Reference Guide to the Router Lab

**Purpose**

The routing lab makes it possible to test different routing protocols in a close to live environment. You can learn how to configure Cisco routers, and test different routing protocols in different topologies.

**1 Overview**

The router lab consists of

- 5 routers Cisco 2800 series
- One Linksys switch, 100 Mbps, FastEthernet
- One terminal server (Cisco router 2611 XM)
- A front-end host and tftp server

The physical links between the routers are fixed (Figure 1). By changing the state of the different interfaces, you activate or deactivate the individual physical links. By this method you can adapt the router lab to a configuration that fits your needs.

By using the routers feature of configuring loopback interfaces it is possible to simulate one or more virtual subnets behind each individual route.

You access the router lab via the front-end host using ssh. Once logged into the front-end you have access to the routers console ports via the terminal server. You connect to the different console ports by setting up telnet sessions to a specific TCP port on the terminal server.

The front-end host also functions as a tftp server. With tftp you can copy configurations to and from the routers. The terminal server loads its running image from the tftp server.

**2 Booking the lab session**

The lab must be booked in advance. If you have a valid lab account you perform the bookings yourselves. You use the same the same userid/passwd for both the booking system and the lab.

You can book up to 4 sessions. Each session is 1 hour. The booking system is found at [http://194.29.169.2](http://194.29.169.2). Help on how to use the booking system is found once you have logged in to the booking system.

**3 The Hardware**

**3.1 The routers**

The routers are of type Cisco 2800 series. They are equipped with two serial V.35 2Mbps interfaces and one 100 Mbps FastEthernet interface. The routers are running Cisco IOS version 12.4(6)T7.

The console port on each router can always be accessed via the terminal server. When the router has connection to the lab Ethernet segment it is also possible to gain access to the router console via telnet from the front-end. The routers OS and CLI is described in Chapter 4.1.
Fig. 1. The Router Lab Layout
3.2 The front-end

The front-end host is a PC running OpenBSD version 4.1. It is equipped with three Ethernet interfaces, but works as a normal host only on all the three interfaces. The front-end host does not perform routing nor bridging between its three interfaces.

The front-end has an ssh server listening on all the three interfaces. This is the only service accessible through the interface connected to the open Internet, FE0. The address to the router lab front-end is 194.29.169.2. The front-end is totally stand-alone and does not have NFS mounts what so ever. All file transfer to and from the outside world have to be done with scp protocol.

Interface FE1 is connected to an Ethernet with only two hosts: the front-end and the Terminal Server.
Interface FE2 is connected to the router lab’s Ethernet, thereby making it possible to generate some limited traffic into the router lab.

3.3 Telnet on the front-end

With telnet you can establish contact either to the router console ports, or directly to the router CLI.

There are no special concerns if you use telnet to access the router, other than that the router must be connectable via the front-end’s Ethernet interface FE2.

You can always access the routers via the terminal server. Since telnet sessions to the terminal server are not ended when you log out of the router, you have to make it possible to escape out of each telnet session to end it. By adding the option –e to the front-end’s telnet command you set an escape character for this session. In this documentation we use # as the escape character.

To initiate a telnet session to a console port via the terminal server you therefore use this command:

```
>> telnet -e# 192.168.254.1 <TCP port>
```

Another consideration is that you must use telnet’s character mode when you connect via the terminal server. If you use the default line mode you will not see any echoed characters on your screen, and the command completion will not work. You change to character mode when you have opened a telnet session, escaped back to the telnet application and there give the telnet command mode character. A configuration file, .telnetrc, is available where the character mode is set as default for all telnet sessions.

