ETSF10: Internet Protocol

Routing Lab Assignment

1   Introduction

In this lab assignment you will study two different routing protocols for intra domain Internet routing. It will give a hands-on experience in configuring and managing routers and also how to set up routing protocols. You will prepare the lab session, perform the practical exercises, and write lab reports. You will work and hand in the report in groups of two students.

1.1 Overview

The assignment is divided into three sections: *Hands on*, *RIP*, and *OSPF*. Each of these sections can then be divided into preparation, execution, and documentation. The first section *Hands on* is to be performed during the first study period of the course, the two latter in the second study period. For deadlines see the course home page.

- *Hands on*
    - Task 1 – 5
    - Section 2.1, pp 4 – 5
- *RIP*
    - Task 6 – 10
    - Section 2.2, pp 6 – 7
- *OSPF*
    - Task 11 – 17
    - Section 2.3, pp 8 – 10

Each task is assigned points. You must have 80% of the total points per section or more to pass. Each task must be answered.

The preparations are a crucial part of the lab assignment. Without them there is no possibility to fulfil the practical elements within the specified time; trial-and-error is not an efficient way of using the router lab.

The carrying out of this lab is performed on the department's router lab. The lab is accessible from a computer of your choice via Internet. The only demand on your computer is that it has an ssh client and an Internet connection.

You will practise on routers from Cisco and thus Cisco's router operation system IOS. As can be understood from the description of the router lab given in the Reference Guide the lab is fixed configured on the physical level. You change the outline of the lab networks by opening and closing individual router interfaces to build a network for your specific needs.

When you are ready for the practical sessions you book the lab; find more information on the course home page.

1.2 Assignment Elements

Each assignment section has these elements:
- Study the Router Lab documentation.
- Plan the laboratory moments.
- Perform the practical elements.
- Add the results of the practical exercises to the report.
- Complete the report and hand it in. It might be the case that you have to revise it after the teacher's assessment.

1.3 Bug reports

Please report any errors found in this manual or in the lab reference material to the author Jens_A.Andersson@eit.lth.se.

1.4 Preparations

You must study the Router Lab Reference Guide as a first step in the preparation process. You must also make yourself familiar with the documentation that is given you as links on the Router Lab home page. And of course, you must study and understand appropriate theory elements of the course textbook. The FAQ found on the Router Lab web site is also a good source of information.

You must make notations on what steps you need to take to fulfil the specified tasks. These notes include appropriate configuration and control commands.

Please, make sure you have prepared yourself properly before using the lab. Only one group at a time can access the lab; thus available time in the lab is a limited resource.

1.5 The Reports

This lab assignment concludes with a written report. The report shall consist of answers to the tasks found in this manual and some printouts from commands. The first page of the report must contain all group members full name, their mail addresses and the group id given to you. To ease correcting process you are asked to add the tasks and subtasks and its points – bold in this document – and enter your answers below each separate task or subtask. Failure to do this will lead to the report not being corrected.

1.6 Cleaning Up

Before leaving the router lab, please clean up. If you want to save your configuration files, use ftp or tftp to copy the running configuration. If you have changed only the running configuration the cleaning up procedure is merely a matter of reloading the routers. Otherwise, you have to restore the start-up configuration with the default configurations. See the Router Lab Reference Guide for details.

