Instituto Superior de Engenharia de Lisboa

Computer Networks

Phase 2 - Connecting Devices

Projeto ISEL 2023/24 — LEETC

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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. 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

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 ammount 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 us to save on 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 also 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.

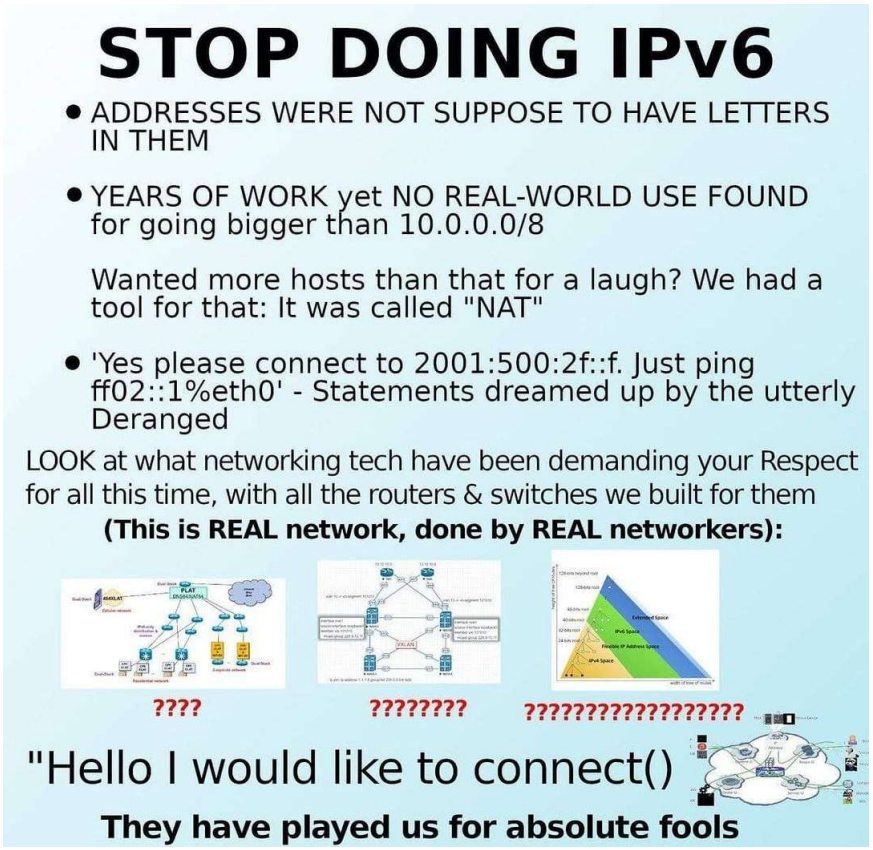


Figure 2.1: Guess IPv4 is enough for everything

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.

<table>
<tr><td colspan="2">Version
4 bits</td><td>Header Length
4bits</td><td>Type of Service
8 bits</td><td colspan="4">Total Length
16 bits</td></tr>
<tr><td colspan="3">Identification
16 bits</td><td>Reserved
1 bit</td><td>Don't Fragment
1 bit</td><td>More Fragment
1 bit</td><td>Fragment Offset
13 bits</td></tr>
<tr><td colspan="2">Time to Live
8 bits</td><td>Protocol
8 bits</td><td colspan="4">Header Checksum
16 bits</td></tr>
<tr><td colspan="7">Source IP
32 bits (4 Bytes)</td></tr>
<tr><td colspan="7">Destination IP
32 bits (4 Bytes)</td></tr>
<tr><td colspan="7">Option
0 - 40 Bytes</td></tr>
<tr><td colspan="7">DATA
20 Bytes - 65536 Bytes</td></tr>
</table>

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 magnificient world, starting with these steps:

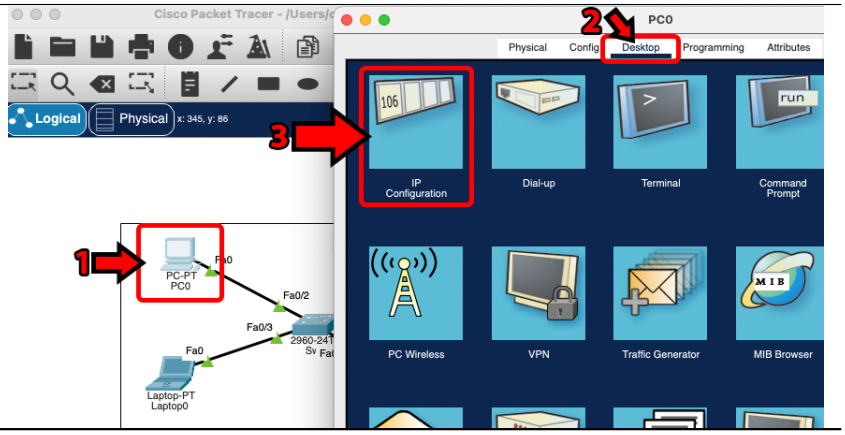
Steps	Example
To configure the IP on a device we must **single-click** in the intended device (1), go to the *desktop tab* (2) and select *IP Configuration* (3).	

