



Computer Networks

Phase 1 - Web Server

Projeto ISEL 2023/24 — LEETC

Coordination

General: Carlos Meneses Course: Nuno Cruz

Grupo LP-07

Supervisor: Luís Pires

Student

Nuno Brito <A46948@alunos.isel.pt>

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Acronyms list

API	Application Programming Interface
CLI	Command Line Interface
CMD	Command Prompt
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
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. Its 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 distribution 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 distribution

A distribution where it's software release cycle is more frequent than those of Long Term Support (LTS). It's up to the Linux-based distributor 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 its latest version being 11. Due to its 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

For phase 2 we were tasked to configure two local area networks using a router. By applying the principles of subnetting we can dimension our network pragmatically, keeping in check the assigned requirements, wasting only a minimal amount of unallocated IP addresses.

Since the next phases overlap in planning, the majority of information presented in this report will be used for the upcoming parts. Time is of essence, this little manuveur allowed to save time and energy since all the hard work is done.

To better understand what we're dealing with we'll also explore a little bit about IP version 4, what it contains and how does it work. Concepts about routers, configuring our devices, taking advantage of switches and so on are displayed in this phase.

Chapter 2

Phase 2

2.1 The IP Header

Before getting our hands-on business. Let's acquaintance our Internet Protocol (IP) friend, IPv4. To keep it simple we'll not touch IPv6.

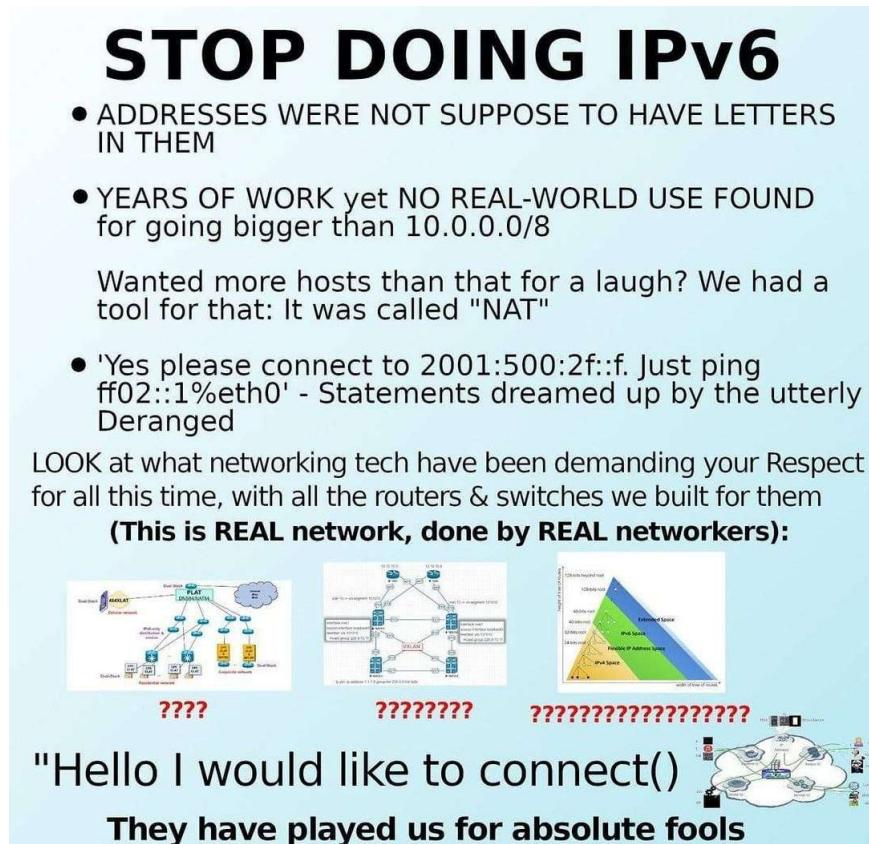


Figure 2.1: Guess IPv4 is enough for everything

Ok, now that we're at ease, we can explore the IP datagram.

IP Datagram is the data transmitted over a network connection carried in messages, using specific formats as seen in table 2.1.

Version 4 bits	Header Length 4bits	Type of Service 8 bits	Total Length 16 bits			
Identification 16 bits		Reserved 1 bit	Don't Fragment 1 bit	More Fragment 1 bit	Fragment Offset 13 bits	
Time to Live 8 bits	Protocol 8 bits	Header Checksum 16 bits				
Source IP 32 bits (4 Bytes)						
Destination IP 32 bits (4 Bytes)						
Option 0 - 40 Bytes						
DATA 20 Bytes - 65536 Bytes						

Table 2.1: IPv4 datagram dissected

Each line, excluding *option* and *data*, have 32 bits (4 Bytes) of size.

Breaking down each part of the protocol we can see the following:

- **Version:** the IP version, 4 for IPv4.
- **Header Length:** the number of 32 bits words in the header with a minimum value of 5 and a maximum value of 15.
- **Type of service:** low delay, high throughput or reliability.
- **Total Length:** header plus data length with minimum value of 20 Bytes and a maximum value of 65535 Bytes. 32 bits in total (4 Bytes)
- **Identification:** a unique packet id.
- **Flags**
 - **Reserved bit:** must be zero.
 - **Don't Fragment**
 - **More Fragment**
- **Fragment offset:** number of data Bytes ahead of the particular fragment in the particular datagram. 32 bits in total (4 Bytes)
- **Time to live:** datagram lifetime.
- **Protocol:** name of the protocol.
- **Header checksum:** allows error checking in the header. 32 bits in total (4 Bytes)
- **Source IP**
- **Destination IP**
- **Option:** optional information for network administrators.

2.2 Connecting two devices with a switch

This first part is very simple. There are two devices (PC0 and Laptop0) connected to a switch and their network starts with 192.168.**GROUP NUMBER.0**.

Therefore:

- Group: 7 [192.168.7.0/24]
- Laptop0 [192.168.7.1]
- PC0 [192.168.7.2]

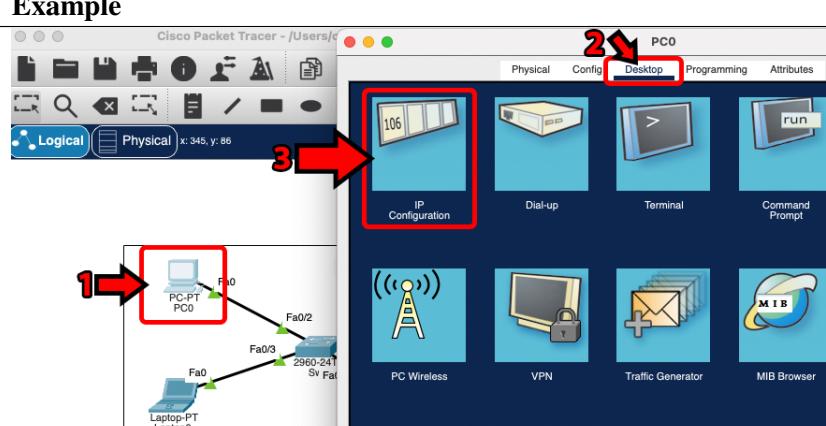
After applying the configuration we must run a set of commands to test our network.