When you escape out of the telnet session you can give a command to telnet:
1. close ends the session completely and return you back to the OS command prompt.
2. hitting carriage return resumes the telnet session

3.4 The Terminal Server

A terminal server is connected to all routers console ports via V.24/RS-232 connections, and to the front-end via an Ethernet segment. The terminal server and the front-end are the only hosts on this segment.
The terminal server is configured so that each router console corresponds to an individual TCP port:

- R1-L = TCP port 2033
- R2-L = TCP port 2034
- R3-L = TCP port 2035
- R1-P = TCP port 2037
- R2-P = TCP port 2038

To connect to R1-L’s console port you establish a telnet session to the terminal server ip address, TCP port 2001:

```bash
>> telnet -e# 192.168.254.1 2033
```

### 3.5 The Switch

The switch constitutes the router lab’s Ethernet segment. All routers and one interface on the front-end is connected to this hub.

### 4 The Router Software

#### 4.1 IOS

The routers run Cisco IOS. On the router lab’s web page you can find several links to in-depth information on IOS. Here only a very brief introduction is given. IOS is the router operating system, as well as its “applications”. You control IOS, and thereby the router, with IOS’ command line interface, for short CLI.

##### 4.1.1 Command Completion and Help

The most commands have not to be written in full. As soon as there are enough characters so that the CLI can differentiate between any command given you can stop entering characters. If you are not sure of which command that are available you can always enter a ?. This is also true if you want to check subcommands, like what show commands there are. You can also use the TAB key for command completion.

##### 4.1.2 Modes

IOS has several command levels or modes. Depending on mode you can use different commands. When you connect to a router you enter the EXEC mode. The command you will use most in this mode is the `show` command. You can also use the `ping` command, or the `telnet` command. In EXEC mode the command prompt ends with a `>`:

```
R1-L>
```

To be able to control the router you must change to PRIVILEGED mode. You do that by entering command `enable` in EXEC mode. The privileged mode is protected by a password, `cisco`. This password is the same for all routers in our router lab. In PRIVILEGED mode the command prompt ends with a `#`:

```
R1-L#
```

You return to EXEC mode from PRIVILEGED mode with the command `exit`. Another mode is the CONFIG mode (see Chapter 4.1.4).
4.1.3 Configuration

The router has two configuration storages. The first one is the `startup-config`. This configuration is stored in non-volatile memory, and is read into `running-config` memory when the router starts up or reboots.

The `running-config` memory contains is the configuration that is used when the router is up and running. When you are in CONFIG mode and enter configuration commands you change the running-config immediately, thereby changing the behavior of the router.

To copy the running-config to startup-config memory you issue the command **write**.

*Note! In this lab it is good practice not to store your configurations in the startup-config memory. By not doing so you can easily revert to the default configuration by issuing the `reload` command. If you would like to store your configurations you can copy it to the front-end with tftp.*

4.1.4 The Configure Command

To enter CONFIG mode you issue the `config` command. This command takes parameters, and in our case you want to enter configuration commands from the terminal. So the command should look like this:

```
# configure terminal
or for short just
# conf t
```

Once in CONFIG mode remember that each configuration commands you enter is activated immediately. It is easy to cut off the branch you are sitting on, trust me. In our lab, though, you access via the console port, which is very hard to shut down.

Each function in the router can be set or unset. To set a function you just use the specific configuration command. To unset a function you write no in front of the same command. All functions have a default status, for most of them this state is unset. The default state is not printed in the configuration listing. So those few commands that have the state set as the default state, you will not see in the configuration print out. They will only be listed if you have unset them, that is they will show in the listing with a no in front of them and will be unseen again if you activate that function.

CONFIG mode has several sub modes, for instance the interface configuration sub mode. You enter this mode by typing the interface configuration command:

```
(config)# interface fastethernet 0/0
or for short just
(config)# in fa0/0
```

In configure interface sub mode you can assign the interface and IP address. Use the command `ip address <ip address> <mask>`. In this sub mode you can also open and close individual interfaces. To close an interface you use the `shutdown` command. And as a consequence of what is said above you open an interface with the command `no shutdown`. You also create and delete virtual interfaces, so called loop back interfaces, in the configure interface sub mode. To create a new loop back interface just given the configure command `interface loopback <interface-number>`. You exit from CONFIG mode or any sub mode thereof to PRIVILEGED mode by typing `ctrl`+`Z`. To exit from a sub mode or from the CONFIG mode use the `exit` command.

