Dept of Electrical and Information Technology
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vers 4.0.2

ETSF05 & ETSF10: Internet Protocol

Routing Lab Assignment

1 Purpose and Goals

This lab assignment 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 a lab report, which describes the whole lab, including planning, preparations, and results. You will work and hand in the report in groups of two students.

The lab report will be assessed. Each Task is assigned points. The total number of points you can get is 76. You must have 55 points or more to pass. Each task must be answered.

2 Overview

The assignment is divided into preparation, execution, and documentation.

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.

3 Assignment Elements

The assignment has these elements:

- Study the Router Lab documentation.
- Plan the laboratory moments.
- Plan the outline of the report.
- 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.

4 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.

5 Preparations

You must study the Router Lab Reference Guide. 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.

6 The Report

This lab assignment concludes with a written report. The report shall consist of answers to the questions found in this manual and printouts from commands.

The report shall also present how long time in total you spent for the lab; that is the time you spent for preparations, in the lab and writing the report. Your own reflections and comments on the lab assignment is compulsory.

7 The Tasks

The practical task is divided into three main sections:

- Hands on IOS CLI
- RIP
- OSPF

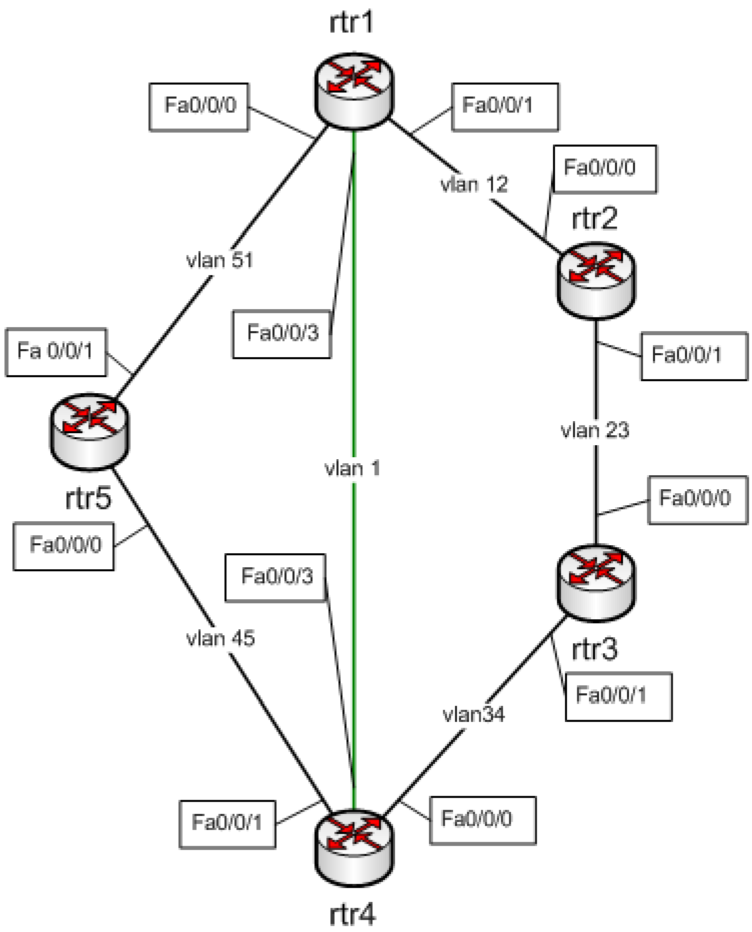

Figure 1: Lab network layout

7.1 Hands on

7.1.1 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.

7.1.2 Configuration

Configure the lab according to Figure 1. First allocate appropriate network and host IP addresses. Make sure each subnet have a unique network identity; each vlan is a subnet. Remember that each router interface must have a unique IP address on the subnet the interface connects to.

