Dept of Electrical and Information Technology 2010-10-13
Jens A Andersson vers 3.1

ETS110: 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; grading is passed/failed. A grading bonus will be applied; check the course home page for details.

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 will not work.

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 demands on your computer are that it has a 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 session you book the lab for a two-hour period; find more information on the course home page. This time should be enough to complete the practical elements and to gather information that goes into your lab report, but only if you have prepared yourself. You add the results from the practical session to your report and complete it.

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

The preparations should be concluded before you book a practical session. In case you opt to not follow this advice you will unnecessarily block the lab for other students, without any time gain for you.

You shall study the Router Lab Reference Guide. You shall make yourself familiar with the documentation that is given you as links on the Router Lab home page. You shall also study 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 configuration and control commands.

6 The Report

This lab assignment finishes with a written report. The report shall consist of not less than 2–3 pages of your own text; any printouts from commands and such are not included in this amount. The report shall describe your planning and preparations as well as your findings during the practical elements.

The report shall also present how long time in total you spent for the practical elements; that is the time you spent in "the lab". A chapter with your own reflections and comments on the lab assignment concludes the report.

7 The Tasks

The practical task is divided into three main sections:

- Hands on IOS CLI
- RIP
- OSPF

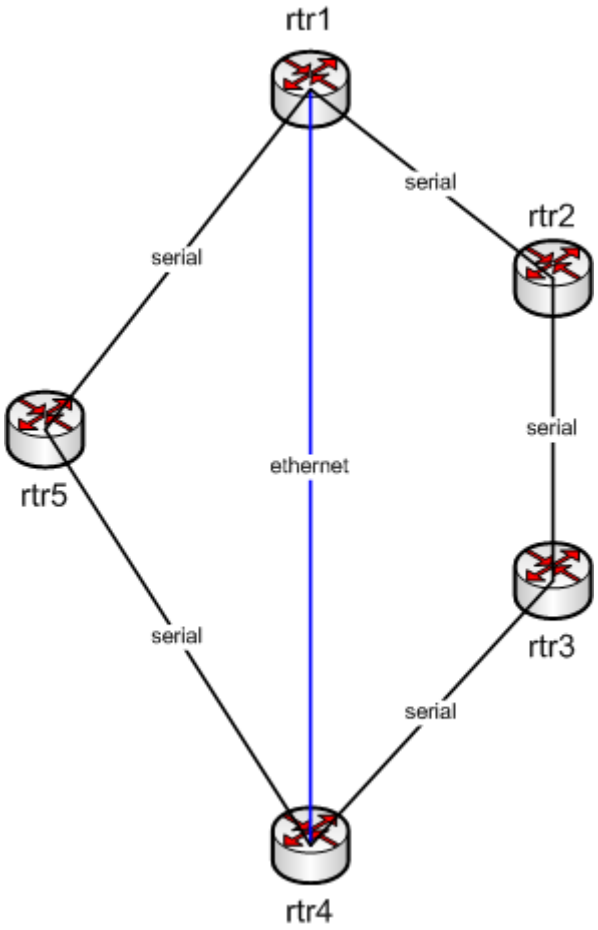

Figure 1: Lab Network Layout

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).

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. Allocate appropriate network and host IP addresses. Remember that each router interface must have a unique IP address on the subnet the interface connects to. Make sure each subnet have a unique network identity.
Hint 1: Use configuration command `ip address <ip address> <mask>` to configure the IP address of an interface.
Hint 2: Read about serial interface configuration in section 6.4 in the Reference Guide to the Router Lab.

Hint3: 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`.

7.1.3 CDP

Use CDP and check your configuration.

- What information do you get with `show cdp neighbor`? Try this command on each router in the network.
- What information do you get with `show cdp neighbour <interface> detail`? Try this command on one of the routers rtr1 or rtr2.
- Copy examples of output of these commands into your report.

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.

- Ping a neighbour using the command `ping <host>`. How many packets are sent?
- Explain the information you get from the output of this command?
- How long time does the router wait until a ping is declared lost?
- Which routers can you reach from which routers?
- Why is it so?

Traceroute is not so meaningful as of yet but try it anyway. Add output of both ping and traceroute commands to your report.

Note! Serial interfaces on the routers in the lab do not answer to ping if not both interfaces on the serial link are configured correctly. This is especially true for the IP addresses; both interfaces on the serial link must have IP addresses in the same subnet before any of them answers to ping requests.