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Table 2.2 continued from previous page

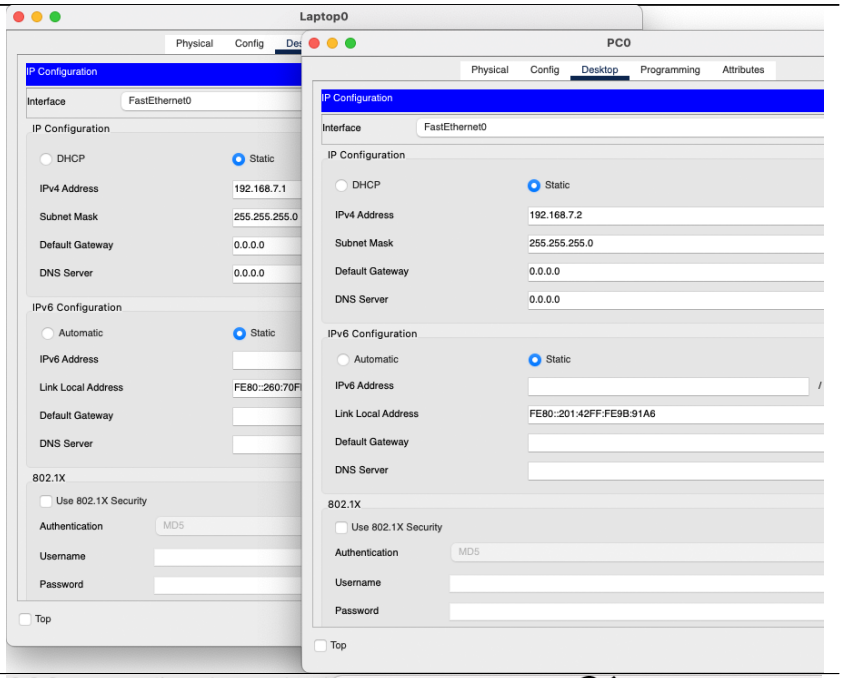
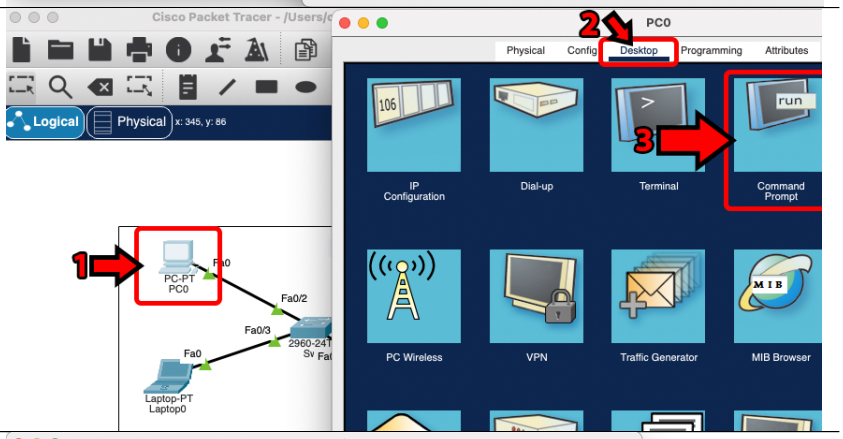
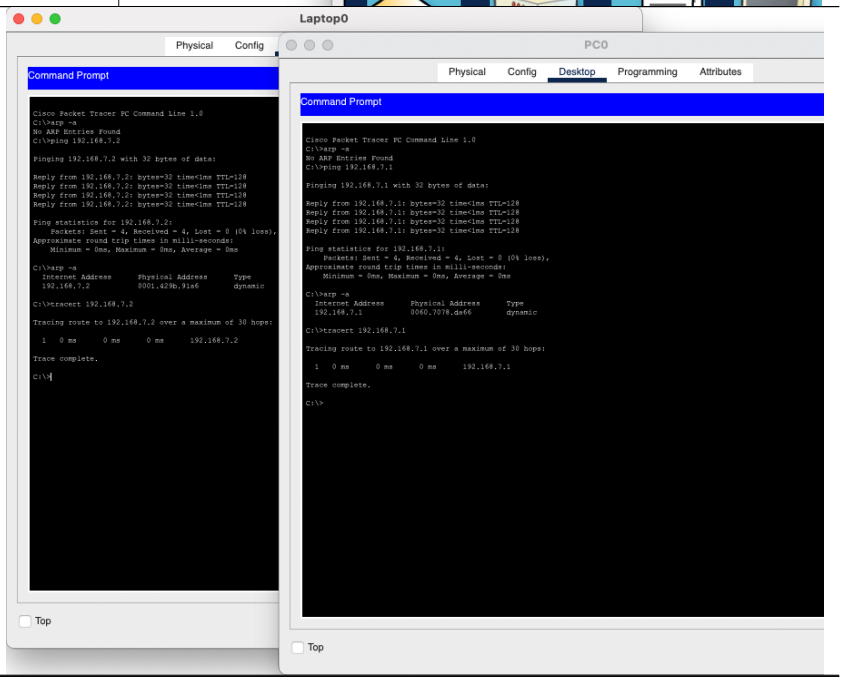
Steps	Example
Now we configure our devices according to the required addresses.	
To test the connection we select a device by **single-clicking** it (1), go to the *desktop tab* (2) and select *Command Prompt* (3).	
We start by running *arp -a* command, no prior discovery was made so the arp table will 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.	

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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:

```
Cisco Packet Tracer PC Command Line 1.0
C:\>arp -a
No ARP Entries Found
C:\>ping 192.168.7.1

Pinging 192.168.7.1 with 32 bytes of data:

Reply from 192.168.7.1: bytes=32 time<1ms TTL=128
Reply from 192.168.7.1: bytes=32 time<1ms TTL=128
Reply from 192.168.7.1: bytes=32 time<1ms TTL=128
Reply from 192.168.7.1: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.7.1:
    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
  Internet Address      Physical Address      Type
  192.168.7.1           0060.7078.da66        dynamic

C:\>tracert 192.168.7.1

Tracing route to 192.168.7.1 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.1

Trace complete.

C:\>
```