Task 1:

a) **Which network identities have you allocated for the six vlans? (2p)**
b) **Which ip addresses have you assigned the router interfaces? (2p)**

Next, open and close appropriate interfaces, so that the lab resembles Figure 1. When performing the lab assignment you must temporary close interface Fa0/1 on all routers. But you must open it whenever you need to transfer data between a router and the front-end.

Hint 1: Use interface configuration command `ip address <ip address> <mask>` to configure the IP address of an interface.
Hint2: You open interfaces with the interface configuration command `no shutdown`. Notice that the default state of interfaces varies. A good command to check status of interfaces 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 2 according to Figure 1 in the Reference Guide*. This is a little bit tricky, so if you feel that you do not completely understand this discuss this with your supervisor before continuing.

7.1.3 CDP

Use CDP and check your configuration.

Task 2:

a) **Try the command `show cdp neighbors` on each router in the network. Add the output of this command from rtr1 to the report. Explain in you own words what information about rtr1's neighbours you get from this command ? (2p)**
b) **Try the command `show cdp neighbors <interface> detail` on rtr1. What additional information in excess of the information in task 2a) do you get? (2p)**
c) **One information you get in b) is very handy in a situation when you have a working link to a router from its neighbour but you nevertheless can connect to it from this neighbour. Which information is this, and why is it handy? (3p)**

7.1.4 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 3:

a) **From any router, 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)**
d) **Which routers can you reach from which routers, and which not? (2p)**

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

7.1.5 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 4:

a) **Add the output of this command to your report.**
b) **What have networks that are found in the routing table in common? (2p)**
c) **Explain why not all networks you have configured are found in the routing table. (2p)**

7.1.6 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 IP packets you use the command `debug ip packet`. Ping one of rtr1's neighbours.

Task 5:

a) **How many IP packets are printed? (1p)**
b) **Which IP addresses are involved? (1p)**
c) **Which protocol other than IP is used? (1p)**

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

7.2 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.

Task 6:

Discuss static (i.e. manually managed) routing versus using a routing protocol. Add the discussion to your report. (3p)

7.2.1 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`.

7.2.2 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 7:

a) **Add the routing table from rtr1 to the report.**
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)**

7.2.3 Study RIP updates

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

Task 8:

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.

7.2.4 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 9:

a) **From the routing table in router rtr1 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)**

7.2.5 Study convergence in error situation

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 vlan 1 on rtr4. Note the time!
6) Ping the target host. Note the result. Compare with the routing table!
7) Observe periodically on router rtr1 until the network has converged the changes in the routing table concerning the target network at the same time as you 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) At last, restore the network by opening interface vlan 1 on rtr4. Observe routing table and debug output. Note how long the convergence time is in this case.

Task 10:

a) **Give an explanation to the outcome of the ping test 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? (3p)**

b) **Which routers announce the target network to rtr1 during the 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? (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)**

Turn off all debugging.

7.3 OSPF

In this 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.

7.3.1 Remove RIP

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

7.3.2 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`*.

7.3.3 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 11:

What single command will 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 7.2.2.

Task 12:

a) **Add the routing table from rtr1 to the report.**
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.

7.3.4 Check path

Repeat exercise 7.2.4, but this time using OSPF. You shall compare the routing table of rtr1 and the result of a traceroute.

Task 13:

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)**

7.3.5 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 14:

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 7.2.5 i.e. the link between routers rtr4 and rtr3.

Task 15:

a) **What kind of messages are 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 Vlan 1 on router rtr4, and observe the output of the debugging on router rtr1. Check with traceroute that this path is used.

Task 16:

Which is now the best path to our target network? (1p)

Open the interface again, and observe. Estimate the time 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 7.2.5.

Task 17:

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

Now you can turn off debugging in router rtr1.

8 Cleaning Up

Before leaving the router lab, please clean up. If you want to save your configuration files, use 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 stored on the tftp server. See the Router Lab Reference Guide for details.

9 Last assignment

As the last assignment 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?

10 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