

POLITECNICO DI TORINO

Dyn@NG Tutorial

User guide and helpful tips

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1 Introduction

This tutorial aims at providing an overview of the functionalities of the Dyn@NG virtual networking laboratory. It will also present how to access the software functionalities and it will introduce users to the main features of the system. Server-side installation and some more details on the Dyn@NG internals are available in separate documents enclosed in the source pack.

From the end-user perspective, the main component is the Dyn@NG web interface (the graphical network simulator), which enables the simulation of complex networks featuring some selected Cisco devices. In fact, the Dyn@NG project is basically a front-end to Dynamips, Dynagen and Qemu and can emulate the behavior of some selected Cisco routers using ad-hoc virtual machines. Some of its features, mainly the ability to capture packets on every established link, make it an ideal instrument to learn how to deal with some issues of the “real life” devices without actually having access to them.

Dyn@NG executes the virtual machines associated to Cisco routers leveraging the user from setting up and configuring such infrastructure. Moreover, Dyn@NG enables system administrators to set up a single, powerful server to be used by many users concurrently, each one simulating its own virtual network; users do not interfere with each other and do not have to own an extremely powerful computer to run their simulations on.

1.1 How it works

The Dyn@NG system is based on transforming network devices (e.g., routers) into Virtual Machines, executed in a virtualization environment, which emulates also the network connectivity between them.

As a result we are able to emulate a network, including cables, switches and routers, in a single (powerful) PC. The emulated links will be crossed by the traffic generated by the routers, and those packets can be captured and shown on screen.

The virtualization environment requires each router to be associated with an operating system image; when the step dedicated to the creation of the network topology has been completed, the user can turn on (manually) the router and start a new emulation session (more details in Section 2.4.2).

1.2 Network issues

Being the Dyn@NG service completely based on web technologies, users are required to have an unfiltered connection to the TCP port the server listens at. Depending on the server installation, those ports are typically ports 80 or 8080 for HTTP, 443 for HTTPS¹. Even the connections

¹Currently Dyn@NG does not provide a special and secure mechanism for the user authentication phase. For instance, if the web server is configured to use HTTP only, the password is sent in clear to the server. In order to guarantee secure communications, it is strongly advised to configure the server to work only in HTTPS.

to the consoles of the routers are web-based, featuring a special web server configuration with rewriting rules and a *proxy*.

The software backend interfaces with Dynamips and spawns different communication ports for each virtual router and user. All these operations are then presented to the user through a unified web interface, that therefore wraps all the connections (that usually would require access to arbitrary TCP/UDP ports) over HTTP.

1.3 What do you need

Dyn@NG is a web-based application that requires no additional application to be installed on the client machine in addition to a modern web browser. All the installation is done once, server-side. However, you may want to install a network sniffer (e.g., Wireshark) to analyze capture files offline; in any case, a basic interface that can visualize network captures is integrated in the Dyn@NG web interface.

Due to some inconsistencies in the different browsers, Firefox is the suggested choice. For instance, Chrome has the problem that the “backspace” key does not cancel the last character you typed in the console, but it will allow you to navigate backward on the page history, losing all the job you have done.

2 Connecting to Dyn@NG

2.1 Dyn@NG servers

The Dyn@NG service is available through a web URL. Unfortunately, due to the fact that Dyn@NG is in its early stages of development, each Dyn@NG instance is a standalone service, with its local database for users, etc. Hence, in order to guarantee better scalability, the administrator can install multiple servers and customize the initial web page with a set of links toward the secondary servers.

Please refer to the local Dyn@NG service administrator to have the link for your Dyn@NG service.

2.1.1 Dyn@NG service @ Politecnico di Torino

The Dyn@NG service @ Politecnico di Torino is available at the following addresses:

`http://dynng.ipv6.polito.it/`

`http://fucur.ipv6.polito.it/`

Due to some limitations of our network, if the user connects from *outside* the University it has to use port 8080 when logging in into the secondary server (**fucur**):

`http://fucur.ipv6.polito.it:8080/`

WARNING: Before logging in, please pay attention to the CPU load of the server you are connecting to (the load is shown on the main page of the server). If the load is **HIGH** it is advised to use the other server in order to avoid any loss or crash of the server. A screenshot of the main page on the primary server is depicted in Figure 1.