Listing 2.1: PC0 CMD output

```

Cisco Packet Tracer PC Command Line 1.0
C:\>arp -a
No ARP Entries Found
C:\>ping 192.168.7.2

Pinging 192.168.7.2 with 32 bytes of data:

Reply from 192.168.7.2: bytes=32 time<1ms TTL=128
Reply from 192.168.7.2: bytes=32 time<1ms TTL=128
Reply from 192.168.7.2: bytes=32 time<1ms TTL=128
Reply from 192.168.7.2: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.7.2:
    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
  Internet Address      Physical Address      Type
  192.168.7.2           0001.429b.91a6        dynamic

C:\>tracert 192.168.7.2

```

```
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

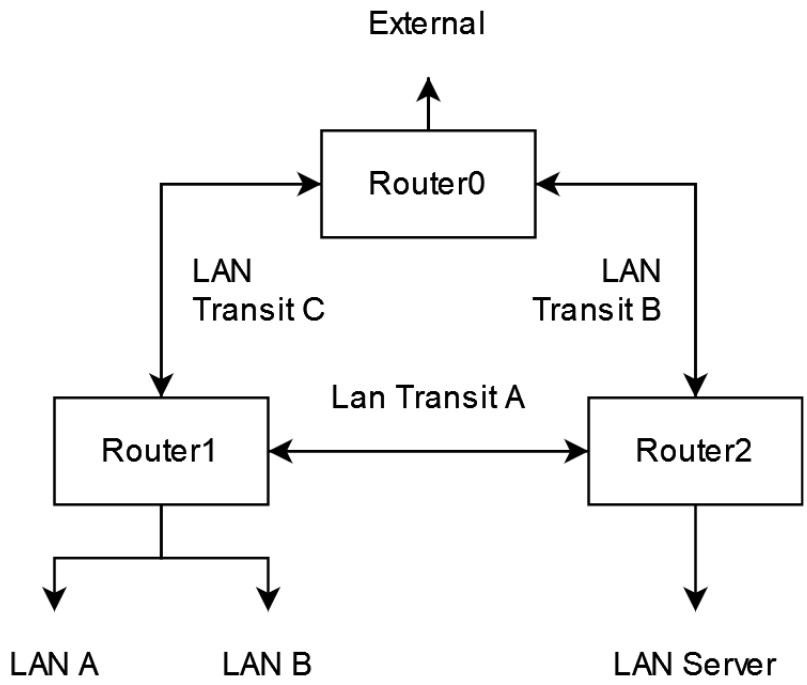


Figure 2.2: Part 2 network diagram

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.

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

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

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

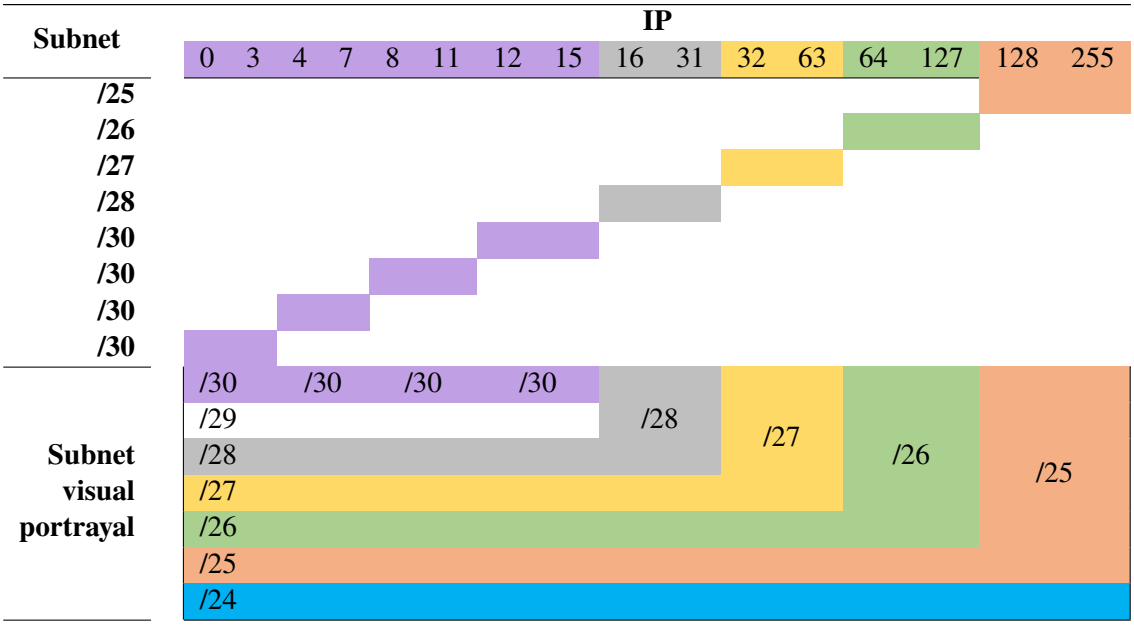


Table 2.3: Visual LAN allocation

Name	Network	Usable IPs	Router	Broadcast	Subnet Mask	Populated
	192.168.7.				255.255.255.	
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	LAN A	192.168.7.65	255.255.255.192	192.168.7.126
Laptop0	Fa0 - Sw0 Fa0/3		192.168.7.66	255.255.255.192	192.168.7.126
PC1	Fa0 - Sw1 Fa0/2	LAN B	192.168.7.33	255.255.255.224	192.168.7.62
Laptop1	Fa0 - Sw1 Fa0/3		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	LAN Server	192.168.7.129	255.255.255.128	192.168.7.254
DNS Server	Fa0 - Sw2 Fa0/2		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	LAN A			
	Fa0/2 - PC0				
	Fa0/3 - Laptop0				
Sw1	Fa0/1 - R1 Fa1/0	LAN B			
	Fa0/2 - PC1				
	Fa0/3 - Laptop1				
Sw2	Fa0/1 - HTTP	LAN Server			
	Fa0/2 - DNS				
	Fa0/3 - DHCP				
