Instituto Superior de Engenharia de Lisboa

Computer Networks

Phase 4 - Deploy Services

Projeto ISEL 2023/24 — LEETC

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Listings

Acronyms list

API	Application Programming Interface
CLI	Command Line Interface
CMD	Command Prompt
DHCP	Dynamic Host Configuration Protocol
DNS	Domain Name System
GUI	Graphical User Interface
HTTP	Hyper Text Transfer Protocol
HTTPS	Hyper Text Transfer Protocol Secure
IP	Internet Protocol
IPv4	Internet Protocol version 4
IPv6	Internet Protocol version 6
LAN	Local Area Network
OS	Operating System
OSS	openSUSE
OSI	Open Systems Interconnection
PC	Personal Computer
PHP	PHP: Hypertext Preprocessor
SSL	Secure Sockets Layer
TCP	Transmission Control Protocol
TLS	Transport Layer Security
TUI	Terminal User Interface
UDP	User Datagram Protocol
VPN	Virtual Private Network
WWW	World Wide Web
XAMPP	Cross-Platform, Apache, MySQL, PHP, and Perl

Glossary

Apache2
An opensource HTTP web server.

Bit
A unit of information in computing and digital communications. The bit represents a logical state with one of two possible values, 0 or 1 (other representations such as *true / false* are also valid).

Byte
Also a unit of digital information, consists of 8 bits.

Broadcast
A method of transferring a message to all recipients simultaneously.

Browser
A browser is a internet navigation software. It comes in multiple flavours, nowadays the big three are Microsoft Edge, Mozilla Firefox and Google Chrome.

Cisco Packet Tracer
A cross-platform visual network simulation tool.

Command Prompt
The default command-line interpreter for Windows operating systems.

Firewall
A barrier between networks. Controls inbound and outbound traffic.

Gateway
A network gateway provides a connection between networks and devices. Known as protocol translation gateways or mapping gateways, can perform protocol conversions to connect networks with different network protocol technologies.

LibreWolf
An internet browser based on Mozilla's Firefox. It's primary purpose is to allow privacy, and with it comes security. It achieves this by removing telemetry and data collection.

Linux
Open-source Unix-like operating systems based on the Linux kernel.

MariaDB
A community-developed fork of MySQL database server.

openSUSE Tumbleweed
An openSUSE (OSS) is an open-source community driven Linux-based distribuition sponsored by SUSE Software Solutions. Tumbleweed is a rolling release version allowing for up-to-date software releases.

Operating system
A program that manages a computer's resources from software to hardware.

Ping
A software utility used to test the reachability of a host on an IP network.

Tracert
Or **traceroute** in unix and linux systems, is a computer network diagnostic command for displaying possible routes and measuring transit delays of packets across an IP network.

Ipconfig
Or **ifconfig** in unix and linux systems, is a console application program that displays all current TCP/IP network configuration values.

Python
Python is a high-level programming language, object-oriented.

Perl
A high-level, general-purpose, interpreted, dynamic programming language

Rolling release distribuition
A distribuition where it's software release cycle is more frequent than those of Long Term Support (LTS). It's up to the Linux-based distribuitor to guarantee the testing of a package.

Router
A networking device that forwards data packets between computer networks, including internetworks such as the global Internet.

Switch
A networking hardware that connects devices on a computer network by using packet switching to receive and forward data to the destination device.

Socket
A network socket serves as an endpoint for sending and receiving data across the network.

Subnet Mask
Is a logical subdivision of an IP network.

Unix
Is a family of multitasking, multi-user computer operating systems that derive from the original AT&T Unix.

VPN
A private network creating a secure connection between a device and a network.

Windows
Microsoft's operating system. First released in 1985 as a Graphical User Interface (GUI) for MS-DOS, continued to evolve with it's latest version being 11. Due to it's nature, it's not recommended for server production environment.

Wireshark
Wireshark is a network protocol analyser software. Allows traffic capture between a computer and a network.

XAMPP
A software package environment collection containing Apache2 webserver, MariaDB database, PHP and Perl.

Chapter 1

Introduction

We've reached our big finale. In phase 4 we'll accomplish a network managed by a DHCP server, web surf to an HTTP server and use a DNS to recognize a web page by name.
Applying everything learned until now and much more.