Dyn@NG: Virtual Networking Lab @ NetGroup

Welcome to [NetGroup](#) Virtual Networking Laboratory.

Follow [this link](#) to log on this machine (dynng)

Load on this machine is currently **HIGH** (331.07, 111.52, 50; mem: 8766836/12323912, 12257008 with buffers)

Please use the secondary machine if you have been instructed to do so.

A link to the secondary machine is [here](#).



Figure 1: Main page on the primary Dyn@NG server @ PoliTO.

2.2 Registration

Guest login is not allowed in Dyn@NG; users must be registered to access to the Dyn@NG service. To register an account you have to go to Dyn@NG website and press the “register” button. A new will appear (a screenshot is depicted in Figure 2) that will ask you to insert **Username**, **Password** and **Email**.

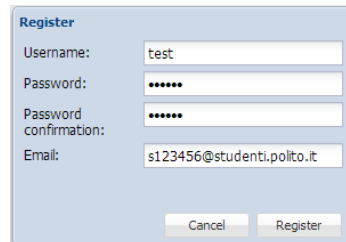


Figure 2: Registration form

After that the server will send you a notification to your email address with the instructions (basically, a web link) needed to activate your account.

Registration is free, provided that your email address belongs to a set of selected academic domains. The administrator can edit this list.

At present, Dyn@NG use a local database, therefore you need an account on each Dyn@NG server in order to be able to log-in.

2.2.1 Dyn@NG service @ Politecnico di Torino

The Dyn@NG service @ Politecnico di Torino has been configured to accept only users whose email account is @polito.it or @studenti.polito.it. Please create an account using one of those email address in order to be allowed to log-in.

Furthermore, remember to register to both Dyn@NG servers, i.e., dynng.ipv6.polito.it and fucur.ipv6.polito.it.

2.3 Login

If you are already registered, you just need to insert your username and password that you provided for that server.

2.4 User Interface Overview

This Section present the main Dyn@NG window and the commands that are available through this GUI. A typical screenshot of the main Dyn@NG window is shown in Figure 3.

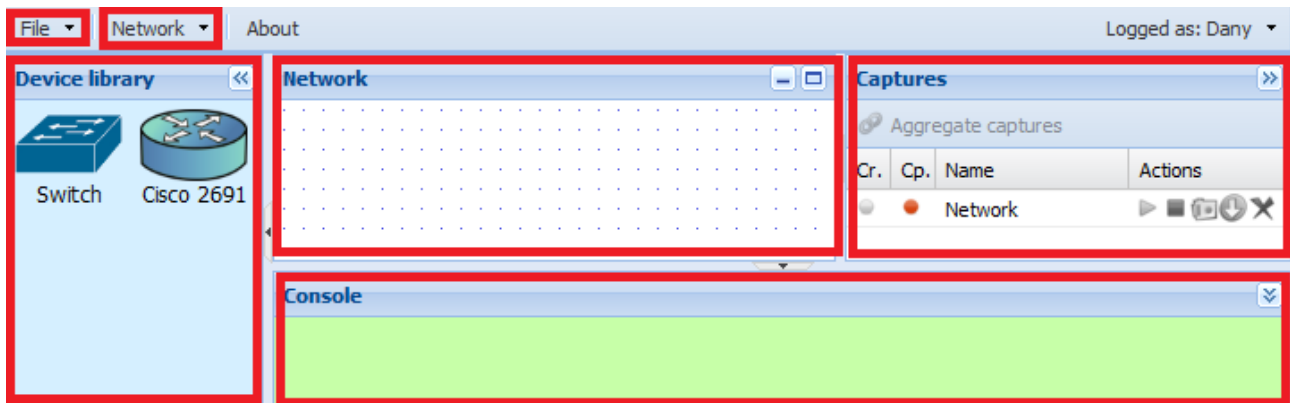


Figure 3: Dyn@NG interface

2.4.1 File Menu

The *File* menu is the first on the top-left side of the main window and it is shown in Figure 4.

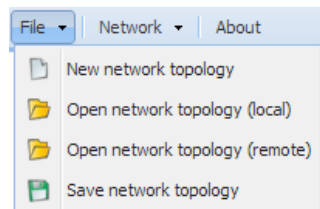


Figure 4: File menu

In this menu you can find four options:

- *New Network Topology*: with this button a new empty workspace will be loaded.
WARNING: All the data present in the network panel will be erased. If you want to start a new topology without losing the one you have done, save it first.
- *Save network topology*: It is possible to save the network topology you created. You can save it in “Local”, i.e., on your local computer (e.g., your hard disk), or “Remote”, i.e., on the server that you are using, as shown in Figure 5.