2   The Tasks

The practical assignment is divided into three main sections:
- Hands on IOS CLI (first section)
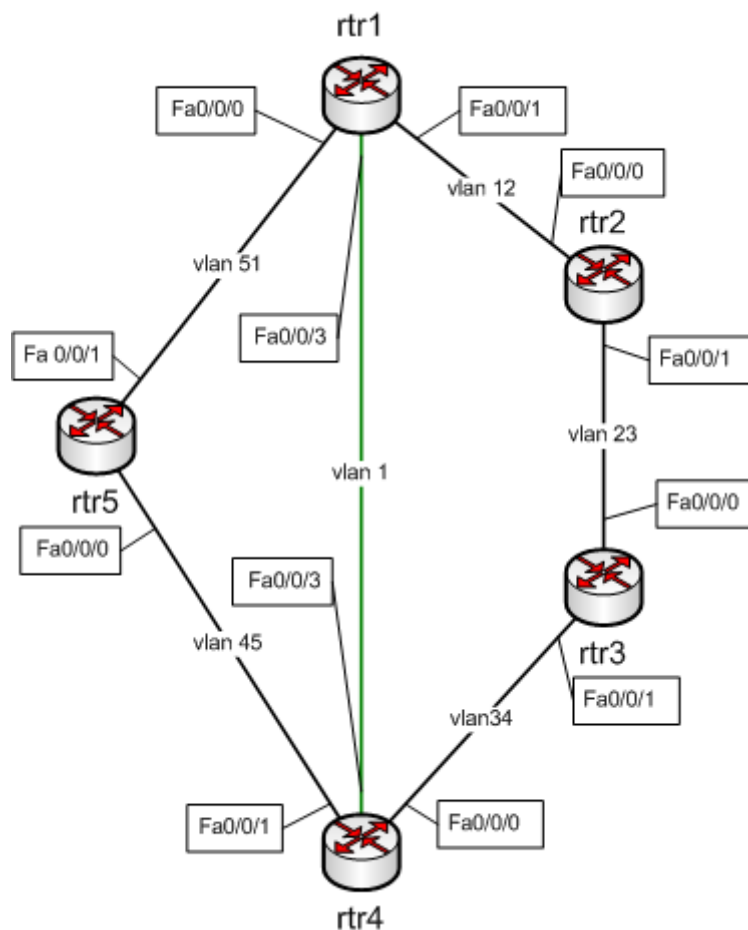- RIP (second section)
- OSPF (third section)

Figure 1: Lab network layout

2.1 Hands on

This section is about getting acquainted with the lab and some basic network configuration and management.

This section gives maximum 19 points. You must have 15 points or more to pass this section.

Prepare yourself for this section by reading the Routerlab Reference Guide and perform the tips found in section 7 of the guide.

2.1.1 Login to the lab

You start this section with logging in to the front-end host. From there you connect to the different routers. Check that they are running the default configuration. If not, install the default configuration according to the Reference Guide. Also remember that it is a good advice to reload the routers so that the time marks in logs and debug printouts will be useful, see Reference Guide Section 6.5. See also chapter 7 in the Reference Guide for performing this section.

Hint: It is possible to create several sessions to the front-end host and then use each session for a unique connection to a router. You thereby have one terminal window for each router.

2.1.2 Configuration

Configure the lab according to Figure 1 and with ip addresses as per the table below. You do this by installing the running configuration on each of the five routers with its lab configuration. Use the configure replace command as in this example for router rtr1:

```
Configure replace tftp://srv/rtr1-lab-confg
```

For router rtr2 the configuration file is named rtr2-lab-confg, and so on.

Router	Interface	IP address
Rtr1	Vlan 1	192.168.1.1
	Vlan 12	192.168.12.1
	Vlan 51	192.168.51.1
Rtr2	Vlan 12	192.168.12.2
	Vlan 23	192.168.23.2
Rtr3	Vlan 23	192.168.23.3
	Vlan 34	192.168.34.3
Rtr4	Vlan 1	192.168.1.4
	Vlan 34	192.168.34.4
	Vlan 45	192.168.45.4
Rtr5	Vlan 45	192.168.45.5
	Vlan 51	192.168.51.5

Table 1: IP addresses

Hint1: When performing the lab assignment the interface Fa0/1 is closed on the routers. You must open this whenever you need to transfer data between a router and the front-end.

Hint2: You open interfaces with the interface configuration command `no shutdown` and you close it with `shutdown`. Notice that the default state of interfaces varies. A good command to check status of all interfaces in a router is `show ip interface brief`.

Hint3: Keep in mind that you configure network layer parameters on the virtual interfaces, vlan 1 , vlan 12, vlan 23 and so on, for all links *except LAN 1 and LAN 2 according to Figure 1 in the Reference Guide*. This is a little bit tricky, so discuss this with your supervisor before continuing if you feel that you do not completely understand.

2.1.3 CDP

Use CDP and check your configuration.

Task 1:
    a) **Try the command `show cdp neighbors` on each router in the network. Add the output of this command from rtr1 to the report.**
    b) **Select what you think are the three most important parameters you get information about issuing this command. Motivate from a network managing perspective why you have chosen these three parameters. (3p)**

2.1.4 ping and traceroute

Make yourself familiar with IOS ping and traceroute commands. Both commands come in two versions, normal and extended. We are only examining the normal version.

Task 2:
    a) **From router rtr1, ping a neighbour using the command ping <host>. Add the output of this command to the report. How many packets are sent? (1p)**
    b) **What is the round trip time? (1p)**
    c) **How long time does the router wait until a ping is declared lost? (1p)**

Traceroute is not meaningful as of yet but you can try it anyway.