Chapter 2

Phase 4

2.1 Tehcnical aspects

For phase 4 there's going to be some recycling.
Mathematical formulas:

$$Clients_{LAN_A} = max\left(20, \left(\sum_{k=0}^{n} studentnumber_k\right) mod 100\right) \quad <=> Clients_{LAN_A} = 48$$

$$Clients_{LAN_B} = \frac{Clients_{LAN_A}}{2} \quad <=> Clients_{LAN_B} = 27$$

Static routes:

Router	From	To	Network	Via	Through
R1	LAN A / LAN B	LAN Servers	192.168.7.0/25	192.168.7.254	R1 > R2
		Any	8.8.8.8/30	192.168.7.249	R1 > R0
R2	LAN Servers	LAN A LAN B	192.168.7.128/26 192.168.7.192/27	192.168.7.253	R2 > R1
		Any	8.8.8.8/30	192.168.7.245	R2 > R0
R0	Any	LAN A LAN B	192.168.7.128/26 192.168.7.192/27	192.168.7.250	R0 > R1
		LAN Servers	192.168.7.0/25	192.168.7.246	R0 > R2

Table 2.1: Static routes table

IP allocation:

Name	Network	Usable IPs	Router	Broadcast	Subnet Mask	Populated
	192.168.7.				255.255.255.	
LAN Server	0	1 - 125	126	127	128	126
LAN A	128	129 - 189	190	191	192	48
LAN B	192	193 - 221	222	223	224	27

Table 2.2 continued from previous page

Name	Network	Usable IPs	Router	Broadcast	Subnet Mask	Populated
	192.168.7.				255.255.255.	
Unused	224	225 - 238		239		0
remaining	240	241 - 242		243		0
LAN Transit C	244	245 - 246		247	252	2
LAN Transit B	248	249 - 250		251	252	2
LAN Transit A	252	253 - 254		255	252	2

Table 2.2: LAN allocation table

But we also have new toys to play with.

A fully functional DHCP server capable of assigning IP addresses to LAN's A and B.
But how does it work? Well, for starters it works in the application layer (7) of the Open Systems Interconnection (OSI) model. A plot twist for sure as it could be easily mistaken for a network layer. It uses UDP protocol for its connectionless model and operates in four phases (no pun intended): server discovery, IP lease offer, IP lease request, and IP lease acknowledgement.

"BUT WAIT, there's more!" Since our DHCP server is located in another subnetwork and behind another router, we must somehow be able to ***relay*** the assigned IP address to our devices in LAN's A and B. So that's exactly what we are going to create, a relay. In the following sections a detailed explained will be presented.

Additionally a web server will also be deployed to serve a single web page. To reach it like a sanely human being a Domain Name Service (DNS) record will also be created.
A DNS is a hierarchical and distributed name service that provides a naming system for computers and other services. There's all types of records: MX for SMTP mail exchangers, NS for name servers, PTR for pointers for reverse DNS lookups, CNAME for domain name aliases and A and AAAA for IP addresses. For this project it's the latter one we're using.

2.2 Changes

For this phase we are reverting some configurations, namely LAN's A and B devices static IP address. The rest are still valid here, now as IP pool addresses.

Name	Ports Link		Network	IP	Gateway	Subnet Mask
	From	To		192.168.7.		255.255.255.
PC0	Fa0	Sw0 Fa0/2	LAN A			192
Laptop0	Fa0	Sw0 Fa0/3				
PC1	Fa0	Sw1 Fa0/2	LAN B			224
Laptop1	Fa0	Sw1 Fa0/3				
R0	Fa0/0	Fa0/0	External			
	Fa4/0	R2 Fa4/0	LAN Transit C	245		252
	Fa5/0	R1 Fa5/0	LAN Transit B	249		
R1	Fa0/0	Sw0 Fa0/1	LAN A	190		192
	Fa1/0	Sw1 Fa0/1	LAN B	222		224
	Fa4/0	R2 Fa5/0	LAN Transit A	253		252

Table 2.3 continued from previous page

Name	Ports Link		Network	IP	Gateway	Subnet Mask
	From	To		192.168.7.		255.255.255.
	Fa5/0	R1 Fa4/0	LAN Transit B	250		
R2	Fa0/0	Sw2 Fa0/4	LAN Server	126		128
	Fa4/0	R0 Fa4/0	LAN Transit C	246		252
	Fa5/0	R1 Fa4/0	LAN Transit A	254		
HTTP-Server	Fa0	Sw2 Fa0/1		3		
DNS-Server	Fa0	Sw2 Fa0/2	LAN Server	2	126	128
DHCP-Server	Fa0	Sw2 Fa0/3		1		
Sw0	Fa0/1	R1 Fa0/0				
	Fa0/2	PC0	LAN A			
	Fa0/3	Laptop0				
Sw1	Fa0/1	R1 Fa1/0				
	Fa0/2	PC1	LAN B			
	Fa0/3	Laptop1				
Sw2	Fa0/1	HTTP-Server	LAN Server			
	Fa0/2	DNS-Server				
	Fa0/3	DHCP-Server				
	Fa0/4	R2 Fa0/0				

Table 2.3: IP configuration table

2.3 Server configuration

Servers should be configured with static IP addresses, either in the device itself of in a network controller.

