable**.
- Enter the global configuration mode with **configure**.
- Enter the router configuration mode using **router rip**.
- Set flash-update-threshold to the value of the update timer value. The syntax is **flash-update-threshold time**.

The command **flash-update-threshold x** specifies that if the update is due in x seconds then do not send a triggered update. Thus, if x is set to a value equal to the update timer then we effectively disable triggered updates.

The hold-down timer is a timer used by RIP. Setting the hold-down timer to h seconds means enforces that a routing update which leads to an increase of the cost (hop count) in a routing table entry, will be delayed by h seconds. Setting hold-down timer to 0 means that the RIP process accepts any new modifications to the route immediately. To set the hold-down timer we need to do the following:

- Enter the enable mode with **enable**.
- Enter Global configuration mode using **config**.
- Enter router configuration using **router rip**.
- The timer values are set using the command **timers basic update invalid holddown flush**

Check List for Lab 5

Complete this check list as you work through the laboratory exercises and hand the form in to the lab instructor before you leave

Names (Please Print): _____



Turn-in Prelab 5 (Pledge your Prelab.)



Check-off for Part 4



Check-off for Part 1



Check-off for Part 5



Check-off for Part 2



Check-off for Part 6



Check-off for Part 3



Turn-in your feedback sheet.

Do not forget to copy your results to your floppy disk.

Feedback Form for Lab 5

- Complete this feedback form at the end of the lab and hand the form to lab instructor before you leave. The feedback is anonymous. **Do not put your name on this form**
- For each exercise, please record the following:
 - **Difficulty:** Grade the degree of difficulty using a range of -2,-1,0,1,2. (-2 = too easy, 0=just right, 2 = too difficult)
 - **Interest Level:** Grade your level of interest when completing the exercise using a range of -2,-1,0,1,2. (-2=low interest, 0= just right, 2 = high interest).
 - **Time:** How much time did you need to complete each part of the lab?

	Difficulty (-2,-1,0,1,2)	Interest Level (-2,-1,0,1,2)	Time (minutes)
Part 1 Setting up the network			
Part 2 Setting up RIP routing			
Part 3 Reconfiguring the Topology (RIP)			
Part 4 Setting up OSPF routing			
Part 5 Reconfiguring the Topology (OSPF)			
Part 6 Count-to-Infinity in RIP			

Please answer the following questions:

- What did you like about this lab?
- What did you dislike about this lab?
- Make a suggestion to improve the lab.