- Ping: to test connectivity between devices over IP.
- Tracert: diagnostic command for displaying possible routes, also measures transit delay of packages across IP.
- Ipconfig: console application program of some computer operating systems that displays all current TCP/IP network configuration values. Unix and linux equivalent is *ifconfig*.

2.2.1 Simulating a network using Cisco Packet Tracer

For this project Cisco Packet Tracer will be our main tool. Using the Command Prompt (CMD) in each device, we'll simulate all referenced commands in the network.

So let's get into this magnificent world, starting with these steps:

Steps	Example
To configure the IP on a device we must single-click in the intended device (1), go to the <i>desktop tab</i> (2) and select <i>IP Configuration</i> (3).	

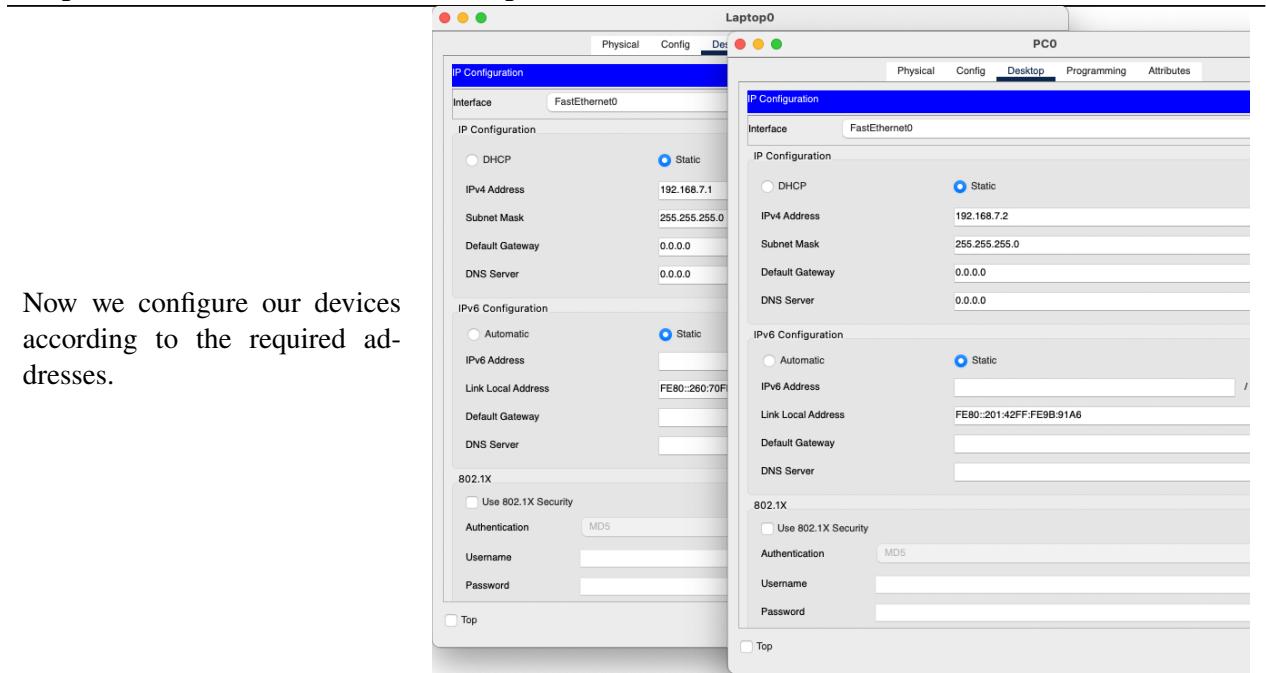
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Table 2.2 continued from previous page

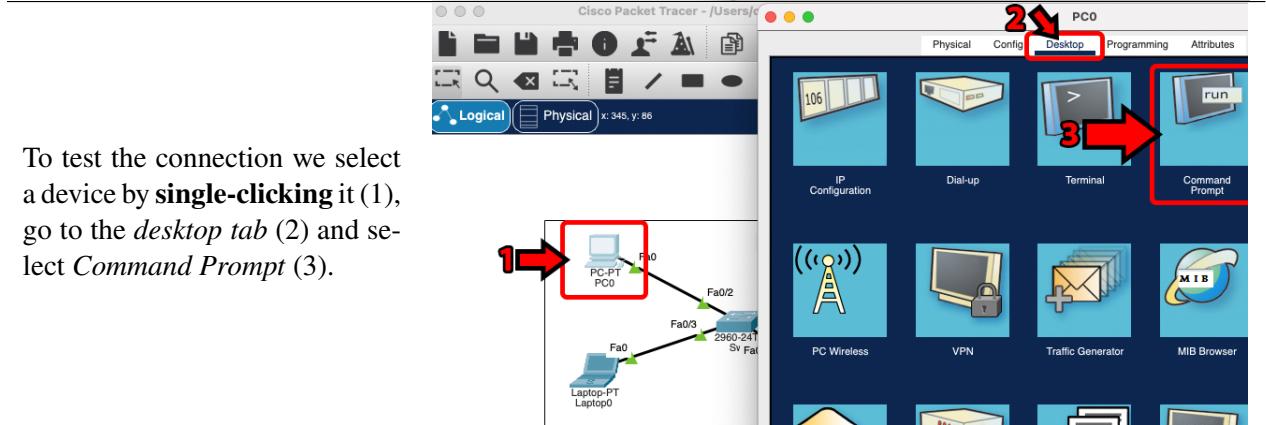
Steps

Example

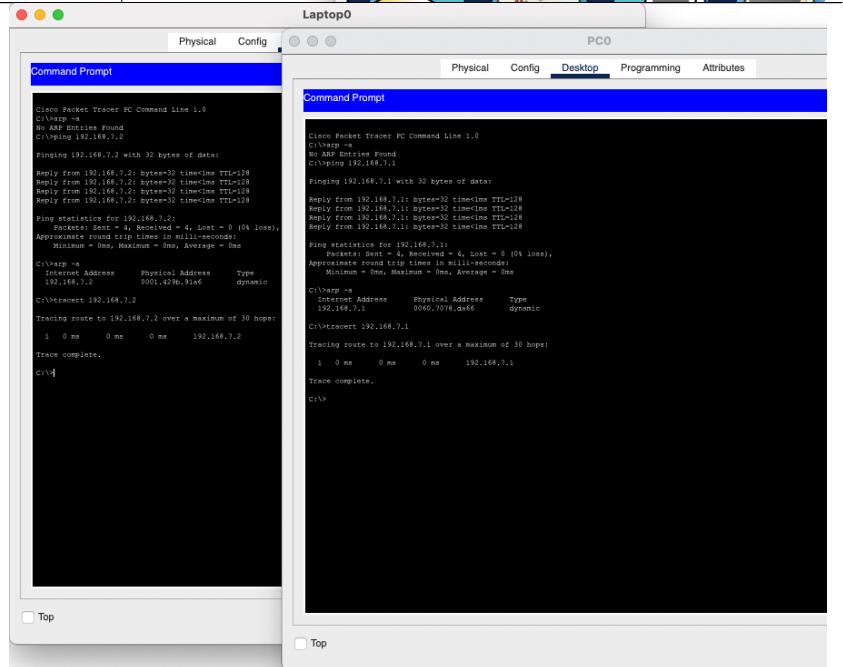
Now we configure our devices according to the required addresses.