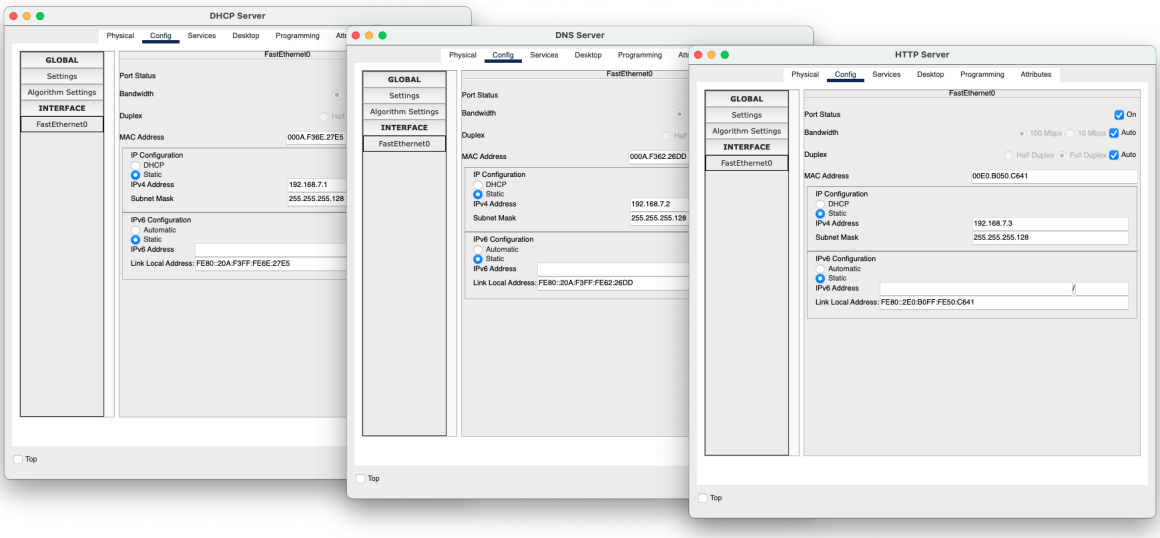

Figure 2.1: LanServer devices static IP addresses

Using our reference table, we proceed with the pool assignment.

To allow access to our HTTP server using a name and not a prisioner number we must configure a record.

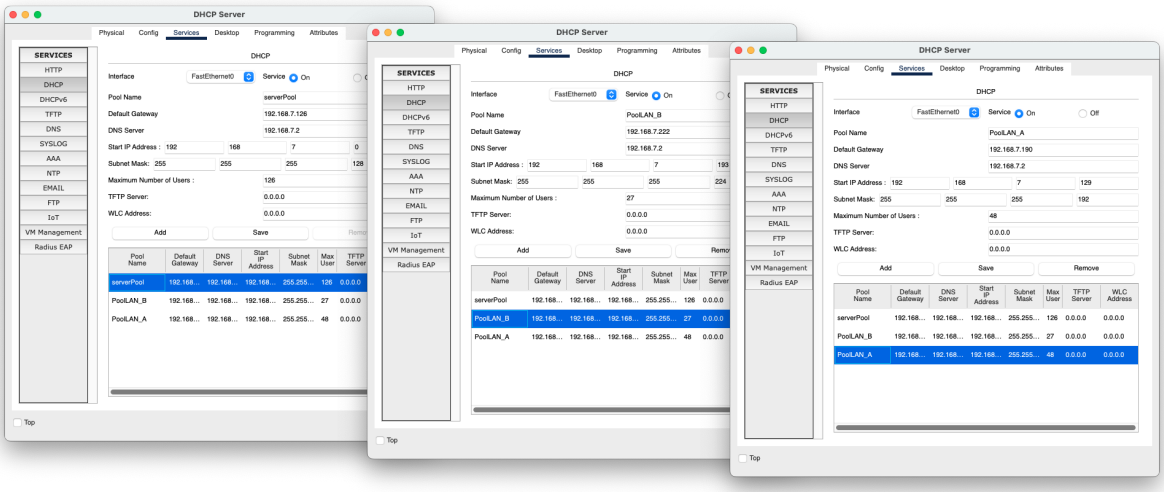

Figure 2.2: DHCP pool configuration

In this case, as refered before, A record.

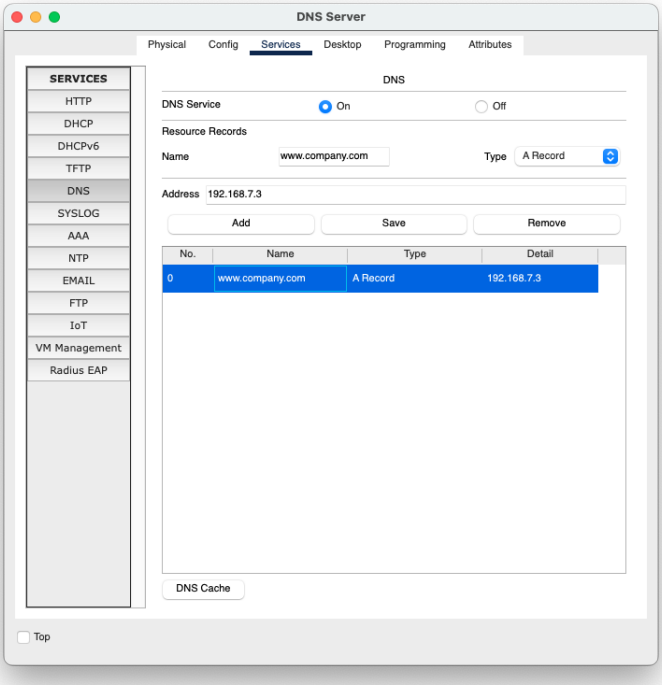

Figure 2.3: DNS records configuration

2.4 Router additional configuration

Router 1 needs a tiny little command to allow our DHCP server: ip helper-address ***DHCP.IP.ADDRESS*** Simple as that.