2.1.5 Check routing table

Check the routing table of one of the routers. For this you use the command `show ip route`. Do this in rtr1.

Task 3:
    a) **Add the output of this command to your report. (1p)**
    b) **Explain why not all network ids configured in the lab are found in the routing table. (2p)**

Hint for task 3b: There are two reasons. One is very obvious. The other is not so obvious, but think of what a router in a network like this has to know to be able to forward packets to all destinations in the network and how it acquires this information.

2.1.6 Debug

Next we will look into the debug command. Make sure that the output from the debug process is written to your terminal by issuing the command `terminal monitor`.

Setup debug of all IP packets on rtr1. To debug all ICMP packets you use the command `debug ip icmp`. Ping one of rtr1's neighbours.

Task 4:
    a) **Describe shortly the information you get in this exercise (1p)**

Before you end this sub-section you should turn off debugging. Use the command `no debug all` to turn off all debugging.

2.1.7 Trouble shooting exercise

CDP is very useful in trouble shooting. To test this, and your abilities to solve problems ;-) we introduce an error by installing a faulty configuration in rtr4. The file rtr4-error-confg is found on the tftp-server. Use the configure replace command to install the error.

Your task is now to find out what the error is and correct it. **The physical configuration is such that rtr4 only has one connection and that is to rtr1.** The corresponding interface is configured with an IP address, and the interface is up. Even though it is impossible to connect to it over IP; It is not possible to ping rtr4 from rtr1 for example.

1) From rt1 try to ping rtr4. See the Table 1 for addresses.
2) Check rtr1 interface's states. Interfaces in question are f0/0/3 and vlan 1.
3) Use `show cdp neighbor f0/0/3 detail` and try to find the cause of the error. Hint: It has to do with IP addresses.
4) You cannot connect to rtr4 (no cheating via the console is allowed) but it is yet possible to correct the error. Adopt rtr1 to the error situation and make it possible to directly connect to rtr4. Note that you can only use the interfaces that directly connect rtr1 and rtr4! Try your rtr1 configuration changes with ping before trying to connect to rtr4.
5) In rtr1 use telnet to connect to rtr4. It should now be possible to correct the error. In this situation it is now very likely that you lose the connection to rtr4 again and that telnet hangs. Use the escape method (see paragraph 6.4 in the Reference Guide) to revert back to rtr1's prompt.
6) Change rtr1's configuration so the connection to rtr1 is restored.

Task 5:
   a) **Note the outcome of the ping test in 1) above. (1p)**
   b) **Note the state of the involved interfaces in both rtr1 and rtr4 found in 2) and 3) above. (1p)**
   c) **What is the error? (2p)**
   d) **What changes did you make to rtr1's configuration in 4) above? (2p)**
   e) **What changes did you make to rtr4's configuration in 5) above? (2p)**
   f) **What changes did you make to rtr1's configuration in 6) above? (1p)**
   g) **To confirm that you have corrected the error ping rtr4 from rtr1 and add the output to the report.**

This exercise might seem a bit weird, but it is actually based on real life experience.

2.2 RIP

In this section you will add RIP, a distance vector protocol, as routing protocol in your network. We are going to investigate RIP version 1. Make sure that all routers are configured with its lab configuration, see paragraph 2.1.2 if in doubt.

This section gives maximum 43 points. You must have 34 points or more to pass this section.

2.2.1 Start RIP

The first task is to start the RIP routing process on the routers. The configuration command `router rip` does this. Note that when issuing this command you enter the router rip configuration sub-mode. Configure `version 1`.

2.2.2 Add interfaces to RIP

Now you have to tell RIP which network ids that shall be involved in the RIP routing process. For this you use the router rip sub-mode command `network <network id>`. The network command takes an argument, the network id of the shall be assigned to the RIP process. The network id is classful, so you must make sure that you enter a network command for all network ids.

With the command `show ip protocol` you get information about parameters and current state of routing processes running on the router. You also get information about which networks that are included in the routing process. Perform this command, and make sure that all network ids that shall be involved in the RIP process, and no other, are involved.
When you have configured all five routers, check the routing table in router rtr1.Make sure that the table contains a route to all active networks in the lab.

Task 6:
  a) **Add the routing table from rtr1 to the report. (1p)**
  b) **What is the cost to reach vlan 23, vlan 34, and 45? (1p)**
  c) **There are two paths to the network between rtr4 and rtr5. Why is that? Why isn't the path over Ethernet vlan 1 between rtr1 and rtr4, which has a capacity of 10 times that of the Ethernet link between rtr1 and rtr5, preferred? (3p)**

2.2.3 Study RIP updates

Turn on debugging of RIP in rtr1. Use the command `debug ip rip`.