4.1.5 Copy using tftp

As long as there is a network connection between a router and the front-end you can copy configurations to and from the routers running-config memory. The copy command can be used to copy files with tftp. Start the procedure by issuing command `copy <from> <to>`, where
from and to can be either running-config or tftp. Example: # copy running tftp You are thereafter asked for the ip address of the tftp server, or the remote host. Currently the address of the front-end is 192.168.101.10. Finally you have to state a file name on the tftp server where the file is to be stored. All files transferred with tftp reside in the /tftpboot directory. There are nine temporary files available for you. These are named temp-1.cfg to temp-9.cfg. Note that these files are available for all user of the lab. If you want to store your files permanently you have to copy them from /tftpboot into your home directory. Your home directory on the front-end is /home/<account>. The environment variable HOME can also be used, that is to copy a file from /tftpboot to your home directory on the front-end use cp /tftpboot/<filename> $HOME. If you want to copy files between the front-end and your local host you must use sftp.

4.1.6 The Debug Command
Another nifty command is the debug command. Normally this is dangerous to use, since by issuing this command you might end up in a situation where all packets going thru the router are displayed on the console terminal. This normally has severe impact on the router throughput. But in the router lab there is normally where little actual traffic between the routers. You can debug nearly anything you want, from each single IP-packet to routing announcements sent between the routers. To see the output from debugging you must direct it to the terminal console you are connected to. Use command terminal monitor. To turn on debugging you issue command debug <parameter …>. To turn it off it is often best to use no debug all.

4.1.7 The Reload Command
With the reload command initialize the router. The router starts fresh all over. When you issue this command you will most probably be asked if you want to save the running-config before restarting:

System configuration has been modified. Save? [yes/no]:

As said in Chapter 4.1.3 this is no a good idea, so be sure to answer this question with a no. You will then be asked if it is ok to proceed:

Proceed with reload? [confirm]

If it is ok, just hit ENTER. If not, the answer is a n as in no.

4.1.8 The Quit Command
To end a terminal, or telnet, session you use the quit command. Note that this command does not end the telnet session to the Terminal Server (see Chapter 3.3).

4.1.9 The Show Command
This commands is the one you will use the most. All parameters of the router can be inspected with this command. Here are some use of it that you will need.

4.1.9.1 Show Running-Config
With this command you inspect the running-configuration. It must be given in PRIVILEGED mode.

4.1.9.2 Show Interface
With this command you inspect the current status of an interface. You can enter an interface name if you don’t want to list them all.

4.1.9.3 Show IP Interface Brief
With this command you get a list of all the router’s interfaces with ip addresses.

4.1.9.4 Show IP Protocol
This command gives you information on parameters and status of routing processes running on the router.
4.1.9.5 Show IP Route
You show the router’s current forwarding table with this command. If you specifically want to
see a routing table for one of perhaps several routing protocols you use the command show ip
route <routing protocol>.

4.1.9.6 Show CDP Neighbor
Cisco Discovery Protocol is a propriety protocol of Cisco. It is used to exchange information
between Cisco equipment of which neighbors that are connected to a device, and also some
basic information about it. This command is a good way to check your connections. If you add
the parameter detailed as a suffix to this command you will get a lot of information.

4.1.10 The ping and traceroute Commands
Both ping and traceroute are available tools in IOS. In their normal form they take the remote
host as parameter. Example:

- ping 192.168.101.10
- traceroute 192.168.7.17

Since a router has several interfaces, i. e. more than one, there is a minor issue here: Which of
the several addresses a router has will be used as source address?
All functions that make use of ip packets, including ping and traceroute, use the interface that is
closest to the remote host as source, and therefore the ip address of this interface is used as
source address. In our lab we will meet situations were this is not what we want. We might
check connection with a routers loop back interface as source.
In PRIVILEDGED mode you can use the extended version of ping and traceroute. Just enter the
ping or traceroute command without any parameters, and you will have several ways to control
these commands, like number of packets sent, packet size, and more. Answer yes to Extended
commands question and you will have the possibility to declare source interface or source ip
address. In the latter case the ip address must be on of the routers own ip addresses.
You can of course use these functions on the front-end host as well. Confront man pages for
ping, traceroute and spray.