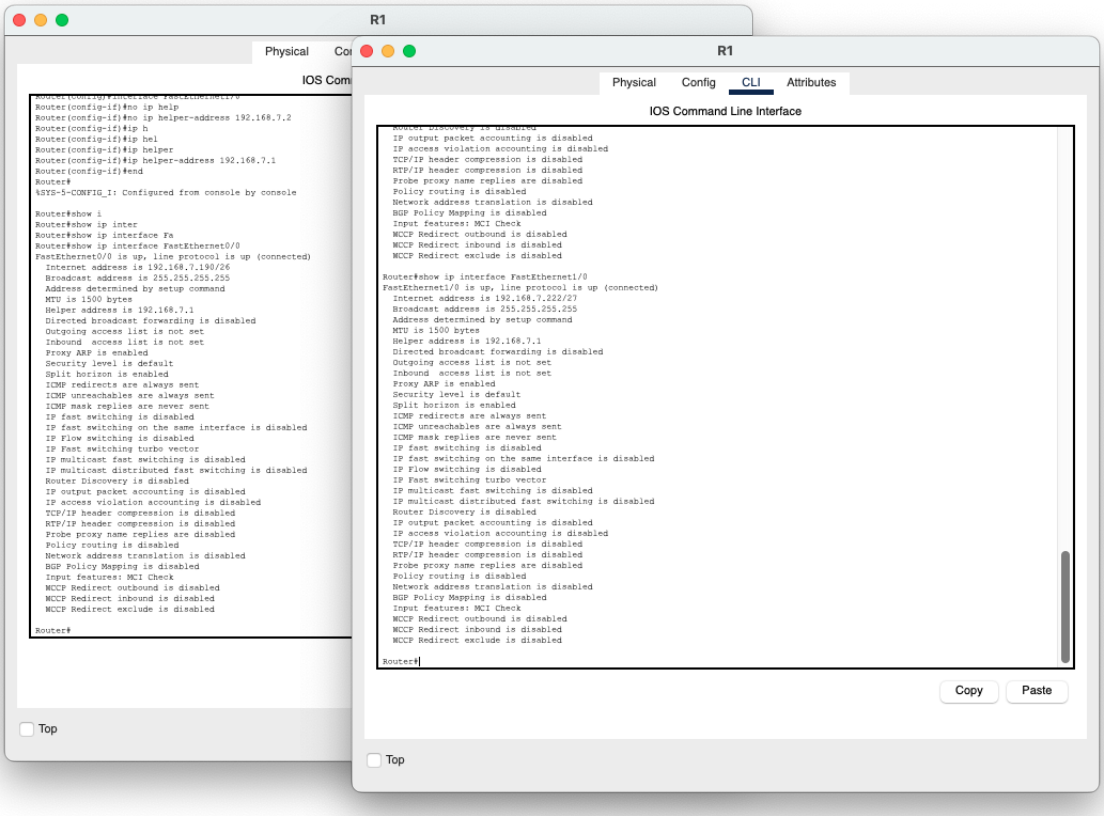

Figure 2.4: Router1 helper-address

2.5 Preparing devices and results

For our devices we'll configure them as DHCP. What follows are the executed commands.

With PC0 we went above and beyond testing the network. First observing the new assigned IP by our DHCP server, then running nslookup to the HTTP server configured website and, to conclude, IP address renewal.
We can also see the browser in action, showing that everything is working as expected.

The remaining devices are in the B.1 section from the appendix A.