To test the connection we select a device by **single-clicking** it (1), go to the *desktop* tab (2) and select *Command Prompt* (3).



We start by running `arp -a` command, no prior discovery was made so the arp table will be empty. Then we'll `ping` our other device. Run the `arp -a` command again and we'll see it populated. If we do a `tracert` there won't be any hops.



Continued on next page

Table 2.2 continued from previous page

Steps	Example
	Table 2.2: Cisco Packet Tracer guide

And to supplement the output images, below are the text versions:

```
1 Cisco Packet Tracer PC Command Line 1.0
2 C:>arp -a
3 No ARP Entries Found
4 C:>ping 192.168.7.1
5
6 Pinging 192.168.7.1 with 32 bytes of data:
7
8 Reply from 192.168.7.1: bytes=32 time<1ms TTL=128
9 Reply from 192.168.7.1: bytes=32 time<1ms TTL=128
10 Reply from 192.168.7.1: bytes=32 time<1ms TTL=128
11 Reply from 192.168.7.1: bytes=32 time<1ms TTL=128
12
13 Ping statistics for 192.168.7.1:
14     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
15 Approximate round trip times in milli-seconds:
16     Minimum = 0ms, Maximum = 0ms, Average = 0ms
17
18 C:>arp -a
19     Internet Address          Physical Address          Type
20         192.168.7.1           0060.7078.da66        dynamic
21
22 C:>tracert 192.168.7.1
23
24 Tracing route to 192.168.7.1 over a maximum of 30 hops:
25
26     1  0 ms      0 ms      0 ms      192.168.7.1
27
28 Trace complete.
29
30 C:>
```

Listing 2.1: PC0 CMD output

```
1
2 Cisco Packet Tracer PC Command Line 1.0
3 C:>arp -a
4 No ARP Entries Found
5 C:>ping 192.168.7.2
6
7 Pinging 192.168.7.2 with 32 bytes of data:
8
9 Reply from 192.168.7.2: bytes=32 time<1ms TTL=128
10 Reply from 192.168.7.2: bytes=32 time<1ms TTL=128
11 Reply from 192.168.7.2: bytes=32 time<1ms TTL=128
12 Reply from 192.168.7.2: bytes=32 time<1ms TTL=128
13
14 Ping statistics for 192.168.7.2:
15     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
16 Approximate round trip times in milli-seconds:
17     Minimum = 0ms, Maximum = 0ms, Average = 0ms
18
19 C:>arp -a
20     Internet Address          Physical Address          Type
21         192.168.7.2           0001.429b.91a6        dynamic
22
23 C:>tracert 192.168.7.2
24
```

```

25 Tracing route to 192.168.7.2 over a maximum of 30 hops:
26
27     1   0 ms      0 ms      0 ms    192.168.7.2
28
29 Trace complete.
30
31 C:\>

```

Listing 2.2: Laptop0 CMD output

Question: How can a PC know if it is connected to a switch? Is traceroute useful in this situation?

Answer: If a device is connected to a switch, the arp table will include both devices IP addresses after a ping to each other. However, if connected to a router (as we'll see in the next section), they we'll only include their gateways IP addresses.

Traceroute isn't very useful here. It only shows hops in a routed network path (layer 3). Layer 2 devices, such as switches, won't show up since they receive and forward ethernet frames.

2.3 Connecting two LANs with a router

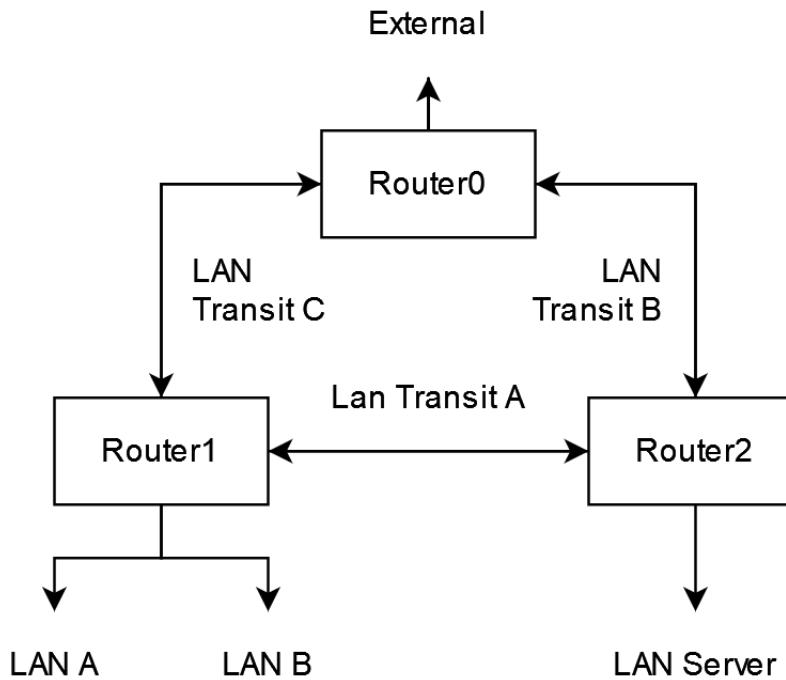


Figure 2.2: Part 2 network diagram

Connecting to devices was pretty straight forward. Now comes the expected progress. What follows next tackles a network approach paramount for the next four phases.

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

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

Using the required mathematical equations, provided in the project, we reach the conclusions presented in the following tables.