Note1! 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.

Note2! See chapter 6.5 for information about escape character!

5 Suggested Address Space
The router lab is only connected to the global internet in one point, and that is the front-end host.
Since there is no routing or bridging performed by the front-end, the lab can be said to have no
connection at all to the outside world. You therefore are free to use any ip addresses you want
in the lab.
Some address space is already allocated and used. This is
- 192.168.255.0 – 192.168.255.255

Suggested address space to use in the lab is
- 192.168.10.0 – 192.168.90.255
- 172.16.0.0 – 172.16.255.255
- 10.0.0.0 – 10.255.255.255
6 Helpful hints

6.1 How to revert to the default configuration for a router

If you have messed up, and both running-config as well as the startup-config are beyond repair, you can copy a default configuration from the front-end with tftp. The only demand is that you can connect from the current router to the front-end.

For each router there is a default configuration. These are named R1-L-default.cfg to R2-P-default.cfg. Simply copy the configuration file from the front-end to the startup-config, and reboot the router.

- Make sure that the routers interface ethernet 0 is up and has correct ip address
- In PRIVILEGED mode issue command `copy tftp startup-config`
- The remote host address is 192.168.101.10
- The file name is for example R1-default.cfg
- When the copying is completed reboot the router with command `reload`

6.2 The selection of network identities and subnetmasks

You can freely choose network id and subnetmask for all of the network segments you use. But if you want to be able to upload or download configurations to or from the front-end using tftp, you must use the ip addresses and subnet masks for the ethernet interfaces which are configured in the default configuration files.

6.3 How to exit a telnet session that is stuck

If you cannot exit from a telnet session for any reason one easy why is to do this:

- Open a new ssh session to the front-end
- Find the PID of the stuck telnet session with the `ps` command
- Kill the stuck telnet session with the `kill` command. Use the PID you found with the `ps` command.
- Close the extra ssh session.

6.4 How to configure a serial link that is using null modem cables

A serial link using V.35 has the need for a synchronization clock. Normally a serial link uses for example modems in each end of a telephone line, and these modes supports the clock. The router is called Data Terminal Equipment, DTE, and the modem Data Communication Equipment, DCE. In our lab we use null modem cables as serial links so there are no modems involved. Thus, one of the routers have to be working as a DCE, and also be responsible for the clocking.

The null modem cables are connected with the DCE end to interface serial 0 and the DTE end to interface serial 1 on the routers. This means that each interface serial 0 has to be configured with the clock rate:

```
Rm
  interface Serial0
  bandwidth 500
  clock rate 500000

Rn
  interface Serial1
  bandwidth 500
```

In this example the link is connected between Rm serial interface 0 and Rn serial interface 1. The interface in Rm produces a clock with the bit rate 500kbps.
6.5 How to change escape character

The normal escape character used when interrupting a command that hangs is CTRL+SHIFT+6. This escape character works well on most terminals connected directly to the router console port. In the router lab this is not the case, and the escape character is changed to “%”. If this is not a good choice for you, you can change it. Use the command `terminal escape-character <escape-characters>` in privileged mode.

6.6 How to get a useful time stamp in logs and debug printouts

The routers are by default configured to use uptime as time stamp in logs and debug printouts. First hours, minutes, and seconds after reboot will be used. This will later be changed to days and hours after reboot, which is to coarse in many situations. It is therefore a good preparation to restart the routers before you start working with them, for the sole purpose of resetting the uptime.