7.1.5 Check routing table

Check the routing table of one of the routers.

- What command do you use?
- Interpret the information given?
- Copy the output from the command to the report, and give a description of it.

7.1.6 Debug

Check 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. What command do you use? Hint: The first word in the command string is `debug`.
- From one router ping one of its neighbours.
- Copy the output to your report, and give an interpretation of the information therein.

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

As you found in the first section you cannot send IP packets through the network, for example from rtr1 to rtr3. To do this routing has to be added to the network. 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.

- First discuss static routing versus using a routing protocol. Add the discussion to your report.

7.2.1 Start RIP

The first task is to start the RIP routing process on the routers. The configuring 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 assign interfaces to the RIP 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 interface(s) that 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 interfaces.

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.

- Does the network information given correspond to the networks you have configured? Explain.

When you have configured all five routers, check the routing information in router rtr1.

- What command do you use? Hint: It is not `show ip protocol` but it starts with `show ip`.
- Copy the output of this command into the report and give an explanation to the output. Hint: The path cost is the number following the slash inside the squared brackets. For example, [120/3] means the cost is 3.
- There are two paths to the network between rtr4 and rtr5. Why is that? Why isn't the path over the Ethernet between rtr1 and rtr4, which has a capacity of 20 times that of the serial link between rtr1 and rtr5, preferred?

7.2.3 Study RIP updates

Turn on debugging of RIP.

- What command do you use?
- How often does this router receive updates from its neighbours?
- What information is sent to this router?
- How often does this router send updates to its neighbours?
- What information does this router send to its neighbours? Note that the information is not the same to all neighbours. Which information is suppressed? What is the name of this suppression technique?
- Copy an example of a sent update into your report and explain the findings.

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.

- From the routing table in router rtr1 find the path to interface serial 1 of router rtr3. Which path will packets take?
- Do a `traceroute` to this interface. Add the output from this command to the report. Did the packets take the expected path?

7.2.5 Study convergence in error situation

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

- First traceroute interface serial 1, the target host in this exercise, on rtr3 from rtr1 and make sure that the connection is ok and that the path is over rtr4.
- Make a note of the target's network id that is the link between rtr3 and rtr4.
- Check the routing table, especially for the target network id.
- On router rtr1 turn on debugging of RIP. Make sure the output is displayed on your terminal.
- Now introduce an error by shutting down interface Ethernet 0 on rtr4. Note the time!
- Ping the target host. What was the result? Compare with the routing table and explain!
- Observe periodically on router rtr1 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! 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.
- Which routers announce the target network? Which path does the routing table indicate? What changes in debug output and routing table information do you observe, and at what time from when you introduced the error.
- How long did it take before an alternative path is used?
- Which path is now taken?
- At last, restore the network by opening interface Ethernet 0 on rtr4. Observe routing table and debug output. How long is the convergence time in this case?
- Explain your findings in the report!

Turn off debugging.

7.3 OSPF

In this section you shall compare a distance vector based routing protocol 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 largest 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 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. Give each loop back interface a unique IP host address. What commands will you use? 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. What command will you use? Hint: The 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.

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.

You also use the network command to assign in which area 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
```

- What command will you use to assign all interfaces in one router to OSPF backbone area?

When you have configured all five routers, check the routing information in router rtr1.

- What command do you use?
- Copy the output of this command into the report and give an explanation to the output. Compare this output with the findings in exercise 7.2.2. In what way does the cost differ? 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.

- From the routing table in router rtr1 find the path to interface serial 1 of router rtr3. What path will packets take?

- Do a `traceroute` to this interface . Add the output from this command to the report. Did the packets take the expected path?

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**.

- What command do you use?
- What events occur? How often? What is the purpose of the information sent and received?

Turn off debugging of OSPF events, and instead turn on debugging of OSPF **flooding**. 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.

- What kind of messages are flooded by OSPF? When, or how often, are these messages sent?
- Which is the best path to the target host, the interface s1 of router rtr3?
- Shut down interface Ethernet 0 on router rtr4, and observe the output of the debugging on router rtr1?
- What is now the best path to our target network? Check with traceroute that this path is used.
- Open the interface again, and observe.
- Estimate the time from the interface status change (note! both changes!) to arrival of first message and update of the routing table. Compare it to your findings concerning RIP in exercise 7.2.5.

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