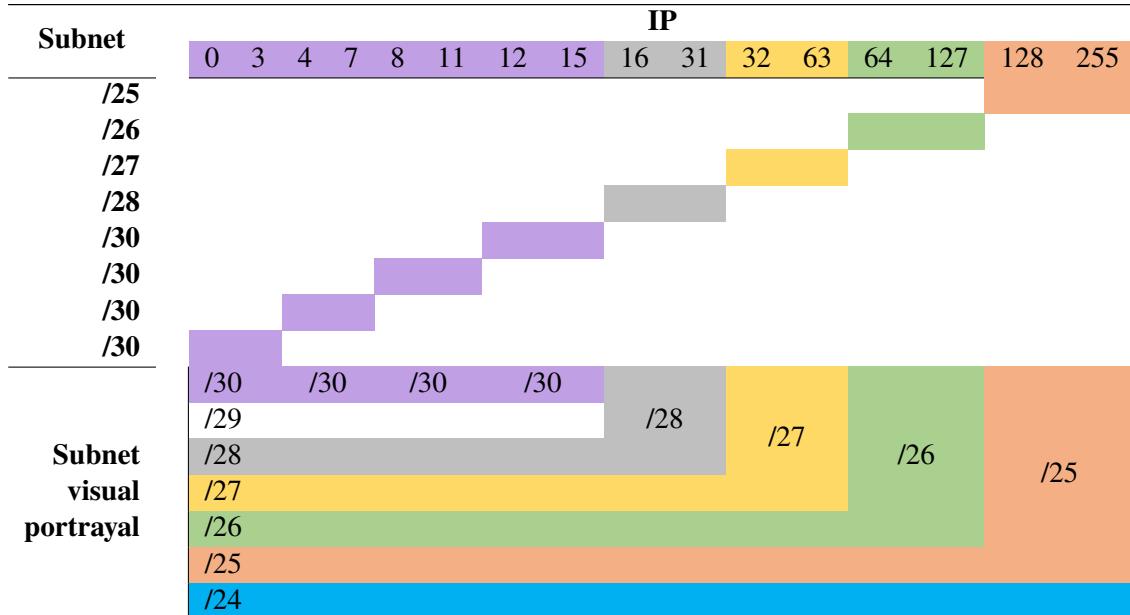


Table 2.3: Visual LAN allocation

Name	Network	Usable IPs	Router	Broadcast	Subnet Mask	Populated
LAN Server	128	129 - 253	254	255	128	126
LAN A	64	65 - 125	126	127	192	48
LAN B	32	33 - 61	62	63	224	27
Unused remaining	16	17 - 31		32		0
	12	13 - 14		15		0
LAN Transit C	8	9 - 10		11	252	2
LAN Transit B	4	5 - 6		7	252	2
LAN Transit A	0	1 - 2		3	252	2

Table 2.4: LAN allocation table

Name	Ports Link	Network	IP	Subnet Mask	Gateway
PC0	Fa0 - Sw0 Fa0/2		192.168.7.65	255.255.255.192	192.168.7.126
Laptop0	Fa0 - Sw0 Fa0/3	LAN A	192.168.7.66	255.255.255.192	192.168.7.126
PC1	Fa0 - Sw1 Fa0/2		192.168.7.33	255.255.255.224	192.168.7.62
Laptop1	Fa0 - Sw1 Fa0/3	LAN B	192.168.7.34	255.255.255.224	192.168.7.62
R0	Fa5/0 - R1 Fa5/0	LAN Transit B	192.168.7.5	255.255.255.252	
	Fa4/0 - R2 Fa4/0	LAN Transit C	192.168.7.9	255.255.255.252	
	Fa0/0	External			
R1	Fa4/0 - R2 Fa5/0	LAN Transit A	192.168.7.1	255.255.255.252	
	Fa5/0 - R1 Fa4/0	LAN Transit B	192.168.7.6	255.255.255.252	
	Fa0/0 - Sw0 Fa0/1	LAN A	192.168.7.126	255.255.255.192	
	Fa1/0 - Sw1 Fa0/1	LAN B	192.168.7.62	255.255.255.224	
R2	Fa5/0 - R1 Fa4/0	LAN Transit A	192.168.7.2	255.255.255.252	
	Fa4/0 - R0 Fa4/0	LAN Transit C	192.168.7.10	255.255.255.252	
	Fa0/0 - Sw2 Fa0/4	LAN Server	192.168.7.254	255.255.255.128	
DHCP Server	Fa0 - Sw2 Fa0/3		192.168.7.129	255.255.255.128	192.168.7.254
DNS Server	Fa0 - Sw2 Fa0/2	LAN Server	192.168.7.130	255.255.255.128	192.168.7.254
HTTP Server	Fa0 - Sw2 Fa0/1		192.168.7.131	255.255.255.128	192.168.7.254
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				
	Fa0/2 - DNS				
	Fa0/3 - DHCP	LAN Server			
	Fa0/4 - R2 Fa0/0				

Table 2.5: IP configuration table

Instead of planning for each phase and re-assigning the entire network, it was opted to fully outline every subnet and device in a pragmatic manner.

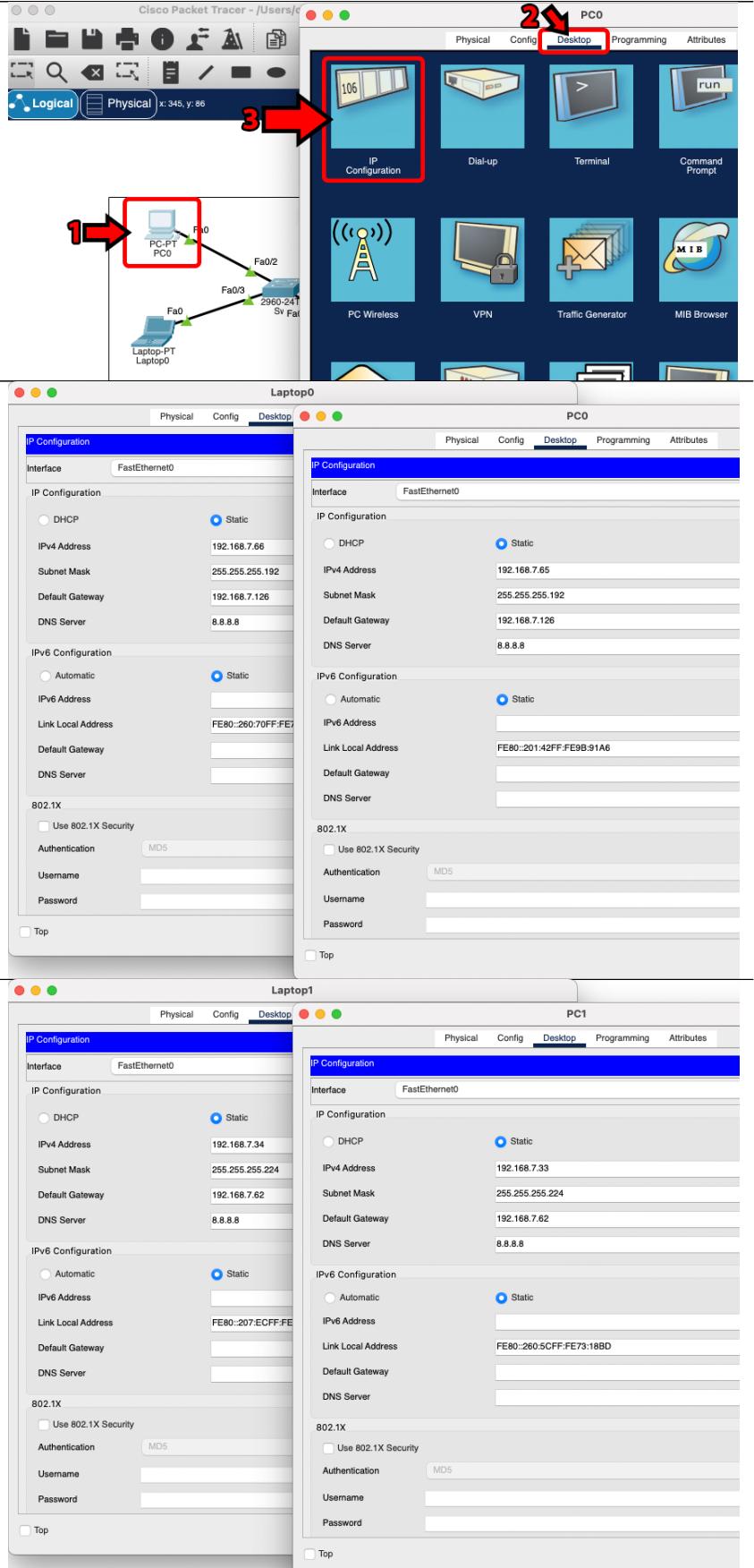
However, here we'll focus on router **R1**, and the respective networks, **LAN A** and **LAN B**.