WARNING: the configuration of the router will be lost even if the “Save current router configuration” checkbox is selected; unfortunately that option does not work correctly. If you want to save and reload the configuration in the future, you will have to write a file with the router commands. (See better later)

- *Open network topology (local/remote)*: you can load the configuration you saved from your local computer or the server you are using.

WARNING: only the network topology will be loaded, while (due to a bug) the router configuration will not be loaded. Routers will boot with the standard default configuration.

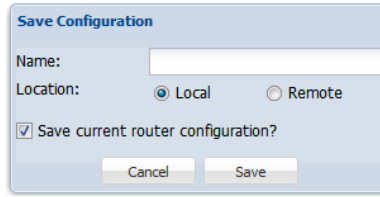


Figure 5: Save interface

2.4.2 Network Menu

This menu (depicted in Figure 6) is used to start, stop and reboot the devices of your network topology. This menu features the following commands:

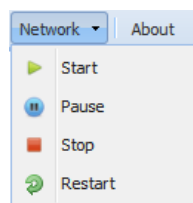


Figure 6: Network menu

- *Start*: this button is used when you want to start the devices of your network topology after creating them.

It is advised to save your network topology locally on your hard disk before starting the network, so in case of errors (e.g., the one depicted in Figure 7) you will be able to load it without have to create it again manually.

Sometimes there can be some problems when starting your topology. Do not worry, unfortunately this happens (some bugs are still present around). First of all try using the “Retry” button several times to see if the problem gets solved. If this does not work, close the “start network” panel. Then go back to the network menu and use the “Stop” button and try again to “Start” the network.

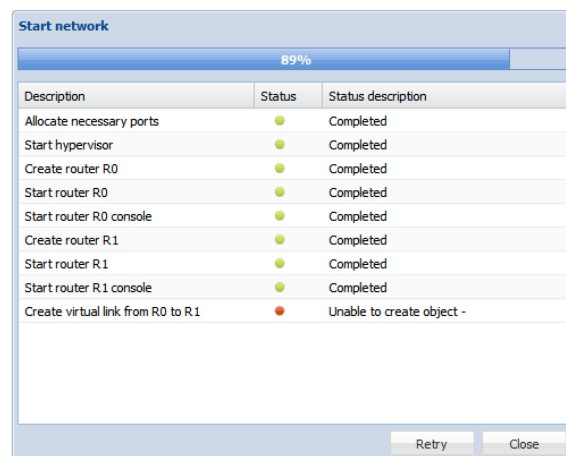


Figure 7: Error message

- *Stop*: this button is used if you want to stop the devices of your topology. It can be used also if the “Start” button does not work, to release some resources that the server reserved to you at a previous time. If by using the “Start” button the network does not start, either, you have to go to the top-right corner, where you find “Logged as:” and log off. After doing this, try logging-in again in order to help the server to release the resources.
- *Restart*: this button will stop your topology, and then using it again it will start the topology.

2.4.3 Device Library

This is the place where you find the devices that you can use for your exercises.

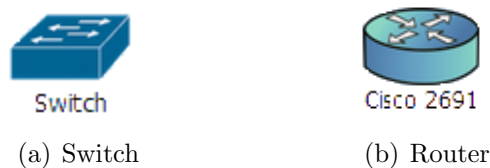


Figure 8: Devices

- *Switch*: this is the simplest device you can use. It is a layer-2 switch with 8 Fast Ethernet interfaces. This switch is provided as is and cannot be configured. The icon representing the switch is depicted in Figure 8(a).
- *Router Cisco 2691*: This is the main device you will use. The icon representing the switch is depicted in Figure 8(b).

The default configuration for this device includes two pre-defined linecards. If you need a different linecard, you need to configure the device and change the linecard in the second slot (formally, slot #1), choosing from one among the three available. To change the linecard you need to use the configuration panel of the router; it is available by right-clicking on the router and pressing the “Configure” button. This will open a new window (Figure 9) where you can modify the name of the router (changing the “Label” value) and change the linecard for slot number 1.

