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FACULTY OF SCIENCES

DEPARTMENT OF COMPUTER SCIENCE

Networks Practical Guide

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1. Introduction

The network course is fundamental for undergraduate students. The course allows them to learn the techniques of how to connect the devices such as computers, printers and others to form networks in which services and data are exchanged. Besides learning the hardware used to ensure the connections, the students also acquire knowledge about the network layers, topologies and protocols. The course is divided into lectures about the previously mentioned concepts as well as exercises sessions in which they practice applying the rules and protocols they learnt in the lecture sessions. Lastly, the course also has practical sessions in which they learn and practice creating different types of networks and configuring them, as well as learning to use the network simulator "Cisco Packet Tracer". This report represents a guide to undergraduate student, more precisely it is destinated for computer science second year bachelor student, that direct them to elaborate networks in real world and simulation environment. It is organized on ten sections which are:

- Local Networks Engineer Tool Set
- RJ45 cable types and standards
- Network configuration
- Connecting two computers via ethernet cable
- Access Point configuration
- Ad hoc network
- File sharing via network
- Sharing printer via network
- Cisco Packet Tracer Guide
- Activity sheet

Lastly, it is concluded by giving some insights on how to increase knowledge and experience about networks.

2. The Local Networks Engineer Tool Set

Network engineer needs a set of tools to construct the networks. In matter of facts, building a network requires two steps: the first is to connect its components and the second is to configurate the network in order to ensure the connectivity and transfer of data. In order to connect the components, the engineers need to have some equipment to make the cables, to coordinate them and to test the hardware connectivity. This is an essential step that precedes the configuration phase. In this section, we introduce the reader to the engineer toolkit and how it is used. Table 1 illustrates the tools along with their names. The utility of each tool is explained hereafter.

Table 1: Network Engineering essential Toolkit

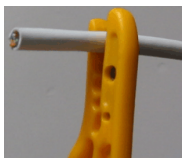
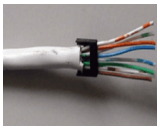
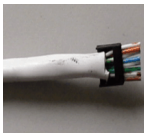
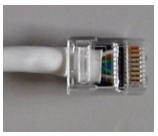
Tool Picture					
Name	RJ45 Connector	RJ45 Cable	RJ45 Stripper	RJ45 Crimper	Connection tester

To create the network, the first step is to design it and then decide on the type of cables, their length, and the connection equipment to use such as: switches, hubs, access points,…etc. depending on the network to be created. The above-mentioned (in Table 1) toolkit are the one essentially found in the engineer package. They are used to create working RJ45 cables to connect multiple equipment.

To make the cable, you need to measure its length basing on the distance between the endpoints you want to connect. After cutting the cable with the desired length, you need to choose the type of cable you will be using, again based on the endpoint types. We explain more about the cable types and their uses in section 3. Once the type is decided, you need to use the stripper to strip the RJ45 cable from the outer cover, then you need to organize the inner 8-wires basing on the correct color code matching the cable type you choose. Cut the lines using the cutter found in the crimper, all the lines must have the same length, which is about 1cm (the length of the connector), enter the wires in the RJ45 connector, until they rich the pins area, all to the end. After that, use the crimper to press the pins over the wires. Lastly, after adding the connectors on both sides of the cable, use the tester to test the connection, if the lights appear from both sides of the tester where the wires are connected, then the cable was

made correctly and it is ready for usage. The steps of preparing RJ45 cable are illustrated in table 2.

Table 2: RJ45 Cable preparation steps. *[1]*

						
Step 1: Stripping the cover		**Step 2:** organizing the wires basing on color code		**Step 3**: Putting the cable into the connector	**Step 4:** Pressing the connector	**Step 5:** Testing the cable

3. RJ45 Cable Types and Standards

We mentioned before that to make an ethernet cable (RJ45), we need to choose its type and organize the wires basing on a code color matching this type. In matter of fact, there are two types of cables which are: straight-through and crossover. The difference between these two types of cables lies in the color-code they have which represents the standard they follow. There are two standards for ethernet network cables which are T568A and T568B. Figure 1 illustrates the order of wires basing on their colors for each standard [2].