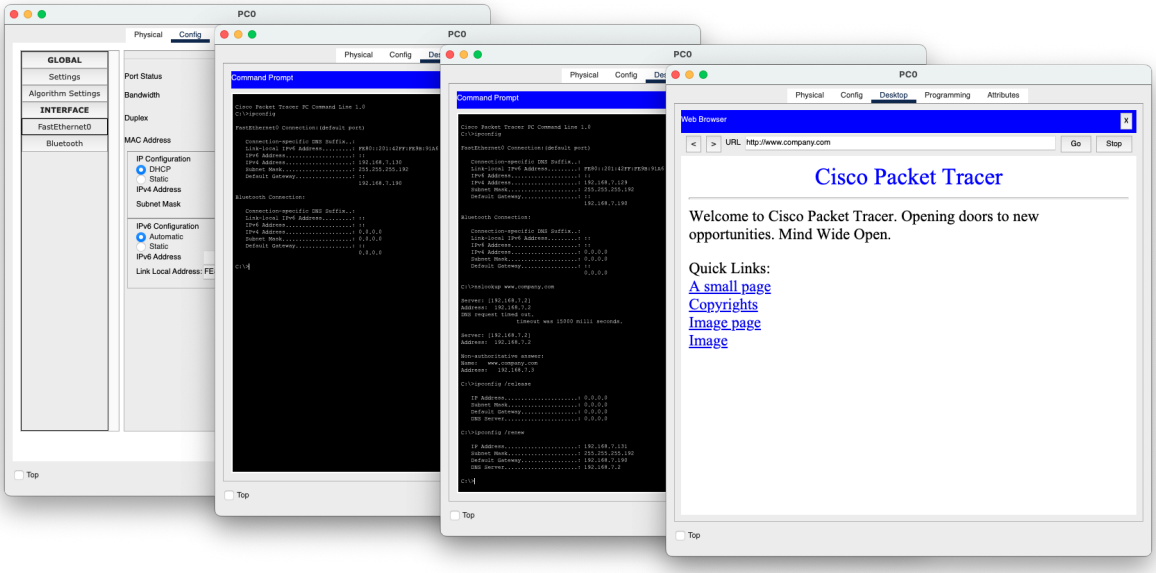

Figure 2.5: PC0 configuration and commands

2.6 Command line outputs

```
1
2  Cisco Packet Tracer PC Command Line 1.0
3  C:\>ipconfig
4
5  FastEthernet0 Connection:(default port)
6
7     Connection-specific DNS Suffix..:
8     Link-local IPv6 Address.....: FE80::201:42FF:FE9B:91A6
9     IPv6 Address.....: ::
10    IPv4 Address.....: 192.168.7.130
11    Subnet Mask.....: 255.255.255.192
12    Default Gateway.....: ::
13                                    192.168.7.190
14
15 Bluetooth Connection:
16
17    Connection-specific DNS Suffix..:
18    Link-local IPv6 Address.....: ::
19    IPv6 Address.....: ::
20    IPv4 Address.....: 0.0.0.0
21    Subnet Mask.....: 0.0.0.0
22    Default Gateway.....: ::
23                                    0.0.0.0
24
25 C:\>
```

Listing 2.1: PC0 output (LAN A)

```
1
2  Cisco Packet Tracer PC Command Line 1.0
3  C:\>ipconfig
4
5  FastEthernet0 Connection:(default port)
6
7     Connection-specific DNS Suffix..:
8     Link-local IPv6 Address.....: FE80::260:5CFF:FE73:18BD
9     IPv6 Address.....: ::
```

```
   IPv4 Address.....................: 192.168.7.193
   Subnet Mask.....................: 255.255.255.224
   Default Gateway.................: ::
                                     192.168.7.222

Bluetooth Connection:

   Connection-specific DNS Suffix..:
   Link-local IPv6 Address.........: ::
   IPv6 Address....................: ::
   IPv4 Address....................: 0.0.0.0
   Subnet Mask.....................: 0.0.0.0
   Default Gateway.................: ::
                                     0.0.0.0

C:\>
```