The three available linecards are:

- *GT96100-FE*: this is a fast Ethernet adapter and has 2 interfaces. This is only a Level 2 adapter therefore you will not be able to configure an IP address.
- *NM-1FE-TX*: this is a fast Ethernet adapter with 1 interface of Level 2 and Level 3.
- *NM-16ESW*: this is a fast Ethernet adapter with 16 interfaces of Level 2 .

2.4.4 Network Window

This is the area where you will create your topology. You will do it by drag-and-dropping the routers and switches from the Device Library to this area and then linking them with the proper connection. Section 3 will present how to create the topology in this window.

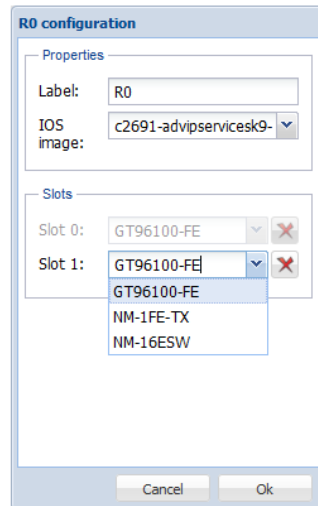


Figure 9: Configuring the additional slots of a router

2.4.5 Console window

In this area you will find the icons that are associated to the consoles, which are used to control and configure the Cisco routers you added to your topology.

2.4.6 Capture Window

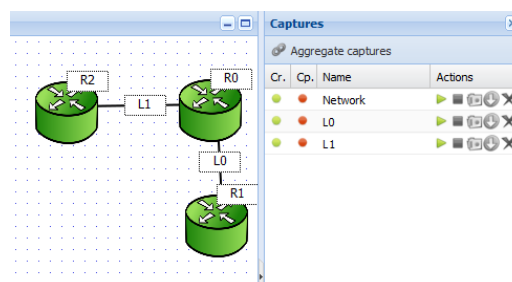


Figure 10: Capture window

This area, depicted in Figure 10 is dedicated to the capture and analysis of the traffic generated in your topology. This area includes the following columns:

- *CR* (Capture Ready): this indicates that the link is ready and available to capture traffic. If you started correctly the network they should be green.
- *CP* (Capture in Progress): this icon will become green as soon as the capture on that link begins. It is red in case the capture is not active.
- *Name*: is the name of the link where you will capture the traffic. Dyn@NG offers the possibility to capture the traffic either on a single link, or on the entire network (represented by the first link in the “Captures” window, called, in fact “network”). In the last case, the list of captured packets will be available by merging of all the packets captured on all the links present in the topology. Notice that we can capture the traffic from different links

and then aggregate the captured packets within the same view by using the “Aggregate captures” on top of the “Captures” window.

- *Action*: this column includes five different buttons:
 - *Start*: it starts the capture on the selected link. Notice that if you use the start button of the “network” link, all other links will start the capture too.
 - *Stop*: it stops the capture on the selected link. If you use the stop button of the “network” link it will stop all other capture too.
 - *Open Capture*: it shows the currently captured packets in a new windows inside the browser. Due to a bug, this feature may not always work correctly, as the windows may not show up. In this case you can download the file on your hard disk and use WireShark to show it.
 - *Download*: it downloads a file containing the captured packets on the local hard disk. Notice that if you download the capture from the “network” link you will get a single file containing the traffic of the entire network.
 - *Cancel*: not yet implemented.

2.5 Load configuration from file

There is the possibility to load the configuration of a router directly from a text file.

To do that first of all you need to prepare a text file with all the commands necessary to make your own configuration. Write all the commands one for each line of the file, then save it. Prepare one file for each router you need to configure. After that open the Console of the router you want to configure. Specify that you want to configure the router manually answering “no” to the first question and press the *Load Configuration* button. Select the configuration file. After a couple of seconds your configuration will be loaded.

NOTICE: Remember to write all the necessary command in order to configure your router, including the additional commands to enter in configuration mode (e.g., `enable` and `configure terminal`).