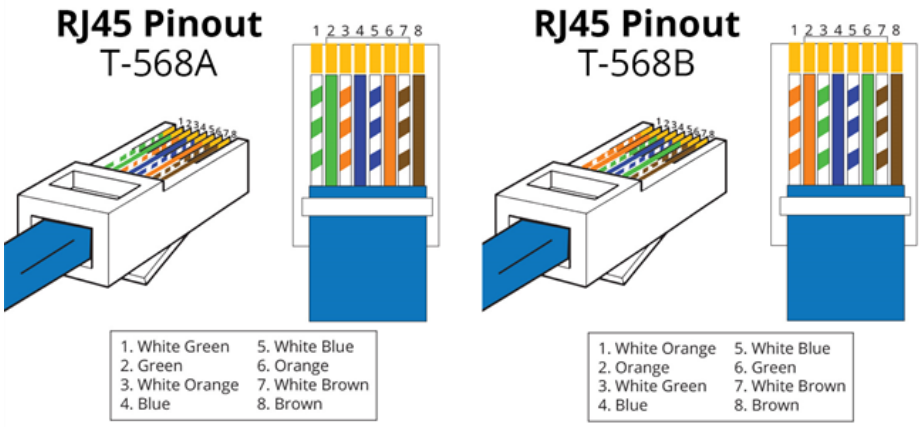


Figure 1: Illustration of Color Code for T-568A (left) and T-568B(right) *[2]*

As it is seen in Figure 1, the color code of T-568A is **white green**, **green**, **white orange**, blue, white blue, **orange,** white brown, brown. The color code of T-568B is **white orange**, **orange**, **white green**, blue, white blue, **green,** white brown, brown.

The ***straight-through cable*** both extremities of the cable have the same code color which means that either **both sides** are coded basing on **T-568A** or **both sides** are coded using **T-568B** (see example of Figure 2). This type of cable is used to connect equipment of different types as illustrated in Figure 3.

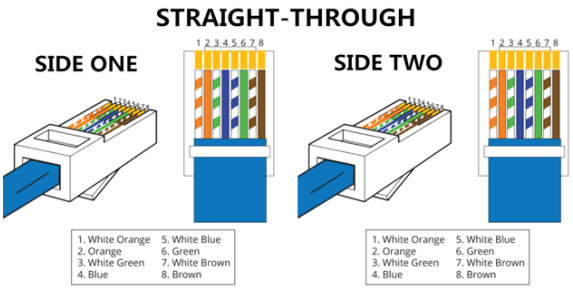


Figure 2: Straight-through cable (T568B - T568B) *[2]*

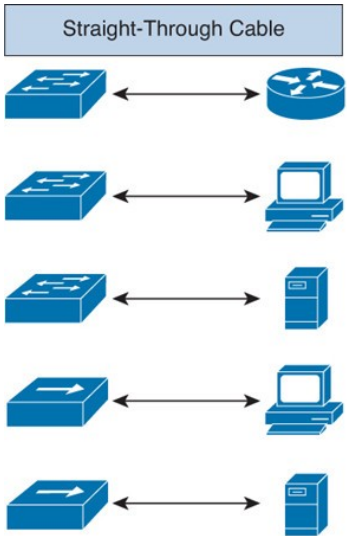


Figure 3: Straight-through cable use cases. *[2]*

The straight-through cable is used to connect a switch to a router, a switch to a computer, s switch to a server, a hub to a server or a computer [2].

The cross-over cable is used to connect similar and non-similar devices. It has different code color for each side, if the one side is coded following the T-568A standard then the other side must follow the T-568B standard (See Figure **4**). Figure **5** illustrates the cross-over cable use cases. Table **3** recaps the use cases of the crossover and straight-through cables [2].