	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 pramatic 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:

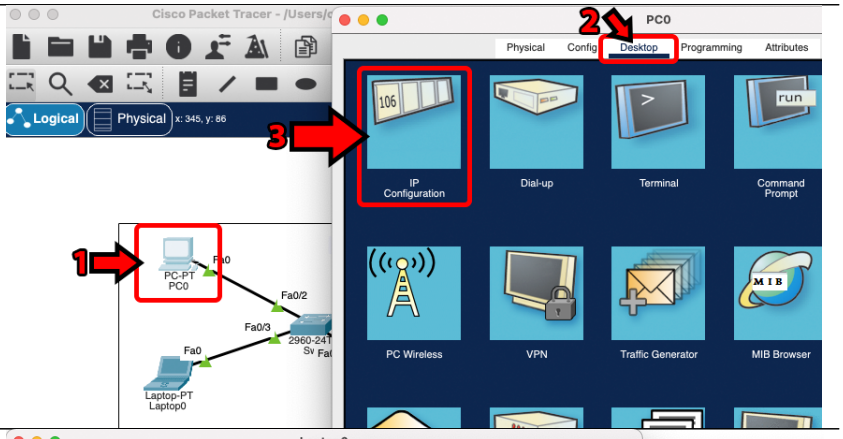
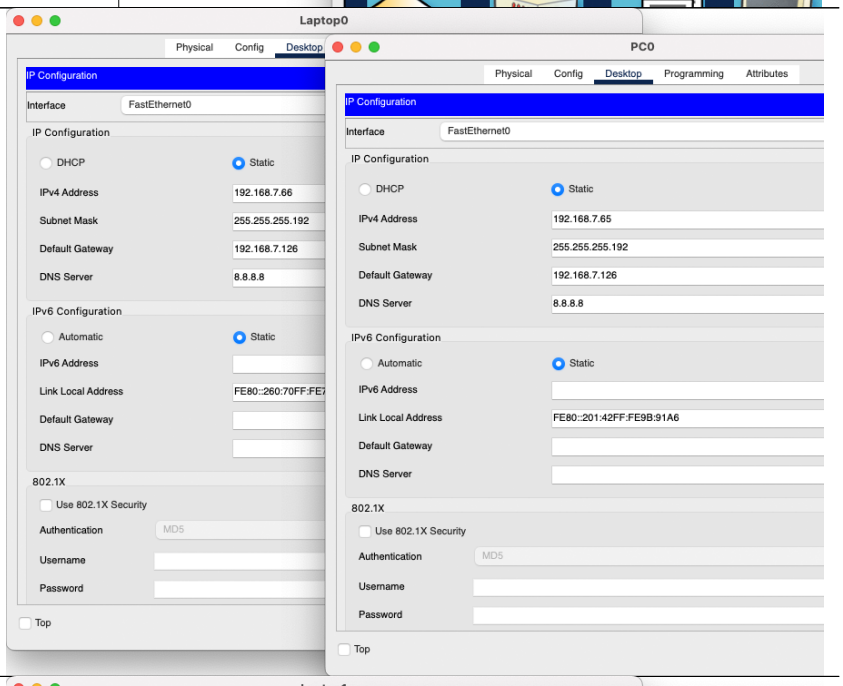
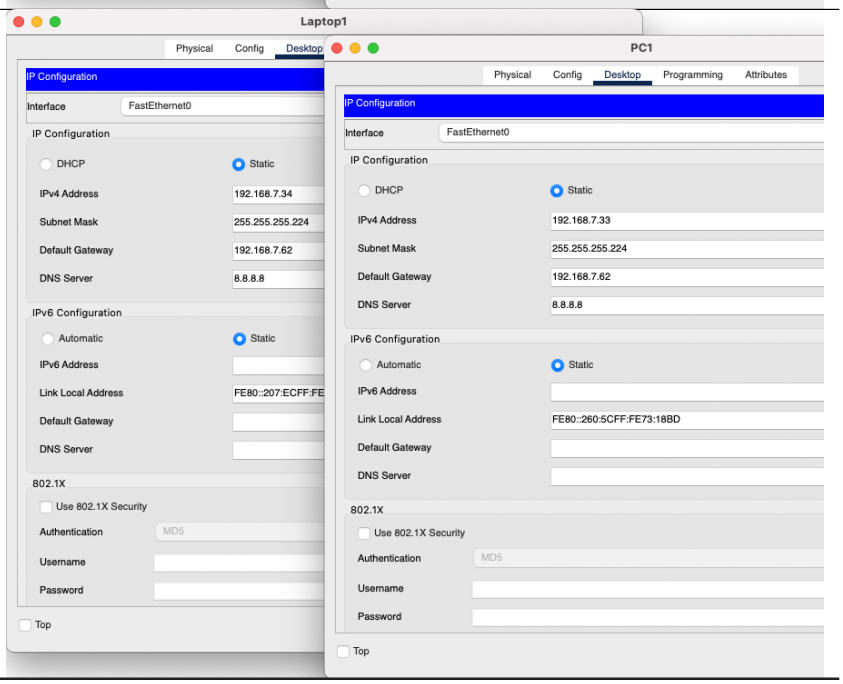
Steps	Example
To configure the IP on a device we must **single-click** in the intended device (1), go to the *desktop tab* (2) and select *IP Configuration* (3).	
Configure Laptop0 and PC0 computers accordingly to our results.	
And the same for Laptop1 and PC1.	

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Table 2.6 continued from previous page

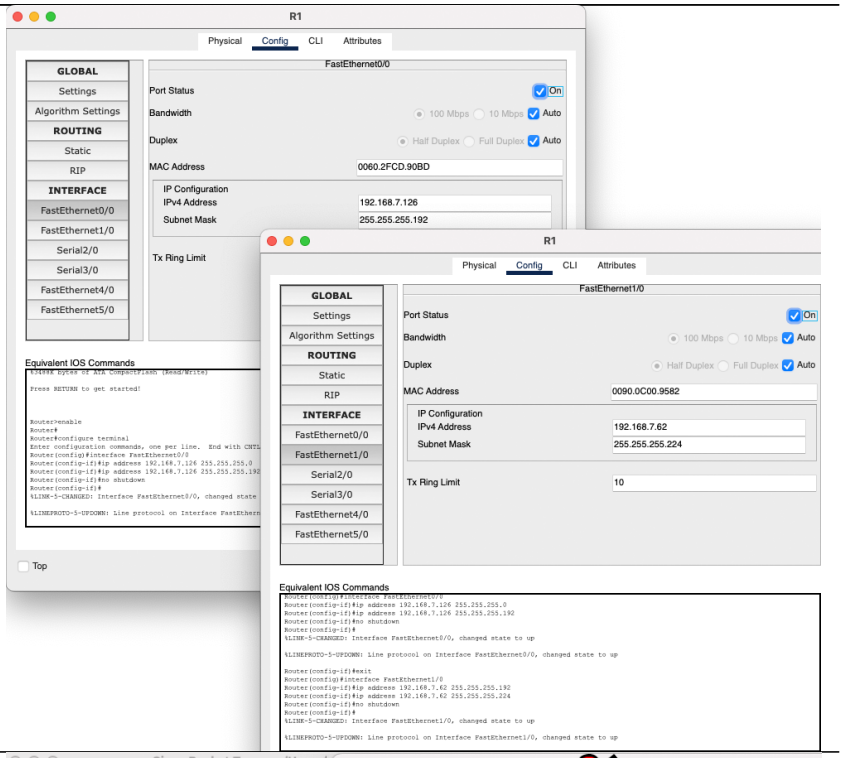
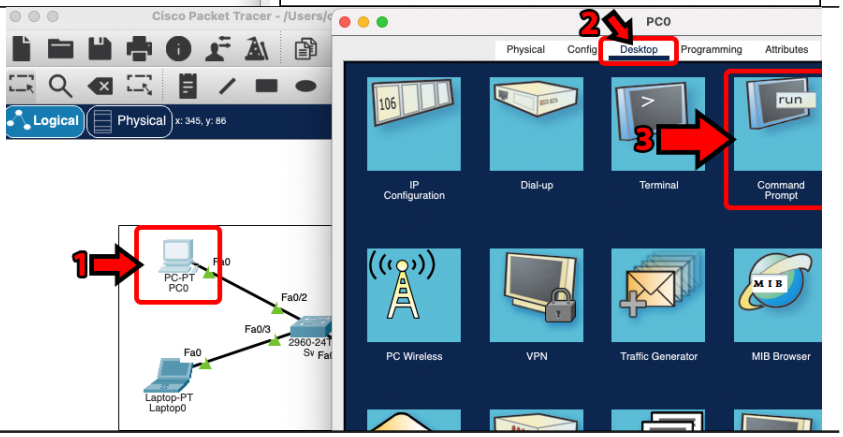
Steps	Example
For the router there's two options, both valid and exhibited in the report. The GUI in the right and the CLI, after this table, along CMD equivalent commands output. We're using **FastEthernet0/0** for *LAN A* and **FastEthernet1/0** for *LAN B*, going by the graphical user interface (GUI) it's crystal clear, just input the necessary IP and subnet mask.	
To test the connection we select a device by **single-clicking** it (1), go to the *desktop tab* (2) and select *Command Prompt* (3).	

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Table 2.6 continued from previous page

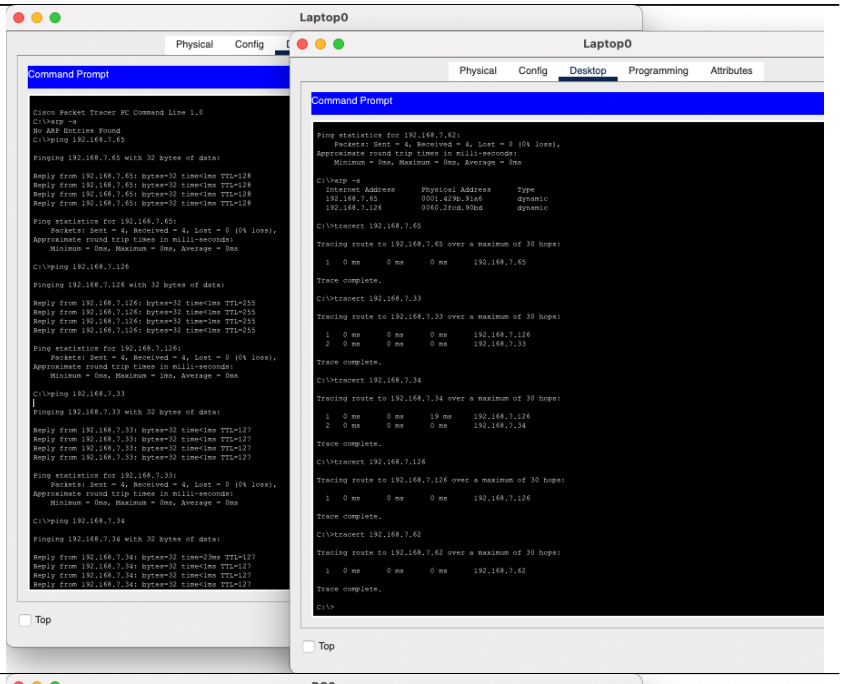
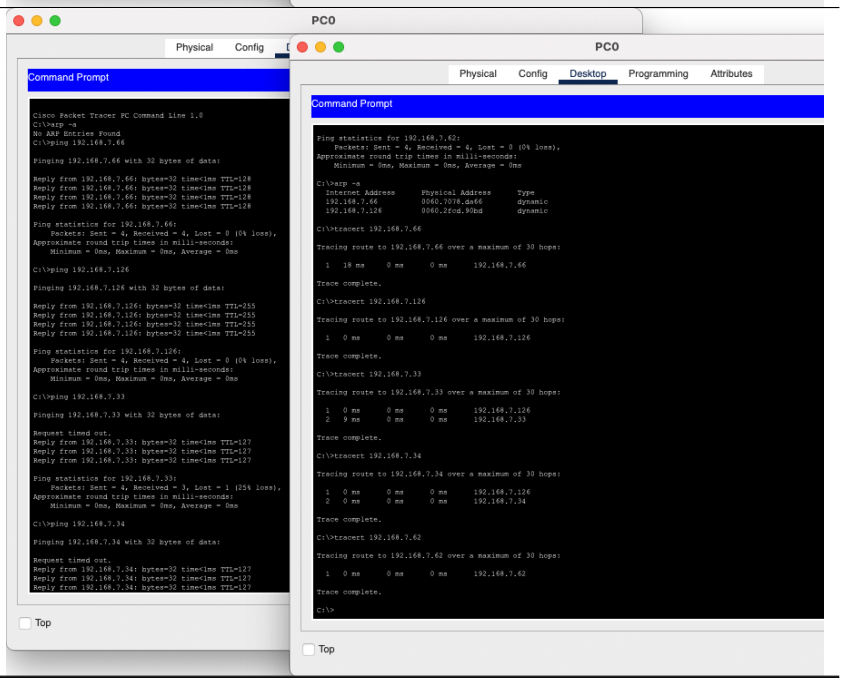
Steps	Example
Contrary to our experiment in the previous section, it's unmistakable that after the first ping, the router provides information related to the whereabouts of the pinged device, due to **arp -a** command showing the router configured gateways.	
From the viewpoint of PC0.	

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Table 2.6 continued from previous page

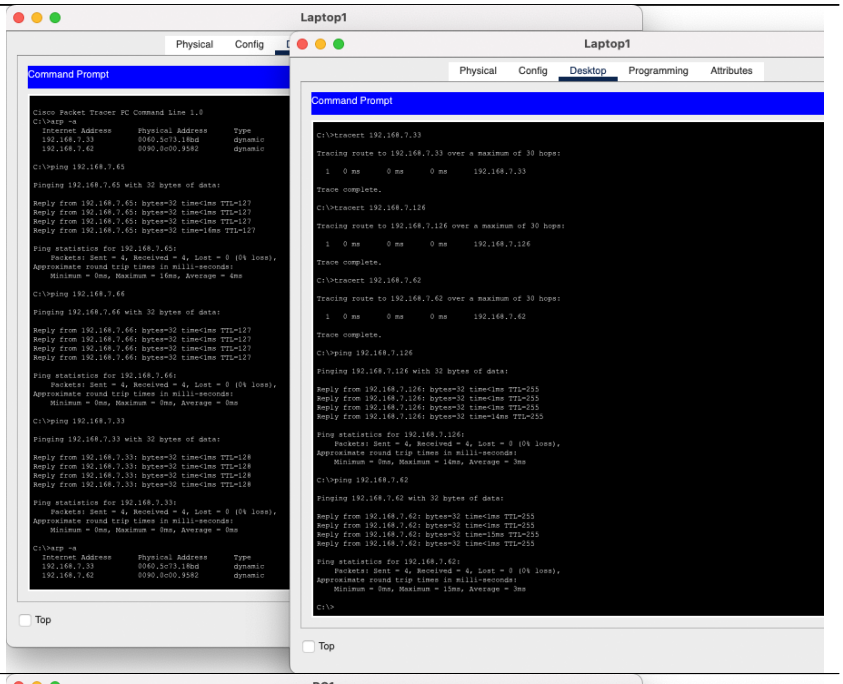