Listing 2.2: PC1 output (LAN B)

```
System Bootstrap, Version 12.1(3r)T2, RELEASE SOFTWARE (fc1)
Copyright (c) 2000 by cisco Systems, Inc.
PT 1001 (PTSC2005) processor (revision 0x200) with 60416K/5120K bytes of memory

Readonly ROMMON initialized

Self decompressing the image :
######################### [OK]

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Software clause at DFARS sec. 252.227-7013.

           cisco Systems, Inc.
           170 West Tasman Drive
           San Jose, California 95134-1706



Cisco Internetwork Operating System Software
IOS (tm) PT1000 Software (PT1000-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)
Technical Support: http://www.cisco.com/techsupport
Copyright (c) 1986-2005 by cisco Systems, Inc.
Compiled Wed 27-Apr-04 19:01 by miwang

PT 1001 (PTSC2005) processor (revision 0x200) with 60416K/5120K bytes of memory
.
Processor board ID PT0123 (0123)
PT2005 processor: part number 0, mask 01
Bridging software.
X.25 software, Version 3.0.0.
4 FastEthernet/IEEE 802.3 interface(s)
2 Low-speed serial(sync/async) network interface(s)
32K bytes of non-volatile configuration memory.
63488K bytes of ATA CompactFlash (Read/Write)

Press RETURN to get started!


%LINK-5-CHANGED: Interface FastEthernet5/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet5/0, changed state to up

%LINK-5-CHANGED: Interface FastEthernet4/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet4/0, changed state to up
```

```
52
53  %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
54
55  %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet1/0, changed state to up
56
57
58  Router>enable
59  Router#
60  Router#configure terminal
61  Enter configuration commands, one per line.  End with CNTL/Z.
62  Router(config)#
63  Router(config)#interface FastEthernet0/0
64  Router(config-if)#
65  Router(config-if)#ip helper-address 192.168.7.1
66  Router(config-if)#exit
67  Router(config)#interface FastEthernet1/0
68  Router(config-if)#
69  Router(config-if)#ip helper-address 192.168.7.1
70  Router(config-if)#exit
71  Router(config)#exit
72  Router#
73  %SYS-5-CONFIG_I: Configured from console by console
74  Router#
75  Router#show ip interface FastEthernet 0/0
76  FastEthernet0/0 is up, line protocol is up (connected)
77    Internet address is 192.168.7.190/26
78    Broadcast address is 255.255.255.255
79    Address determined by setup command
80    MTU is 1500 bytes
81    Helper address is 192.168.7.1
82    Directed broadcast forwarding is disabled
83    Outgoing access list is not set
84    Inbound  access list is not set
85    Proxy ARP is enabled
86    Security level is default
87    Split horizon is enabled
88    ICMP redirects are always sent
89    ICMP unreachables are always sent
90    ICMP mask replies are never sent
91    IP fast switching is disabled
92    IP fast switching on the same interface is disabled
93    IP Flow switching is disabled
94    IP Fast switching turbo vector
95    IP multicast fast switching is disabled
96    IP multicast distributed fast switching is disabled
97    Router Discovery is disabled
98    IP output packet accounting is disabled
99    IP access violation accounting is disabled
100   TCP/IP header compression is disabled
101   RTP/IP header compression is disabled
102   Probe proxy name replies are disabled
103   Policy routing is disabled
104   Network address translation is disabled
105   BGP Policy Mapping is disabled
106   Input features: MCI Check
107   WCCP Redirect outbound is disabled
108   WCCP Redirect inbound is disabled
109   WCCP Redirect exclude is disabled
110 Router#
111 Router#show ip interface FastEthernet 1/0
112 FastEthernet1/0 is up, line protocol is up (connected)
113   Internet address is 192.168.7.222/27
114   Broadcast address is 255.255.255.255
115   Address determined by setup command
116   MTU is 1500 bytes
117   Helper address is 192.168.7.1
118   Directed broadcast forwarding is disabled
119   Outgoing access list is not set
120   Inbound  access list is not set
121   Proxy ARP is enabled
122   Security level is default
123   Split horizon is enabled
124   ICMP redirects are always sent
```

```
  ICMP unreachables are always sent
  ICMP mask replies are never sent
  IP fast switching is disabled
  IP fast switching on the same interface is disabled
  IP Flow switching is disabled
  IP Fast switching turbo vector
  IP multicast fast switching is disabled
  IP multicast distributed fast switching is disabled
  Router Discovery is disabled
  IP output packet accounting is disabled
  IP access violation accounting is disabled
  TCP/IP header compression is disabled
  RTP/IP header compression is disabled
  Probe proxy name replies are disabled
  Policy routing is disabled
  Network address translation is disabled
  BGP Policy Mapping is disabled
  Input features: MCI Check
  WCCP Redirect outbound is disabled
  WCCP Redirect inbound is disabled
  WCCP Redirect exclude is disabled

Router#
```

Listing 2.3: R1 output

The remaining devices are in the A.1 section from the appendix A.

Chapter 3

Issues and fixes

Cisco Packet Tracer in MacOS:

STILL no solution was found to deal with those annoying popups that takes primary focus over other windows, even using the latest version.

Chapter 4

Conclusions

Looking at our output results we realize that everything is working as anticipated.
We have IP addresses being assigned by a DHCP server over different sub networks and behind multiple routers. Renewal requests by devices are served without trouble.
DNS records are also fully functional, devices can reach the web server by name and IP address. Unfortunately the same cannot be done for DHCP assigned IP addresses, only static addresses.

Appendix A

Outputs

A.1 Command line encore

```
1
2  Cisco Packet Tracer PC Command Line 1.0
3  C:\>ipconfig
4
5  FastEthernet0 Connection:(default port)
6
7     Connection-specific DNS Suffix..:
8     Link-local IPv6 Address.........: FE80::260:70FF:FE78:DA66
9     IPv6 Address....................: ::
10    IPv4 Address....................: 192.168.7.129
11    Subnet Mask.....................: 255.255.255.192
12    Default Gateway.................: ::
13                                      192.168.7.190
14
15 Bluetooth Connection:
16
17    Connection-specific DNS Suffix..:
18    Link-local IPv6 Address.........: ::
19    IPv6 Address....................: ::
20    IPv4 Address....................: 0.0.0.0
21    Subnet Mask.....................: 0.0.0.0
22    Default Gateway.................: ::
23                                      0.0.0.0
24
25 C:\>
```