Once again, **Cisco Packet Tracer** to the help:

Steps

To configure the IP on a device we must **single-click** in the intended device (1), go to the *desktop tab* (2) and select *IP Configuration* (3).

Example



And the same for Laptop1 and PC1.

Continued on next page

Table 2.6 continued from previous page

Steps

Example

For the router there's two options, both valid and exhibited in the report. The GUI in the right and the CLI, after this table, along CMD equivalent commands output. We're using **FastEthernet0/0** for *LAN A* and **FastEthernet1/0** for *LAN B*, going by the graphical user interface (GUI) it's crystal clear, just input the necessary IP and subnet mask.

The screenshot shows the Cisco Packet Tracer interface. On the left, a network diagram shows a Router (R1) connected to two PCs (PC0 and PC1) via FastEthernet interfaces. The Router also has a connection to a Laptop (Laptop0). The Router's FastEthernet0/0 interface is connected to PC0 and has an IP address of 192.168.7.126. The Router's FastEthernet1/0 interface is connected to PC1 and has an IP address of 192.168.7.62. Both interfaces have a subnet mask of 255.255.255.192.

On the right, three windows show the configuration details:

- FastEthernet0/0 Configuration:** Shows Port Status (On), Bandwidth (100 Mbps), Duplex (Auto), MAC Address (0060.2FC0.D9B0), and IP Configuration (IP4 Address 192.168.7.126, Subnet Mask 255.255.255.192).
- FastEthernet1/0 Configuration:** Shows Port Status (On), Bandwidth (100 Mbps), Duplex (Auto), MAC Address (0090.0C00.9582), and IP Configuration (IP4 Address 192.168.7.62, Subnet Mask 255.255.255.192).
- Equivalent IOS Commands:** Displays the CLI commands used to configure the interfaces, including `Router(config)#interface FastEthernet0/0` and `Router(config-if)#ip address 192.168.7.126 255.255.255.192`.

Below the configuration windows, the Cisco Packet Tracer interface is shown with a legend for icons: Logical (blue square), Physical (red square), Desktop (yellow square), Programming (green square), Attributes (purple square), IP Configuration (blue square), Dial-up (orange square), Terminal (green square), Command Prompt (red square), PC Wireless (yellow square), VPN (orange square), Traffic Generator (green square), and MIB Browser (purple square). Red arrows numbered 1, 2, and 3 point to the Router, the Desktop tab, and the Command Prompt icon respectively.

To test the connection we select a device by **single-clicking** it (1), go to the *desktop tab* (2) and select *Command Prompt* (3).

Continued on next page

Table 2.6 continued from previous page

Steps

Example

Contrary to our experiment in the previous section, it's unmistakable that after the first ping, the router provides information related to the whereabouts of the pinged device, due to **arp -a** command showing the router configured gateways.

From the viewpoint of PC0.

Continued on next page

The figure consists of three vertically stacked windows from Cisco Packet Tracer. Each window has a title bar with the name of the host (Laptop0 or PC0) and tabs for Physical, Config, Desktop, Programming, and Attributes. The Desktop tab is selected.

Laptop0 (Top Window):

```

Cisco Packet Tracer FC Command Line 1.0
C:\>arp -a
No ARP Entries Found
C:\>ping 192.168.7.65

Pinging 192.168.7.65 with 32 bytes of data:
Reply from 192.168.7.65: bytes=32 time<ms TTL=128

Ping statistics for 192.168.7.65:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 192.168.7.126

Pinging 192.168.7.126 with 32 bytes of data:
Reply from 192.168.7.126: bytes=32 time<ms TTL=255

Ping statistics for 192.168.7.126:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 192.168.7.34

Pinging 192.168.7.34 with 32 bytes of data:
Reply from 192.168.7.34: bytes=32 time<ms TTL=127

Ping statistics for 192.168.7.34:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>arp -a
No ARP Entries Found
C:\>

```

PC0 (Bottom Window):

```

Cisco Packet Tracer PC Command Line 1.0
C:\>arp -a
No ARP Entries Found
C:\>ping 192.168.7.62

Pinging 192.168.7.62 with 32 bytes of data:
Reply from 192.168.7.62: bytes=32 time<ms TTL=128

Ping statistics for 192.168.7.62:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 192.168.7.126

Pinging 192.168.7.126 with 32 bytes of data:
Reply from 192.168.7.126: bytes=32 time<ms TTL=255

Ping statistics for 192.168.7.126:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 192.168.7.34

Pinging 192.168.7.34 with 32 bytes of data:
Reply from 192.168.7.34: bytes=32 time<ms TTL=127

Ping statistics for 192.168.7.34:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
    Approximate round trip times in milli-seconds:
        Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>arp -a
No ARP Entries Found
C:\>

```

Table 2.6 continued from previous page

Continued on next page

Table 2.6 continued from previous page

Steps	Example
-------	---------

Table 2.6: Cisco Packet Tracer guide

And to supplement the output images, below are the text versions (*considering this isn't a report for ants*):

```

1 Cisco Packet Tracer PC Command Line 1.0
2 C:>arp -a
3 No ARP Entries Found
4 C:>ping 192.168.7.66
5
6 Pinging 192.168.7.66 with 32 bytes of data:
7
8 Reply from 192.168.7.66: bytes=32 time<1ms TTL=128
9 Reply from 192.168.7.66: bytes=32 time<1ms TTL=128
10 Reply from 192.168.7.66: bytes=32 time<1ms TTL=128
11 Reply from 192.168.7.66: bytes=32 time<1ms TTL=128
12 Reply from 192.168.7.66: bytes=32 time<1ms TTL=128
13
14 Ping statistics for 192.168.7.66:
15     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
16 Approximate round trip times in milli-seconds:
17     Minimum = 0ms, Maximum = 0ms, Average = 0ms
18
19 C:>ping 192.168.7.126
20
21 Pinging 192.168.7.126 with 32 bytes of data:
22
23 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
24 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
25 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
26 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
27
28 Ping statistics for 192.168.7.126:
29     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
30 Approximate round trip times in milli-seconds:
31     Minimum = 0ms, Maximum = 0ms, Average = 0ms
32
33 C:>ping 192.168.7.33
34
35 Pinging 192.168.7.33 with 32 bytes of data:
36
37 Request timed out.
38 Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
39 Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
40 Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
41
42 Ping statistics for 192.168.7.33:
43     Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
44 Approximate round trip times in milli-seconds:
45     Minimum = 0ms, Maximum = 0ms, Average = 0ms
46
47 C:>ping 192.168.7.34
48
49 Pinging 192.168.7.34 with 32 bytes of data:
50
51 Request timed out.
52 Reply from 192.168.7.34: bytes=32 time<1ms TTL=127
53 Reply from 192.168.7.34: bytes=32 time<1ms TTL=127
54 Reply from 192.168.7.34: bytes=32 time<1ms TTL=127
55
56 Ping statistics for 192.168.7.34:
57     Packets: Sent = 4, Received = 3, Lost = 1 (25% loss),
58 Approximate round trip times in milli-seconds:

```

```

59     Minimum = 0ms, Maximum = 0ms, Average = 0ms
60
61 C:\>ping 192.168.7.62
62
63 Pinging 192.168.7.62 with 32 bytes of data:
64
65 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
66 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
67 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
68 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
69
70 Ping statistics for 192.168.7.62:
71     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
72 Approximate round trip times in milli-seconds:
73     Minimum = 0ms, Maximum = 0ms, Average = 0ms
74
75 C:\>arp -a
76             Internet Address          Physical Address      Type
77             192.168.7.66            0060.7078.da66    dynamic
78             192.168.7.126          0060.2fcd.90bd    dynamic
79
80 C:\>tracert 192.168.7.66
81
82 Tracing route to 192.168.7.66 over a maximum of 30 hops:
83
84     1     18 ms      0 ms      0 ms      192.168.7.66
85
86 Trace complete.
87
88 C:\>tracert 192.168.7.126
89
90 Tracing route to 192.168.7.126 over a maximum of 30 hops:
91
92     1     0 ms      0 ms      0 ms      192.168.7.126
93
94 Trace complete.
95
96 C:\>tracert 192.168.7.33
97
98 Tracing route to 192.168.7.33 over a maximum of 30 hops:
99
100    1     0 ms      0 ms      0 ms      192.168.7.126
101    2     9 ms      0 ms      0 ms      192.168.7.33
102
103 Trace complete.
104
105 C:\>tracert 192.168.7.34
106
107 Tracing route to 192.168.7.34 over a maximum of 30 hops:
108
109    1     0 ms      0 ms      0 ms      192.168.7.126
110    2     0 ms      0 ms      0 ms      192.168.7.34
111
112 Trace complete.
113
114 C:\>tracert 192.168.7.62
115
116 Tracing route to 192.168.7.62 over a maximum of 30 hops:
117
118     1     0 ms      0 ms      0 ms      192.168.7.62
119
120 Trace complete.
121
122 C:\>

```

Listing 2.3: PC0 CMD output

```

1
2 Cisco Packet Tracer PC Command Line 1.0
3 C:\>arp -a

```

```

4 No ARP Entries Found
5 C:\>ping 192.168.7.65
6
7 Pinging 192.168.7.65 with 32 bytes of data:
8
9 Reply from 192.168.7.65: bytes=32 time<1ms TTL=128
10 Reply from 192.168.7.65: bytes=32 time<1ms TTL=128
11 Reply from 192.168.7.65: bytes=32 time<1ms TTL=128
12 Reply from 192.168.7.65: bytes=32 time<1ms TTL=128
13
14 Ping statistics for 192.168.7.65:
15     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
16 Approximate round trip times in milli-seconds:
17     Minimum = 0ms, Maximum = 0ms, Average = 0ms
18
19 C:\>ping 192.168.7.126
20
21 Pinging 192.168.7.126 with 32 bytes of data:
22
23 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
24 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
25 Reply from 192.168.7.126: bytes=32 time=1ms TTL=255
26 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
27
28 Ping statistics for 192.168.7.126:
29     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
30 Approximate round trip times in milli-seconds:
31     Minimum = 0ms, Maximum = 1ms, Average = 0ms
32
33 C:\>ping 192.168.7.33
34
35 Pinging 192.168.7.33 with 32 bytes of data:
36
37 Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
38 Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
39 Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
40 Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
41
42 Ping statistics for 192.168.7.33:
43     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
44 Approximate round trip times in milli-seconds:
45     Minimum = 0ms, Maximum = 0ms, Average = 0ms
46
47 C:\>ping 192.168.7.34
48
49 Pinging 192.168.7.34 with 32 bytes of data:
50
51 Reply from 192.168.7.34: bytes=32 time=23ms TTL=127
52 Reply from 192.168.7.34: bytes=32 time<1ms TTL=127
53 Reply from 192.168.7.34: bytes=32 time<1ms TTL=127
54 Reply from 192.168.7.34: bytes=32 time<1ms TTL=127
55
56 Ping statistics for 192.168.7.34:
57     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
58 Approximate round trip times in milli-seconds:
59     Minimum = 0ms, Maximum = 23ms, Average = 5ms
60
61 C:\>ping 192.168.7.62
62
63 Pinging 192.168.7.62 with 32 bytes of data:
64
65 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
66 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
67 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
68 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
69
70 Ping statistics for 192.168.7.62:
71     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
72 Approximate round trip times in milli-seconds:
73     Minimum = 0ms, Maximum = 0ms, Average = 0ms
74
75 C:\>arp -a
    Internet Address          Physical Address          Type
76

```

```

77 192.168.7.65          0001.429b.91a6      dynamic
78 192.168.7.126         0060.2fcd.90bd      dynamic
79
80 C:\>tracert 192.168.7.65
81
82 Tracing route to 192.168.7.65 over a maximum of 30 hops:
83
84     1    0 ms      0 ms      0 ms      192.168.7.65
85
86 Trace complete.
87
88 C:\>tracert 192.168.7.33
89
90 Tracing route to 192.168.7.33 over a maximum of 30 hops:
91
92     1    0 ms      0 ms      0 ms      192.168.7.126
93     2    0 ms      0 ms      0 ms      192.168.7.33
94
95 Trace complete.
96
97 C:\>tracert 192.168.7.34
98
99 Tracing route to 192.168.7.34 over a maximum of 30 hops:
100
101    1    0 ms      0 ms      19 ms      192.168.7.126
102    2    0 ms      0 ms      0 ms      192.168.7.34
103
104 Trace complete.
105
106 C:\>tracert 192.168.7.126
107
108 Tracing route to 192.168.7.126 over a maximum of 30 hops:
109
110    1    0 ms      0 ms      0 ms      192.168.7.126
111
112 Trace complete.
113
114 C:\>tracert 192.168.7.62
115
116 Tracing route to 192.168.7.62 over a maximum of 30 hops:
117
118    1    0 ms      0 ms      0 ms      192.168.7.62
119
120 Trace complete.
121
122 C:\>