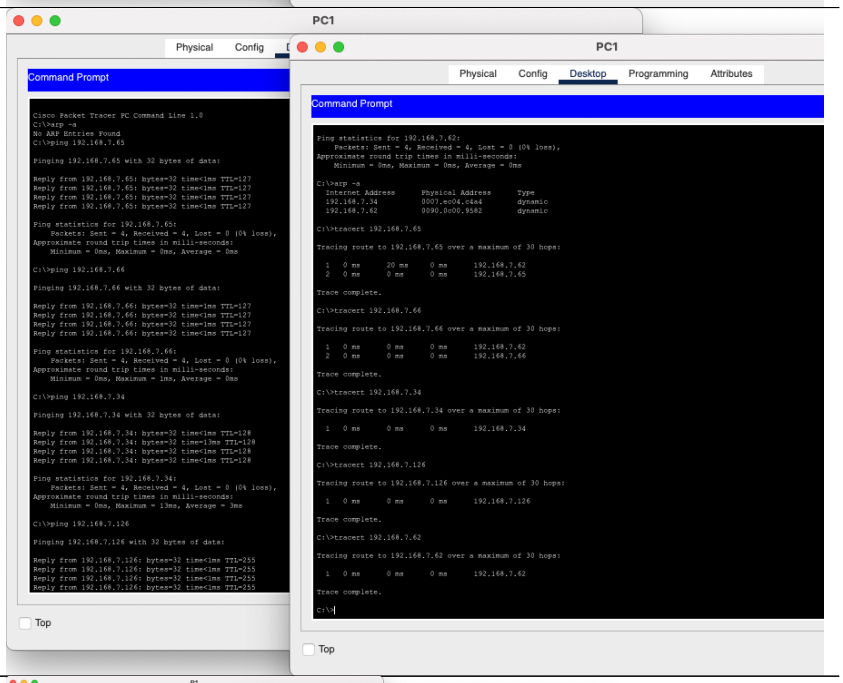
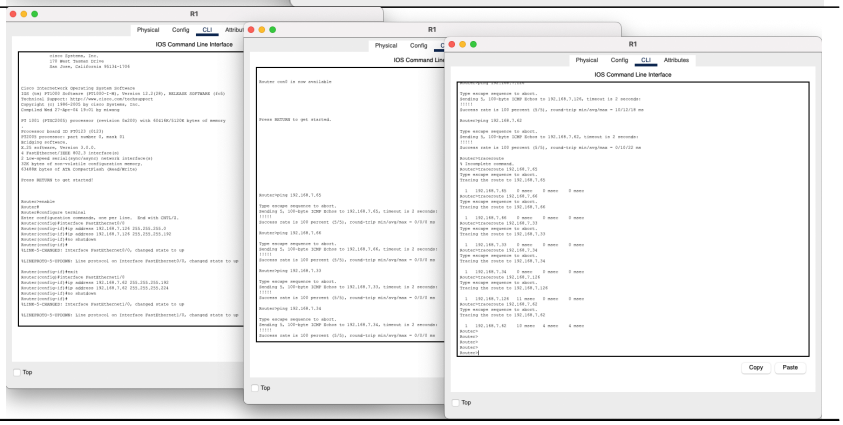
Steps	Example
From the viewpoint of Laptop1.	
From the viewpoint of PC1.	
From the viewpoint of Router1.	

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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
2  Cisco Packet Tracer PC Command Line 1.0
3  C:\>arp -a
4  No ARP Entries Found
5  C:\>ping 192.168.7.66
6
7  Pinging 192.168.7.66 with 32 bytes of data:
8
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:
```

```
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

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<1ms TTL=255
Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
Reply from 192.168.7.62: bytes=32 time<1ms TTL=255

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:\>arp -a
  Internet Address      Physical Address      Type
  192.168.7.66          0060.7078.da66        dynamic
  192.168.7.126         0060.2fcd.90bd        dynamic

C:\>tracert 192.168.7.66

Tracing route to 192.168.7.66 over a maximum of 30 hops:

  1   18 ms     0 ms      0 ms      192.168.7.66

Trace complete.

C:\>tracert 192.168.7.126

Tracing route to 192.168.7.126 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.126

Trace complete.

C:\>tracert 192.168.7.33

Tracing route to 192.168.7.33 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.126
  2   9 ms      0 ms      0 ms      192.168.7.33

Trace complete.

C:\>tracert 192.168.7.34

Tracing route to 192.168.7.34 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.126
  2   0 ms      0 ms      0 ms      192.168.7.34

Trace complete.

C:\>tracert 192.168.7.62

Tracing route to 192.168.7.62 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.62

Trace complete.

C:\>
```