Task 7:
  a) **How often does rtr1 receive updates from its neighbours? (1p)**
  b) **What networks are announced to rtr1 by each of rtr1's neighbours? (2p)**
  c) **What networks are not announced to rtr1 by its neighbours? What is this suppressing technique called? (3p)**
  d) **How often does rtr1 send updates to its neighbours? (1p)**

Turn off debugging again.

2.2.4 Check path

Now that you have full routing running in your network you can check if packets are forwarded the expected paths. You shall compare the routing table of rtr1 and the result of a traceroute.

Task 8:
    a) **From the routing table in router rtr1 manually find the best path to interface vlan 34 of router rtr3. Which path will packets follow? Explain why? (2p)**
    b) **Do a traceroute to this interface. Which path did the packets follow? (1p)**

2.2.5 Study convergence in error situations

In the last exercise on RIP you will study routing convergence when a failure occurs. For this you need two active terminal sessions, one to router rtr1 and one to router rtr4.

1) First traceroute interface vlan 34 on rtr3, the target host in this exercise, from rtr1 and make sure that the connection is ok and that the path is over rtr4.
2) Make a note of the target's network id, i. e. the vlan between rtr3 and rtr4.
3) Check the routing table in rtr1, especially for the target network id. Make a note of the cost to the target host.
4) On router rtr1 turn on debugging of RIP. Make sure the output is displayed on your terminal.
5) Now introduce an error by shutting down **interface f0/0/3 on rtr1**. Note the time!
6) Ping the target host. Note the result. Compare with the routing table!
7) Observe periodically the changes in the routing table concerning the target network on router rtr1 until the network has converged. At the same time observe the debugging output. Look for information concerning the target network! Note which routers that announce the target network to rtr1. Note which path the routing table indicate for the target network. Note changes in debug output and routing table information you observe, and at what time from when you introduced the error. Hint: It is possible to perform normal commands while you have debugging active. The displayed output on the terminal might be somewhat crumbled in cases, but just re-issue the last command.
8) Note which path that is the preferred path to the target host.
9) Restore the network by opening interface f0/0/3 on rtr1. Observe routing table and debug output. Note how long the convergence time is in this case.
10) Repeat steps 5 to 9 but this time shut down **interface vlan1 rtr4** instead.

Task 9A:
    a) **Give an explanation to the outcome of the ping tests in 6) above. Was the target network in the routing table of rtr1? Which path was the preferred path according to the routing table during the error situation and before the routing had converged and adopted to the error? (3p)**
    b) **Which routers announce the target network to rtr1 during the two error? (1p)**
    c) **Are these announcements influencing rtr1's routing table? Why, or why not? (2p)**
    d) **How long did it take until you saw a first change in rtr1's routing table after you introduced the error? (1p)**
    e) **How long did it take until an alternative working path was introduced in rtr1's routing table after you introduced the error? (1p)**
    f) **When you restored the network, how long time did it take until the change was reflected in rtr1's routing table? Compare with the RIP routing algorithm and explain why? (3p)**
    g) **Describe what error you introduced, loss of link or loss of neighbour, and explain the arguments for your answer! (3p)**
Task 9B:
    a) to g): Repeat task 9A a) to g) for the error introduced in step 10) above. (total 14p)

Turn off all debugging.

2.3 OSPF

In the last section you shall compare a distance vector based routing protocol, RIP, with a link state based routing protocol, OSPF. You will use the same network layout as in the RIP exercises, so you do not have to reconfigure the links.

This section gives maximum 29 points. You must have 23 points or more to pass this section.

2.3.1 Remove RIP

First you have to remove all configurations concerning RIP. Use the configuration command `no router rip`.

2.3.2 Start OSPF

In OSPF every router has a unique identity. Cisco routers use the highest IP address assigned to any interface in the router as the router id. The method works well until that interface goes down in which case the router id has to change and the OSPF process has to recalculate and resend its information to its neighbours. It is an advantage if the router id could be fixed, and independent of interface status. Therefore Cisco IOS has given precedence to so called loop back interfaces in the selection of router id. If there is a loop back interface configured on the router, and the loop back interface has been assigned an IP address, this IP address will be used as the router id. A loop back interface has the good side that it is very stable; it never goes down unless the whole router is going down. The conclusion is that it is good practise to always configure a loop back interface in every Cisco router that is to run OSPF.