```

Listing 2.4: Laptop0 CMD output

```

1
2 Cisco Packet Tracer PC Command Line 1.0
3 C:\>arp -a
4 No ARP Entries Found
5 C:\>ping 192.168.7.65
6
7 Pinging 192.168.7.65 with 32 bytes of data:
8
9 Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
10 Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
11 Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
12 Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
13
14 Ping statistics for 192.168.7.65:
15     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
16 Approximate round trip times in milli-seconds:
17     Minimum = 0ms, Maximum = 0ms, Average = 0ms
18
19 C:\>ping 192.168.7.66
20
21 Pinging 192.168.7.66 with 32 bytes of data:

```

```

22
23 Reply from 192.168.7.66: bytes=32 time=1ms TTL=127
24 Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
25 Reply from 192.168.7.66: bytes=32 time=1ms TTL=127
26 Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
27
28 Ping statistics for 192.168.7.66:
29   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
30   Approximate round trip times in milli-seconds:
31     Minimum = 0ms, Maximum = 1ms, Average = 0ms
32
33 C:\>ping 192.168.7.34
34
35 Pinging 192.168.7.34 with 32 bytes of data:
36
37 Reply from 192.168.7.34: bytes=32 time<1ms TTL=128
38 Reply from 192.168.7.34: bytes=32 time=13ms TTL=128
39 Reply from 192.168.7.34: bytes=32 time<1ms TTL=128
40 Reply from 192.168.7.34: bytes=32 time<1ms TTL=128
41
42 Ping statistics for 192.168.7.34:
43   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
44   Approximate round trip times in milli-seconds:
45     Minimum = 0ms, Maximum = 13ms, Average = 3ms
46
47 C:\>ping 192.168.7.126
48
49 Pinging 192.168.7.126 with 32 bytes of data:
50
51 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
52 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
53 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
54 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
55
56 Ping statistics for 192.168.7.126:
57   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
58   Approximate round trip times in milli-seconds:
59     Minimum = 0ms, Maximum = 0ms, Average = 0ms
60
61 C:\>ping 192.168.7.62
62
63 Pinging 192.168.7.62 with 32 bytes of data:
64
65 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
66 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
67 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
68 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
69
70 Ping statistics for 192.168.7.62:
71   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
72   Approximate round trip times in milli-seconds:
73     Minimum = 0ms, Maximum = 0ms, Average = 0ms
74
75 C:\>arp -a
76   Internet Address        Physical Address        Type
77   192.168.7.34           0007.ec04.c4a4        dynamic
78   192.168.7.62           0090.0c00.9582        dynamic
79
80 C:\>tracert 192.168.7.65
81
82 Tracing route to 192.168.7.65 over a maximum of 30 hops:
83
84   1  0 ms        20 ms        0 ms        192.168.7.62
85   2  0 ms        0 ms        0 ms        192.168.7.65
86
87 Trace complete.
88
89 C:\>tracert 192.168.7.66
90
91 Tracing route to 192.168.7.66 over a maximum of 30 hops:
92
93   1  0 ms        0 ms        0 ms        192.168.7.62
94   2  0 ms        0 ms        0 ms        192.168.7.66

```

```

95
96 Trace complete.
97
98 C:\>tracert 192.168.7.34
99
100 Tracing route to 192.168.7.34 over a maximum of 30 hops:
101
102     1    0 ms      0 ms      0 ms      192.168.7.34
103
104 Trace complete.
105
106 C:\>tracert 192.168.7.126
107
108 Tracing route to 192.168.7.126 over a maximum of 30 hops:
109
110     1    0 ms      0 ms      0 ms      192.168.7.126
111
112 Trace complete.
113
114 C:\>tracert 192.168.7.62
115
116 Tracing route to 192.168.7.62 over a maximum of 30 hops:
117
118     1    0 ms      0 ms      0 ms      192.168.7.62
119
120 Trace complete.
121
122 C:\>

```

Listing 2.5: PC1 CMD output

```

1
2 Cisco Packet Tracer PC Command Line 1.0
3 C:\>arp -a
4   Internet Address      Physical Address      Type
5   192.168.7.33          0060.5c73.18bd      dynamic
6   192.168.7.62          0090.0c00.9582      dynamic
7
8 C:\>ping 192.168.7.65
9
10 Pinging 192.168.7.65 with 32 bytes of data:
11
12 Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
13 Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
14 Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
15 Reply from 192.168.7.65: bytes=32 time=16ms TTL=127
16
17 Ping statistics for 192.168.7.65:
18   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
19   Approximate round trip times in milli-seconds:
20     Minimum = 0ms, Maximum = 16ms, Average = 4ms
21
22 C:\>ping 192.168.7.66
23
24 Pinging 192.168.7.66 with 32 bytes of data:
25
26 Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
27 Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
28 Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
29 Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
30
31 Ping statistics for 192.168.7.66:
32   Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
33   Approximate round trip times in milli-seconds:
34     Minimum = 0ms, Maximum = 0ms, Average = 0ms
35
36 C:\>ping 192.168.7.33
37
38 Pinging 192.168.7.33 with 32 bytes of data:
39

```

```

40 Reply from 192.168.7.33: bytes=32 time<1ms TTL=128
41 Reply from 192.168.7.33: bytes=32 time<1ms TTL=128
42 Reply from 192.168.7.33: bytes=32 time<1ms TTL=128
43 Reply from 192.168.7.33: bytes=32 time<1ms TTL=128
44
45 Ping statistics for 192.168.7.33:
46     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
47 Approximate round trip times in milli-seconds:
48     Minimum = 0ms, Maximum = 0ms, Average = 0ms
49
50 C:\>arp -a
51     Internet Address          Physical Address          Type
52         192.168.7.33           0060.5c73.18bd        dynamic
53         192.168.7.62           0090.0c00.9582        dynamic
54
55 C:\>tracert 192.168.7.65
56
57 Tracing route to 192.168.7.65 over a maximum of 30 hops:
58
59     1    0 ms      0 ms      0 ms      192.168.7.62
60     2    0 ms      0 ms      0 ms      192.168.7.65
61
62 Trace complete.
63
64 C:\>tracert 192.168.7.66
65
66 Tracing route to 192.168.7.66 over a maximum of 30 hops:
67
68     1    0 ms      0 ms      0 ms      192.168.7.62
69     2    0 ms      0 ms      0 ms      192.168.7.66
70
71 Trace complete.
72
73 C:\>tracert 192.168.7.33
74
75 Tracing route to 192.168.7.33 over a maximum of 30 hops:
76
77     1    0 ms      0 ms      0 ms      192.168.7.33
78
79 Trace complete.
80
81 C:\>tracert 192.168.7.126
82
83 Tracing route to 192.168.7.126 over a maximum of 30 hops:
84
85     1    0 ms      0 ms      0 ms      192.168.7.126
86
87 Trace complete.
88
89 C:\>tracert 192.168.7.62
90
91 Tracing route to 192.168.7.62 over a maximum of 30 hops:
92
93     1    0 ms      0 ms      0 ms      192.168.7.62
94
95 Trace complete.
96
97 C:\>ping 192.168.7.126
98
99 Pinging 192.168.7.126 with 32 bytes of data:
100
101 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
102 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
103 Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
104 Reply from 192.168.7.126: bytes=32 time=14ms TTL=255
105
106 Ping statistics for 192.168.7.126:
107     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
108 Approximate round trip times in milli-seconds:
109     Minimum = 0ms, Maximum = 14ms, Average = 3ms
110
111 C:\>ping 192.168.7.62
112