Listing 2.3: PC0 CMD output

```

Cisco Packet Tracer PC 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<1ms TTL=128
Reply from 192.168.7.65: bytes=32 time<1ms TTL=128
Reply from 192.168.7.65: bytes=32 time<1ms TTL=128
Reply from 192.168.7.65: bytes=32 time<1ms 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<1ms TTL=255
Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
Reply from 192.168.7.126: bytes=32 time=1ms TTL=255
Reply from 192.168.7.126: bytes=32 time<1ms 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 = 1ms, Average = 0ms

C:\>ping 192.168.7.33

Pinging 192.168.7.33 with 32 bytes of data:

Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
Reply from 192.168.7.33: bytes=32 time<1ms TTL=127
Reply from 192.168.7.33: bytes=32 time<1ms TTL=127

Ping statistics for 192.168.7.33:
    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=23ms TTL=127
Reply from 192.168.7.34: bytes=32 time<1ms TTL=127
Reply from 192.168.7.34: bytes=32 time<1ms TTL=127
Reply from 192.168.7.34: bytes=32 time<1ms 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 = 23ms, Average = 5ms

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<1ms TTL=255
Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
Reply from 192.168.7.62: bytes=32 time<1ms TTL=255

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:\>arp -a
  Internet Address      Physical Address      Type
```

```
  192.168.7.65          0001.429b.91a6        dynamic
  192.168.7.126         0060.2fcd.90bd        dynamic

C:\>tracert 192.168.7.65

Tracing route to 192.168.7.65 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.65

Trace complete.

C:\>tracert 192.168.7.33

Tracing route to 192.168.7.33 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.126
  2   0 ms      0 ms      0 ms      192.168.7.33

Trace complete.

C:\>tracert 192.168.7.34

Tracing route to 192.168.7.34 over a maximum of 30 hops:

  1   0 ms      0 ms      19 ms     192.168.7.126
  2   0 ms      0 ms      0 ms      192.168.7.34

Trace complete.

C:\>tracert 192.168.7.126

Tracing route to 192.168.7.126 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.126

Trace complete.

C:\>tracert 192.168.7.62

Tracing route to 192.168.7.62 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.62

Trace complete.

C:\>
```