Start with configuring loop back interface 0 on all routers. A loop back interface is created the first time you issue the configuration command `interface loopback interface number`. Give each loop back interface a unique IP host address. Hint: A host address is assigned if you combine the IP address with a subnet mask with all ones, i.e. 255.255.255.255.

Now you can initiate OSPF on the routers. The configuration command is very similar to that you used when you started RIP. There is one difference: OSPF needs a process ID. Pick a number from 1 to 65535 of your choice. Use the configuration command `router ospf process ID`.

2.3.3 Add interfaces to OSPF

Adding interfaces to the OSPF routing process is similar to that of RIP in that you use a `network` sub-mode command. But in the case of OSPF you have to state the network address space with a combination of a network id and a so-called wildcard mask. The wildcard mask is the one's complement to that of a subnet mask. Any bit set in the wildcard mask indicates a position in the network id that has no significance for area assignment.

This said, implementing that you also use the network command to assign in which area an network or rather an interface shall reside. In our case we will only use one area, the backbone area, for all networks. We therefore can use the same network command in all routers. The general form of the network command is

```
network address wildcard-mask area area-id
```

Task 10:
> **What single command can you use to assign <u>all</u> interfaces in one router to OSPF backbone area? (1p)**

When you have configured all five routers, check the routing information in router rtr1. Compare this output with the findings in exercise 2.2.2.

Task 11:
    a) **Add the routing table from rtr1 to the report. (1p)**
    b) **What is the cost to reach vlan 23, vlan 34, and 45? (2p)**
    c) **In what way does the cost differ from the cost that RIP uses? What network parameter does the OSPF cost reflect? (2p)**

Hint: The path cost is the number following the slash inside the squared brackets. For example, [110/3] means the cost is 3. Also use the command `show ip ospf interface` to find more information about costs.

2.3.4 Check path

Repeat exercise 2.2.4, but this time using OSPF. You shall compare the routing table of rtr1 and the result of a traceroute.

Task 12:
    a) **From the routing table in router rtr1 find the path to interface vlan 34 of router rtr3. Which path will packets follow? Explain why? (2p)**
    b) **Do a traceroute to this interface. Which path did the packets follow? (1p)**

2.3.5 Study OSPF updates and convergence in error situation

Go to router rtr1 and turn on OSPF debugging. In this case you shall study OSPF **events**, so start debugging with the command `debug ip ospf events`.

Task 13:
    a) **What events occur regularly? (1p)**
    b) **How often? (1p)**
    c) **What is the purpose of the information sent and received? (2p)**

Turn off debugging of OSPF events, and instead turn on debugging of OSPF **flooding**, command `debug ip ospf flood`. Also check the routing table of router rtr1, especially concerning the target network. This is the same as in exercise 2.2.5 i.e. the link between routers rtr4 and rtr3.

Task 14:
    a) **What kind of messages is flooded by OSPF? (1p)**
    b) **In which situations are these messages sent? (1p)**
    c) **What is the purpose of the information sent and received? (2p)**

Shut down interface f0/0/3 1 on router rtr4, and observe the output of the debugging on router rtr1. Check with traceroute that this path is used.

Task 15A:
        Which is now the best path to our target network? (1p)

Open the interface again, and observe. Estimate the time it takes from the interface status change (note! both changes!) to the arrival of the first message and the update of the routing table. Compare it to your findings concerning RIP in exercise 2.2.5.

Task 16B:

     a) How long did it take from the introduction of the error to a new path could be used? (1p)

     b) How long did it take from the restoring of the original path to the convergence of the network? (1p)

Task 15B and 16B:
     Repeat task 15 and 16 but this time you shut down interface vlan1 instead. (total 3p)

Now you can turn off debugging in router rtr1.

Task 17:
     What could be said about convergence of OSPF compared to RIP, both when an error occur and when the network is restored? (3p)

3   Last assignments

Task 18:
     Discuss pros and cons for static (i.e. manually managed) routing versus using a routing protocol. Consider administration and management as well as reliability and availability. Add the discussion to your report. (3p)

As the last assignment you shall present how you as a group and as individuals fulfilled the project, who did what and why you chose to do as you did. Also please give your personal comments on this lab. How did you experience the lab? What was good, what was not so good? Was it relevant for the course?

Complete and hand in the second report covering tasks 6 – 17.

4   Documentation

- URL http://www.eit.lth.se/index.php?id=rtrlab
- Reference Guide to the Router Lab (link on router lab web page)
- Course Textbook