3 Simulate your first topology

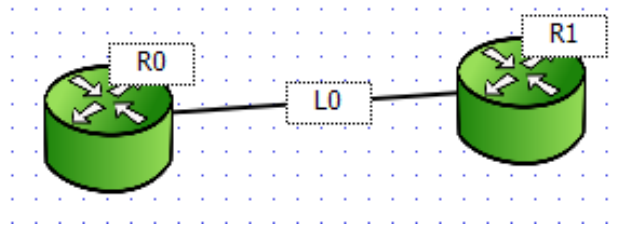


Figure 11: Our first network topology

Now we can try to create a simple network topology with two routers directly connected through a link, as depicted in Figure 11. First of all we need to create our topology. Go to the Device Library and drag and drop the *Cisco 2691* router to the network window. After inserting the routers we need to create a link that connects the two devices together. To do this select the first router as the source device and click on the second router as the destination device while holding the left CTRL key (just in case you do not remember which is the correct key, when you click on the first router an help pop-up appears on the left side of the window, reminding you how to complete this procedure).

A window like the one depicted in Figure 12 will be opened.

Select a network adapter from the “Select a slot” option (e.g., *0:GT96100-FE*) for both devices and then a free interface (e.g., interface *0*). Now that the two routers are connected they will be linked and we just need to activate the virtual machines associated to the routers, which translates into the “start topology” command. Routers can be configured through the “console” only when they are active, i.e., their associated virtual machine is up and running.

For starting the topology (which is required in order to enable the console), we can go to the *Network Menu* and press the “start” button.

Figure 12: Router Link Form

Dyn@NG uses different icons to show the status of the router. For instance, a router that is switched off is shown with a blue icon, while an active router is shown with the green icon. When the router is active, we can open the associated console window and configure the device. To configure our topology, open the console of the **router R0** and press the Enter key on your keyboard a couple of times; this is a known problem, as sometimes the router prompt does not appear if you do not press **Enter**. If everything is ok, after some seconds you should see the following prompt on the console:

Would you like to enter the initial configuration dialog? [yes/no]

Answer “no” to the request. You will configure the machines manually. Wait until the Router> prompt appears in the console. You need now to:

- Enter in *privileged-mode* of the router using the command `enable`;
- Enter in *configuration mode* using the command `configure terminal`².

Now we need to select the interface we want to configure. To do that we need to use the command `interface FastEthernet x/y` where “x” is the number of the slot you chose before, and “y” is the number of the interface (within that slot) you used. You can also use the shortcut “`in fa x/y`”. For instance, as we choose the slot 0 and interface 0, we write the command `interface FastEthernet 0/0`. Now we will configure the IP address with the following commands:

Command	Description
<code>ip address 192.168.0.1 255.255.255.0</code>	Configure the IP address 192.168.0.1/24 on the selected interface. This address will become immediately active.
<code>no shutdown</code>	Turn on the interface. Some interfaces of the router are turned off by default, hence it is always better to type this command although this may not be always needed.
<code>end</code>	Exit from the configuration mode.

Obviously, a similar configuration must be repeated on the second router. On the console of R1 you can apply do the same commands, just changing the IP address into 192.168.0.2.

Here a brief summary of all the commands you typed in order to configure the address on the router, where the last digit of the IP address (written as “z”) will be the actual IP address of the router:

```
enable
configure terminal
  interface FastEthernet0/0
    ip address 192.168.0.Z 255.255.255.0
    no shutdown
  end
```

You have now configured the interfaces on the link.

²Notice that you can also use shortcuts such “`ena`” and “`conf t`” for those commands. More details on command line shortcuts will be given in Section 5.2

3.1 Verify that the network operates correctly

Now that you finished your configuration you can use the `ping` command in order to generate a stream of 5 ICMP Echo Request and ICMP Echo Reply to verify that the network topology works and that routers can exchange traffic between them. Open the console of the router R0. Assuming that the configuration of the router is the one suggested in previous section, you just need to use the command below to ping the router R1.

```
ping 192.168.0.2
```

You should see a similar text appearing on each console:

```
Router# ping 192.168.0.2
Sending 5, 100-byte ICMP Echos to 192.168.0.2, timeout is 2 seconds:
.!!!!
Success rate is 80 percent (4/5), round-trip min/avg/max = 4/4/20 ms
Router#
```

Please note that Cisco routers tend to miss the first reply to the `ping` command, while the remaining four are received correctly. A missing answer is shown with the dot sign “.”, while a successful answer is shown with the exclamation mark (“!”). Therefore, if you type the `ping` command for the first time and the first (or, in some cases, the first two) answers are missing, nothing is wrong on your side. Vice versa, if all the five answers are negative, something is wrong in your configuration.