Listing 2.4: Laptop0 CMD output

```

Cisco Packet Tracer PC 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<1ms TTL=127
Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
Reply from 192.168.7.65: bytes=32 time<1ms TTL=127

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 192.168.7.66

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
```

```

Trace complete.

C:\>tracert 192.168.7.34

Tracing route to 192.168.7.34 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.34

Trace complete.

C:\>tracert 192.168.7.126

Tracing route to 192.168.7.126 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.126

Trace complete.

C:\>tracert 192.168.7.62

Tracing route to 192.168.7.62 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.62

Trace complete.

C:\>
```

Listing 2.5: PC1 CMD output

```

Cisco Packet Tracer PC Command Line 1.0
C:\>arp -a
  Internet Address      Physical Address      Type
  192.168.7.33          0060.5c73.18bd        dynamic
  192.168.7.62          0090.0c00.9582        dynamic

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<1ms TTL=127
Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
Reply from 192.168.7.65: bytes=32 time<1ms TTL=127
Reply from 192.168.7.65: bytes=32 time=16ms TTL=127

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 = 16ms, Average = 4ms

C:\>ping 192.168.7.66

Pinging 192.168.7.66 with 32 bytes of data:

Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
Reply from 192.168.7.66: bytes=32 time<1ms TTL=127
Reply from 192.168.7.66: bytes=32 time<1ms TTL=127

Ping statistics for 192.168.7.66:
    Packets: Sent = 4, Received = 4, Lost = 0 (0% loss),
Approximate round trip times in milli-seconds:
    Minimum = 0ms, Maximum = 0ms, Average = 0ms

C:\>ping 192.168.7.33

Pinging 192.168.7.33 with 32 bytes of data:

```

```
Reply from 192.168.7.33: bytes=32 time<1ms TTL=128
Reply from 192.168.7.33: bytes=32 time<1ms TTL=128
Reply from 192.168.7.33: bytes=32 time<1ms TTL=128
Reply from 192.168.7.33: bytes=32 time<1ms TTL=128

Ping statistics for 192.168.7.33:
    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
  Internet Address      Physical Address      Type
  192.168.7.33          0060.5c73.18bd        dynamic
  192.168.7.62          0090.0c00.9582        dynamic

C:\>tracert 192.168.7.65

Tracing route to 192.168.7.65 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.62
  2   0 ms      0 ms      0 ms      192.168.7.65

Trace complete.

C:\>tracert 192.168.7.66

Tracing route to 192.168.7.66 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.62
  2   0 ms      0 ms      0 ms      192.168.7.66

Trace complete.

C:\>tracert 192.168.7.33

Tracing route to 192.168.7.33 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.33

Trace complete.

C:\>tracert 192.168.7.126

Tracing route to 192.168.7.126 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.126

Trace complete.

C:\>tracert 192.168.7.62

Tracing route to 192.168.7.62 over a maximum of 30 hops:

  1   0 ms      0 ms      0 ms      192.168.7.62

Trace complete.

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<1ms TTL=255
Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
Reply from 192.168.7.126: bytes=32 time<1ms TTL=255
Reply from 192.168.7.126: bytes=32 time=14ms 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 = 14ms, Average = 3ms

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<1ms TTL=255
Reply from 192.168.7.62: bytes=32 time<1ms TTL=255
Reply from 192.168.7.62: bytes=32 time=15ms TTL=255
Reply from 192.168.7.62: bytes=32 time<1ms TTL=255

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 = 15ms, Average = 3ms

C:\>
```

Listing 2.6: Laptop1 CMD output

```
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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(c) of the Commercial Computer Software - Restricted
Rights clause at FAR sec. 52.227-19 and subparagraph
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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!



Router>enable
Router#
Router#configure terminal
Enter configuration commands, one per line.  End with CNTL/Z.
Router(config)#interface FastEthernet0/0
Router(config-if)#ip address  255.255.255.192
% Incomplete command.
Router(config-if)#ip address 192.168.7.126 255.255.255.192
Router(config-if)#no shutdown
```

```
Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet0/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet0/0, changed state to up

Router(config-if)#exit
Router(config)#interface FastEthernet1/0
Router(config-if)#ip address  255.255.255.224
% Incomplete command.
Router(config-if)#ip address 192.168.7.62 255.255.255.224
Router(config-if)#no shutdown
Router(config-if)#
%LINK-5-CHANGED: Interface FastEthernet1/0, changed state to up

%LINEPROTO-5-UPDOWN: Line protocol on Interface FastEthernet1/0, changed state to up

Router>ping 192.168.7.65

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.7.65, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms

Router>ping 192.168.7.66

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.7.66, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms

Router>ping 192.168.7.33

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.7.33, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms

Router>ping 192.168.7.34

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.7.34, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/0/0 ms

Router>ping 192.168.7.126

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.7.126, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 10/12/18 ms

Router>ping 192.168.7.62

Type escape sequence to abort.
Sending 5, 100-byte ICMP Echos to 192.168.7.62, timeout is 2 seconds:
!!!!!
Success rate is 100 percent (5/5), round-trip min/avg/max = 0/10/22 ms

Router>traceroute 192.168.7.65
Type escape sequence to abort.
Tracing the route to 192.168.7.65

  1   192.168.7.65    0 msec    0 msec    0 msec
Router>traceroute 192.168.7.66
Type escape sequence to abort.
Tracing the route to 192.168.7.66

  1   192.168.7.66    0 msec    0 msec    0 msec
Router>traceroute 192.168.7.33
Type escape sequence to abort.
Tracing the route to 192.168.7.33

  1   192.168.7.33    0 msec    0 msec    0 msec
```

```
Router>traceroute 192.168.7.34
Type escape sequence to abort.
Tracing the route to 192.168.7.34

  1   192.168.7.34    0 msec    0 msec    0 msec
Router>traceroute 192.168.7.126
Type escape sequence to abort.
Tracing the route to 192.168.7.126

  1   192.168.7.126   11 msec   0 msec    0 msec
Router>traceroute 192.168.7.62
Type escape sequence to abort.
Tracing the route to 192.168.7.62

  1   192.168.7.62    10 msec   4 msec    4 msec
Router>
```

Listing 2.7: Router 1 CLI output

It's evident why tracert 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 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 two distinct LANs. And it checks out, layered 3 devices store arp tables, displaying only their gateways through tracert (traceroute).

Appendix A

Appendix