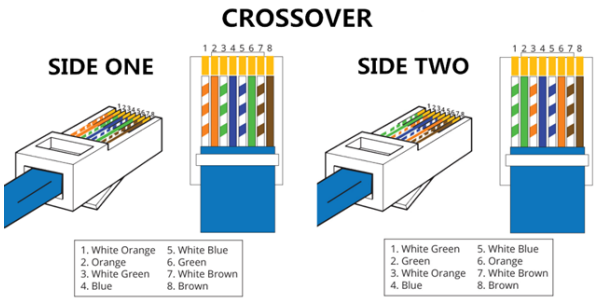


Figure 4: Crossover cable (T568B - T568A) *[2]*

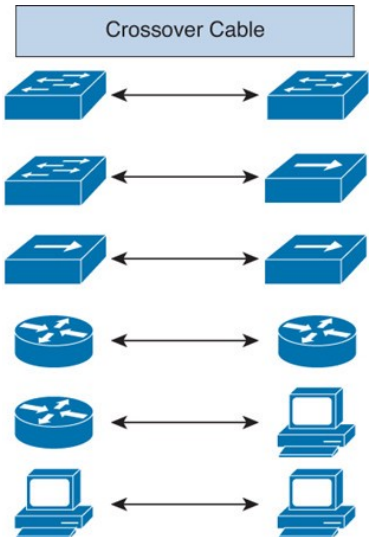


Figure 5: Crossover cable use cases *[2]*

Table 3: Crossover vs Straight-through use cases recap *[3]*

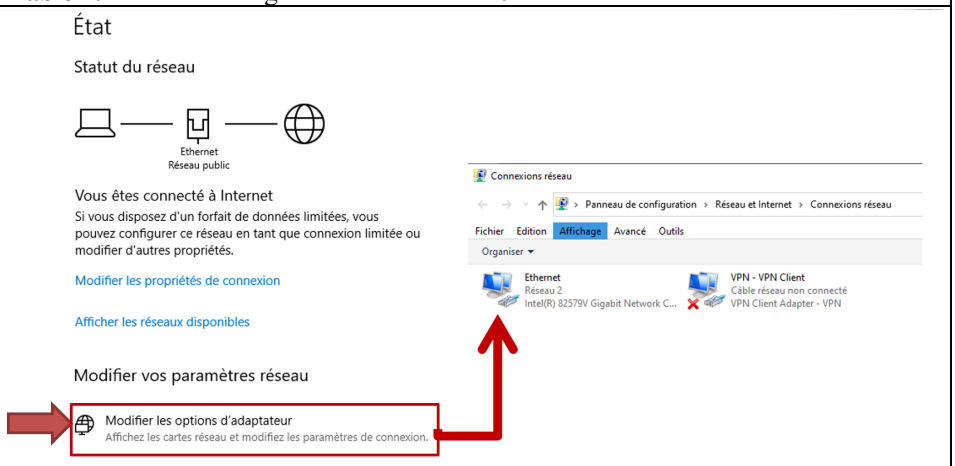
	HUB	SWITCH	ROUTER	PC
Hub	Crossover	Crossover	Straight	Straight
Switch	Crossover	Crossover	Straight	Straight
Router	Straight	Straight	Crossover	Crossover
PC	Straight	Straight	Crossover	Crossover