```

```

113 Pinging 192.168.7.62 with 32 bytes of data:
114 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
115 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
116 Reply from 192.168.7.62: bytes=32 time=15ms TTL=255
117 Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
118
119
120 Ping statistics for 192.168.7.62:
121     Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
122 Approximate round trip times in milli-seconds:
123     Minimum = 0ms, Maximum = 15ms, Average = 3ms
124
125 C:>

```

Listing 2.6: Laptop1 CMD output

```

1 System Bootstrap, Version 12.1(3r)T2, RELEASE SOFTWARE (fc1)
2 Copyright (c) 2000 by cisco Systems, Inc.
3 PT 1001 (PTSC2005) processor (revision 0x200) with 60416K/5120K bytes of memory
4
5 Readonly ROMMON initialized
6
7 Self decompressing the image :
8 ##### [OK]
9
10          Restricted Rights Legend
11
12 Use, duplication, or disclosure by the Government is
13 subject to restrictions as set forth in subparagraph
14 (c) of the Commercial Computer Software - Restricted
15 Rights clause at FAR sec. 52.227-19 and subparagraph
16 (c) (1) (ii) of the Rights in Technical Data and Computer
17 Software clause at DFARS sec. 252.227-7013.
18
19          cisco Systems, Inc.
20          170 West Tasman Drive
21          San Jose, California 95134-1706
22
23
24
25 Cisco Internetwork Operating System Software
26 IOS (tm) PT1000 Software (PT1000-I-M), Version 12.2(28), RELEASE SOFTWARE (fc5)
27 Technical Support: http://www.cisco.com/techsupport
28 Copyright (c) 1986-2005 by cisco Systems, Inc.
29 Compiled Wed 27-Apr-04 19:01 by miwang
30
31 PT 1001 (PTSC2005) processor (revision 0x200) with 60416K/5120K bytes of memory
32 .
33 Processor board ID PT0123 (0123)
34 PT2005 processor: part number 0, mask 01
35 Bridging software.
36 X.25 software, Version 3.0.0.
37 4 FastEthernet/IEEE 802.3 interface(s)
38 2 Low-speed serial(sync/async) network interface(s)
39 32K bytes of non-volatile configuration memory.
40 63488K bytes of ATA CompactFlash (Read/Write)
41
42 Press RETURN to get started!
43
44
45
46 Router>enable
47 Router#
48 Router#configure terminal
49 Enter configuration commands, one per line. End with CNTL/Z.
50 Router(config)#interface FastEthernet0/0
51 Router(config-if)#ip address 255.255.255.192
52 % Incomplete command.
53 Router(config-if)#ip address 192.168.7.126 255.255.255.192
54 Router(config-if)#no shutdown

```

```

55 Router(config-if)#
56 %LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up
57
58 %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up
59
60 Router(config-if)#exit
61 Router(config)#interface FastEthernet1/0
62 Router(config-if)#ip address 255.255.255.224
63 % Incomplete command.
64 Router(config-if)#ip address 192.168.7.62 255.255.255.224
65 Router(config-if)#no shutdown
66 Router(config-if)#
67 %LINK-5-CHANGED: Interface FastEthernet1/0, changed state to up
68
69 %LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet1/0, changed state to up
70
71 Router>ping 192.168.7.65
72
73 Type escape sequence to abort.
74 Sending 5, 100-byte ICMP Echos to 192.168.7.65, timeout is 2 seconds:
75 !!!!!
76 Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms
77
78 Router>ping 192.168.7.66
79
80 Type escape sequence to abort.
81 Sending 5, 100-byte ICMP Echos to 192.168.7.66, timeout is 2 seconds:
82 !!!!!
83 Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms
84
85 Router>ping 192.168.7.33
86
87 Type escape sequence to abort.
88 Sending 5, 100-byte ICMP Echos to 192.168.7.33, timeout is 2 seconds:
89 !!!!!
90 Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms
91
92 Router>ping 192.168.7.34
93
94 Type escape sequence to abort.
95 Sending 5, 100-byte ICMP Echos to 192.168.7.34, timeout is 2 seconds:
96 !!!!!
97 Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms
98
99 Router>ping 192.168.7.126
100
101 Type escape sequence to abort.
102 Sending 5, 100-byte ICMP Echos to 192.168.7.126, timeout is 2 seconds:
103 !!!!!
104 Success rate is 100 percent (5/5), round-trip min/avg/max = 10/12/18 ms
105
106 Router>ping 192.168.7.62
107
108 Type escape sequence to abort.
109 Sending 5, 100-byte ICMP Echos to 192.168.7.62, timeout is 2 seconds:
110 !!!!!
111 Success rate is 100 percent (5/5), round-trip min/avg/max = 0/10/22 ms
112
113 Router>traceroute 192.168.7.65
114 Type escape sequence to abort.
115 Tracing the route to 192.168.7.65
116
117     1  192.168.7.65      0 msec      0 msec      0 msec
118 Router>traceroute 192.168.7.66
119 Type escape sequence to abort.
120 Tracing the route to 192.168.7.66
121
122     1  192.168.7.66      0 msec      0 msec      0 msec
123 Router>traceroute 192.168.7.33
124 Type escape sequence to abort.
125 Tracing the route to 192.168.7.33
126
127     1  192.168.7.33      0 msec      0 msec      0 msec

```

```

128 Router>traceroute 192.168.7.34
129 Type escape sequence to abort.
130 Tracing the route to 192.168.7.34
131
132     1  192.168.7.34      0 msec      0 msec      0 msec
133 Router>traceroute 192.168.7.126
134 Type escape sequence to abort.
135 Tracing the route to 192.168.7.126
136
137     1  192.168.7.126    11 msec      0 msec      0 msec
138 Router>traceroute 192.168.7.62
139 Type escape sequence to abort.
140 Tracing the route to 192.168.7.62
141
142     1  192.168.7.62    10 msec      4 msec      4 msec
143 Router>

```

Listing 2.7: Router 1 CLI output

It's evident why traceroute is showing hops here. Now we have a router managing two local networks, as a consequence, each device goes through the router path.

Ergo, the arp table is filled, not with device addresses but, with the router's network IP address.

We're one step closer to become full network engineers!



Figure 2.3: The best kind there is!

Chapter 3

Issues and fixes

Cisco Packet Tracer in MacOS:

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

By outlining our entire project we reached a, somewhat, relief.

By testing first with a switch we understood how arp tables work, storing it's information in devices since layered 2 equipments don't provide that functionality. Right after we got to put that argument to the test by using a router to connect to distinct LANs. And it checks out, layered 3 devices keep arp tables, displaying only their gateways through traceroute.

Appendix A

Appendix