Listing A.1: Laptop0 output (LAN A)

```
1
2  Cisco Packet Tracer PC Command Line 1.0
3  C:\>ipconfig
4
5  FastEthernet0 Connection:(default port)
6
7     Connection-specific DNS Suffix..:
8     Link-local IPv6 Address.........: FE80::207:ECFF:FE04:C4A4
9     IPv6 Address....................: ::
10    IPv4 Address....................: 192.168.7.194
11    Subnet Mask.....................: 255.255.255.224
12    Default Gateway.................: ::
13                                      192.168.7.222
14
15 Bluetooth Connection:
16
17    Connection-specific DNS Suffix..:
```

```
   Link-local IPv6 Address.....: ::
   IPv6 Address.....: ::
   IPv4 Address.....: 0.0.0.0
   Subnet Mask.....: 0.0.0.0
   Default Gateway.....: ::
                                 0.0.0.0

C:\>
```

Listing A.2: Laptop1 output (LAN B)

Appendix B

Remaining devices

B.1 Printscreens

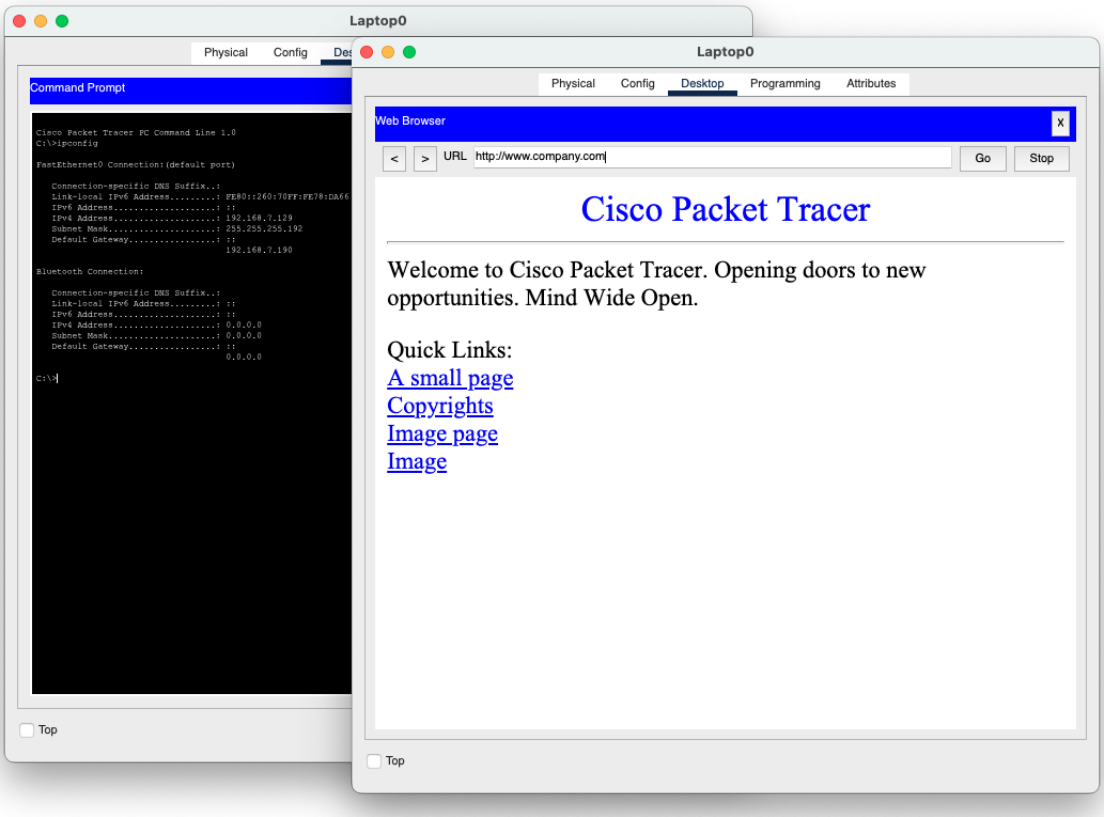

Figure B.1: Laptop0 configuration and commands

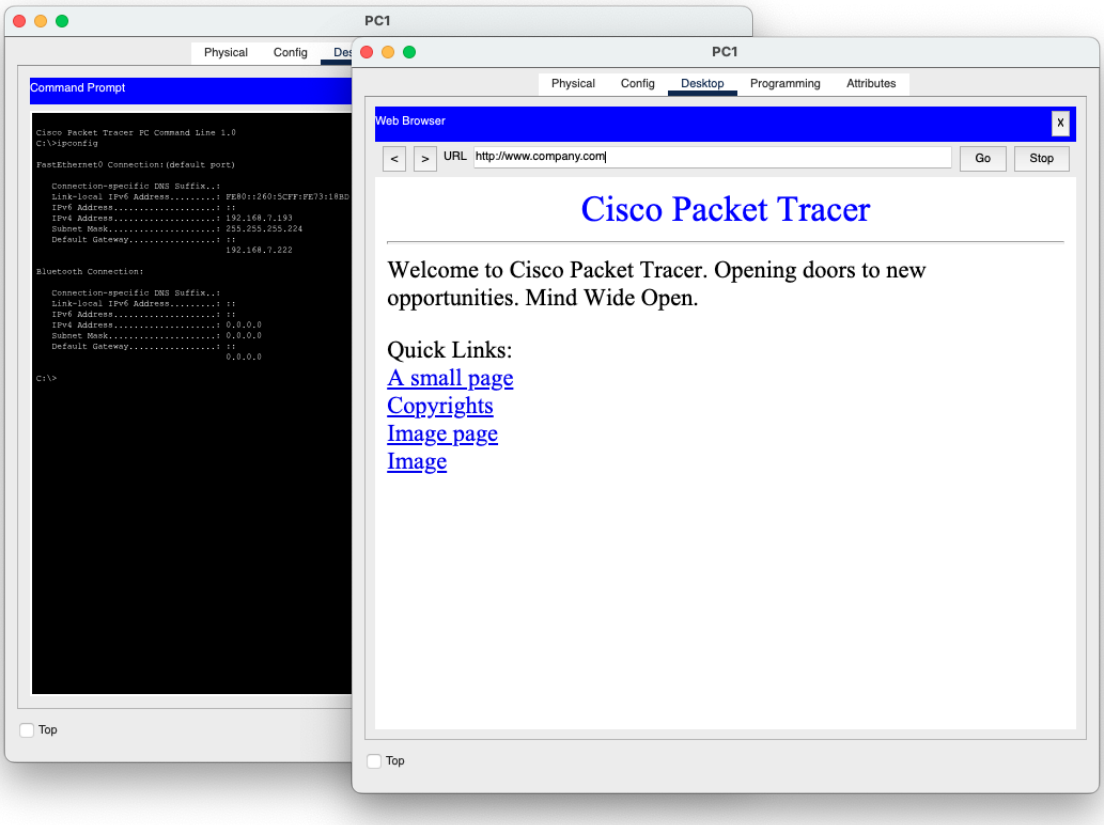

Figure B.2: PC1 configuration and commands

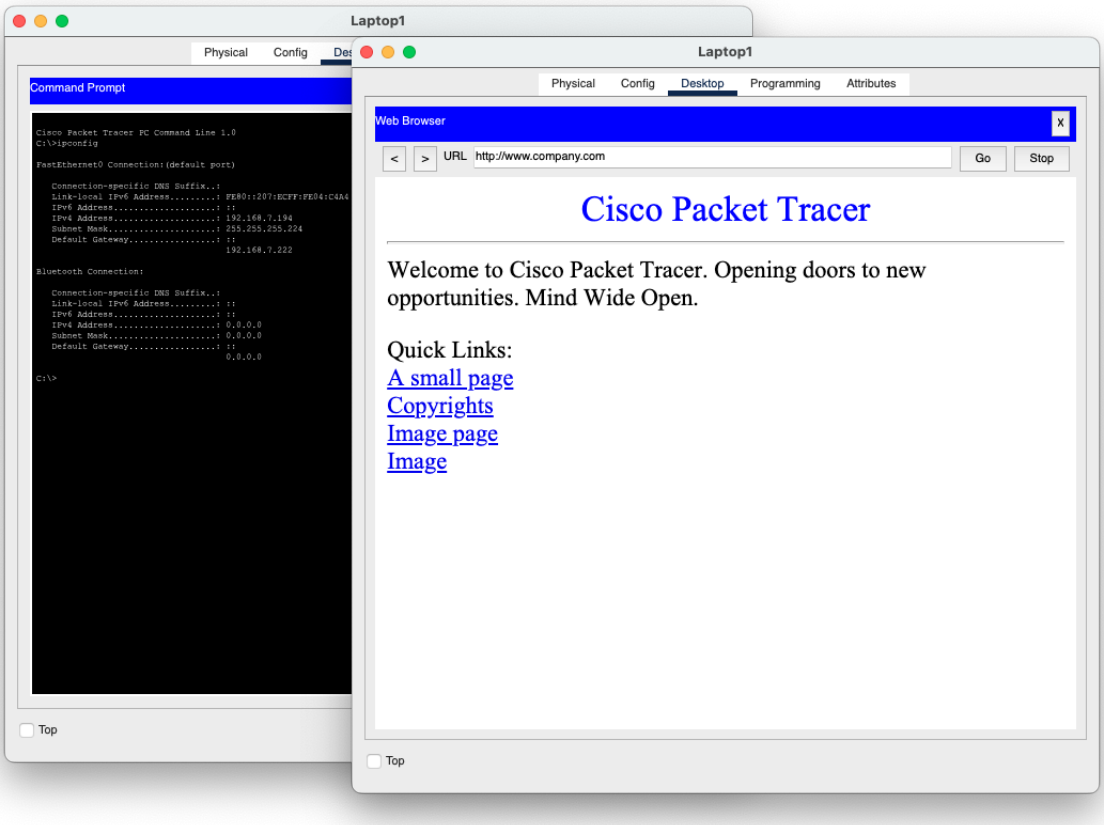

Figure B.3: Laptop1 configuration and commands