3.2 Make your first capture

Now we can try to capture the traffic generated by the `ping` command.

Go to the capture window and press the on the start button associated to the link L0. This will start capturing the traffic generated on that link.

Now come back to the router R0 and type again the `ping` command as we saw before. When the `ping` command terminates, go back to the capture window and press the *Stop* button.

Now download the file using the *Download* button or show the captured packets directly in the web browser.

Opening the capture you will see the stream of packet generated between the two routers, i.e., most likely 5 ICMP Echo Requests and 5 ICMP Echo Replies. Some additional traffic may be present, which is generated by some protocols active on the router and that are used to exchange some data on the network. For instance, the Cisco Discovery Protocol (CDP) is active by default on a Cisco device and it is used to discovery the capabilities (e.g., installed hardware, software version, etc.) of the devices present on the network.

4 Simulate a more complex topology

Now that we know how to create the topology, how configure terminals and how to capture traffic we can create a little bit more complex network composed by three routers (depicted in Figure 13) and see what kind of problems we can encounter. First, stop the previous topology (which translated into the “*stop network*” command), which in fact asks the Dyn@NG server to turn off the virtual machines associated to the routers and stop emulating the network. Then go to the *File* menu and select the new network topology command. Now create the topology depicted in Figure 13.

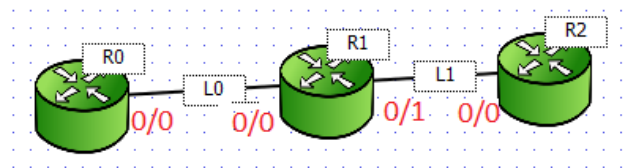


Figure 13: Our second network topology

In order to connect the routers together, use the interfaces depicted in Figure 11. For instance, use the interface 0/0 on router R1 to connect to the interface 0/0 of router R1, and so on. Notice that the number of the interface you select is completely independent on the two routers. Now we can start the network (“start network” command in the main menu) and configure the routers through the consoles. Please note that routers R0 and R2 belong to different IP networks, therefore we need to configure the necessary static routes to enable the communication between them. Open the console panel and use the following commands:

R0:

```
enable
configure terminal
  interface FastEthernet 0/0
    ip address 192.168.0.1 255.255.255.0
    no shutdown
  exit
ip route 192.168.1.0 255.255.255.0 192.168.0.2
exit
```

The command `ip route` specifies how to reach the remote destination. The syntax of this command is the following:

```
ip route [network address] [netmask of the network] [next hop]
```

In this case we specify that the network configured on the left interface of router R2 (i.e., 192.168.1.0) is reachable through the next hop represented by the rightmost interface of router R1 (i.e., 192.168.0.2). After that we can move to the configuration of R1, which has two active interfaces.

R1:

```
enable
configure terminal
  in fa 0/0
    ip address 192.168.0.2 255.255.255.0
    no shutdown
  exit
  in fa 0/1
    ip address 192.168.1.2 255.255.255.0
    no shutdown
  exit
exit
```

Since R1 is directly connected to both IP networks present in our topology, we do not need to specify any static routing entry. Finally we can configure R2, with a set of commands that are definitely similar to R0.

R2:

```
enable
configure terminal
  interface FastEthernet 0/0
    ip address 192.168.1.1 255.255.255.0
    no shutdown
  exit
  ip route 192.168.0.0 255.255.255.0 192.168.1.2
exit
```

Now the topology is ready and configured. Go to the capture panel and press the *Start* button on the network layer. Then, using the console of router R0, ping the router R2 using the following command: `ping 192.168.1.1`.

When the `ping` command terminates, stop the capture of the network link, download the capture file of all the links (included the network one). Opening them you can see how the capture of the network layer contains all the packet generated on the network, ordered by timestamp.

As we can imagine the ICMP packets on this capture are duplicated due to the two links passed through to arrive to the destination.

However, there are some small differences in those packets: MAC addresses at the Ethernet level will change, and the Time To Live (TTL) field in the IP packets will be different, as the second packet is forwarded through a router and hence the value of that field is decremented.

Congratulations!

You have completed this tutorial.

You are now able to create a simple topology, start it, configure its devices, capture exchanged packets and analyze them in Wireshark. Before going further with other tutorials, you should read the other sections of this manual, especially Section 5, called *IOS command line configuration tips*. They will help you to learn how to make the system work as you want.