4. Network Configuration

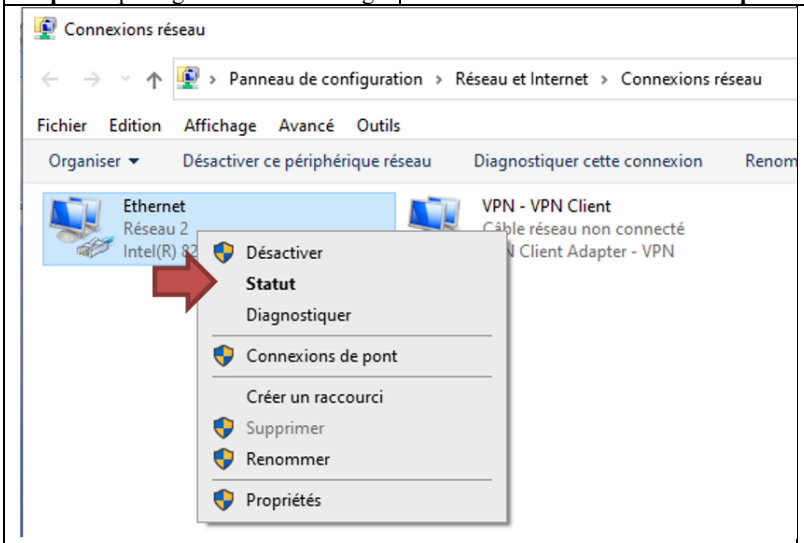
After preparing the cables and the devices to connect, it is necessary to be able to know how to configurate the network, i.e. how to set and change the IP addresses of the devices. Actually, there are two methods, either to set them automatically, if there is a DHCP server in the network which dynamically assigns the IP addresses to the devices. Or, to set them statically, in this case, the admin which is the one doing the network configuration should make sure that each device has a unique IP address to avoid IP address conflict. The network configurations steps are illustrated bellow for Windows (Table 4), Linux (Table 5), and Mac operating systems (Table 6).