5 IOS command line configuration tips

5.1 Configuration modes

The Cisco IOS command line interface has several configuration modes. The ones you will probably use most are listed in Table 1.

<i>EXEC-mode</i> [Router>]	In this mode you are allowed to use some of the available commands. However, you are not allowed to change the configuration. This is the default mode in which you enter after connecting to the router console.
<i>Privileged mode</i> [Router#]	This is the privileged, “administration” mode. You are allowed to execute all the commands that do not change the configuration. You enter this mode by typing enable in the exec-mode.
<i>Global configuration mode</i> [Router(config)#]	In this mode you are allowed to change the global configuration. Changes are applied immediately. You enter this mode by typing configure terminal in the privileged mode.
<i>Interface configuration mode</i> [Router(config-if)#]	In this mode you can change the configuration of a specific interface. You enter this mode by typing the interface keyword followed by the interface name, e.g., interface FastEthernet0/0 , or interface Vlan1000 in the global configuration mode.

Table 1: Main Cisco IOS command prompt modes

You can go back to the previous mode (e.g., from the global configuration mode to the privileged mode) by typing **exit**. If you type **exit** in the EXEC mode, you will be logged off the console (not a big deal, just press RETURN to get back in).

A command exists that allow you to exit from any configuration mode (including all the additional configuration modes, e.g., interface configuration mode). If you type **end** you will jump back to the privileged mode.

5.2 Command shortening and online help

When there is no ambiguity you can shorten the commands by only typing their first letters. For example, the basic IP configuration of an interface can be typed as:

```
en
conf t
  in fa0/0
    ip addr 192.168.0.1 255.255.255.0
    no shut
end
```

which is equivalent to:

```
enable
configure terminal
  interface fastethernet0/0
    ip address 192.168.0.1 255.255.255.0
    no shutdown
  end
```

If you are not sure whether you can shorten a command or not, press TAB after the first letters. If the command self-completes, you can use just those letters instead of the full command; otherwise you have to provide a longer hint. If TAB does not complete your command, press “?” (a question mark) to have a list of alternatives. Also, if you press “?” *after a space following a command*, you will receive some help about the immediately following accepted parameters.

5.3 Console timeout

If a router console is inactive, after some time you will be logged out. You can then press RETURN to get back in, and you will be brought back to the EXEC prompt. If you want to avoid this annoyance, you can disable the timeout by typing:

```
configure terminal
  line console 0
    exec-timeout 0 0
  end
```

5.4 Connecting a router to a switch

If you connect a *routed*³ interface of one router to a *switched* interface of another router, you will get some *CDP* warning messages when turning up the routed interface (switched interfaces are up by default). In this case, the above interfaces will fail to negotiate a common speed and duplex setting; this seems to be a bug in the simulator. To solve this problem, you need to disable the auto-negotiation in the routed interface and set up speed and duplex mode manually:

```
configure terminal
  interface FastEthernet0/X
    shutdown
```

³A *routed* interface is an interface that can accept L3 configuration commands (e.g., IP addresses). A *switched* interface cannot accept L3 configuration command and it act as a pure data-link interface. The type of the interfaces depends on the particular linecard installed in the router. Please refer to the specification of the linecard to detect whether your interfaces are *routed* or *switched*.

```
speed 100
duplex full
no shutdown
end
```

WARNING: it is important that the changes are made when the interface is down.

6 Troubleshooting

6.1 Physical links appear not to be working

Sometimes it may happen that not all the links are working in the topology. To check for this problem, you may launch the following command in the privileged mode:

```
show cdp neighbors
```

CDP is a Cisco proprietary protocol used, among other things, to discover neighboring Cisco devices. Use it to check for connectivity between routers linked to each other. On a router connected to four other machines on the interfaces Fa1/0 - Fa1/3, for example, you should obtain:

Capability Codes: R - Router, T - Trans Bridge, B - Source Route Bridge
S - Switch, H - Host, I - IGMP, r - Repeater

Device ID	Local Intrfce	Holdtme	Capability	Platform	Port ID
Router	Fas 1/3	174	R S I	2691	Fas 1/0
Router	Fas 1/1	179	R S I	2691	Fas 0/0
Router	Fas 1/0	175	R S I	2691	Fas 0/0
Router	Fas 1/2	172	R S I	2691	Fas 1/0

If you find persistent anomalies, you can try to restart the simulation.