Table 4: Network configuration - Windows 10

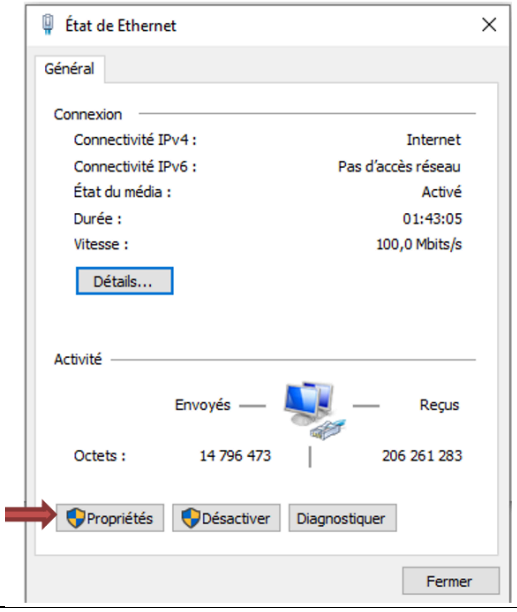
Step 1 : Opening the network setting



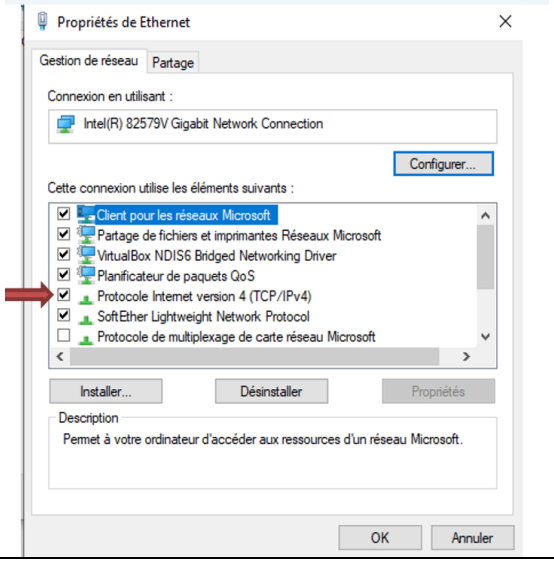
Step 2 : Changing the adapter settings



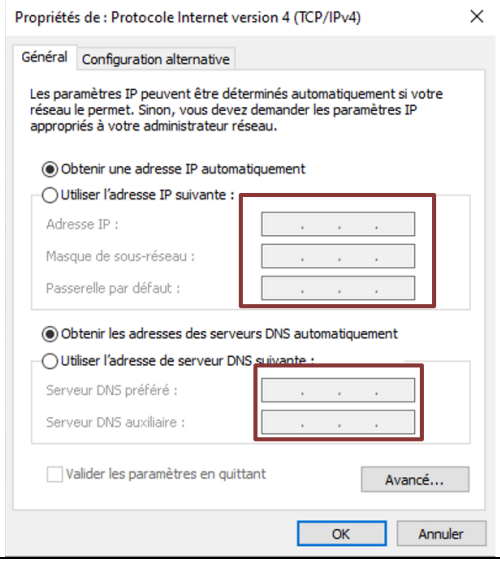
Step 3 : Checking current settings



Step 4 : More Network Characteristics

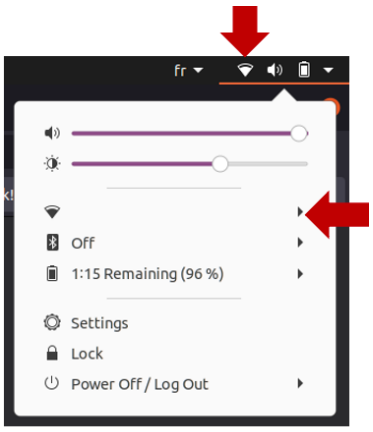


Step 5 : IP Settings

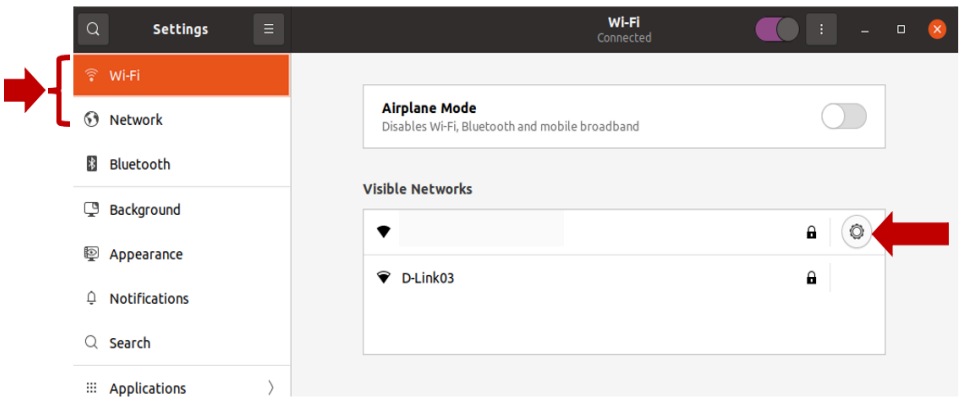


Step 6 : Setting IP address (either to automatic or static)

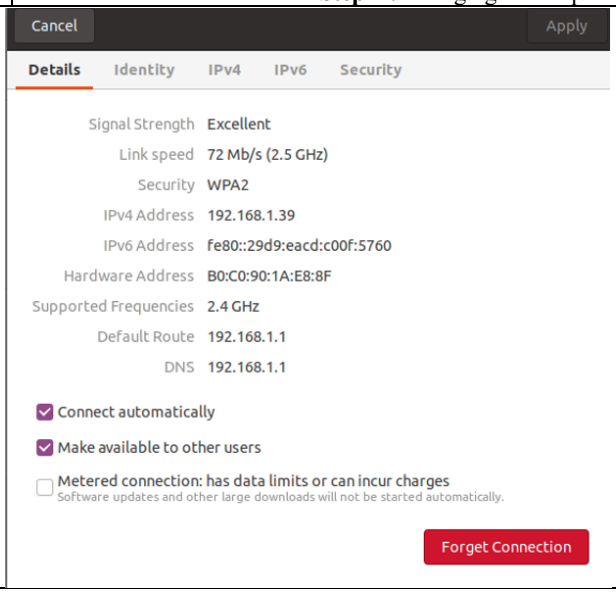
Table 5: Network configuration - Linux



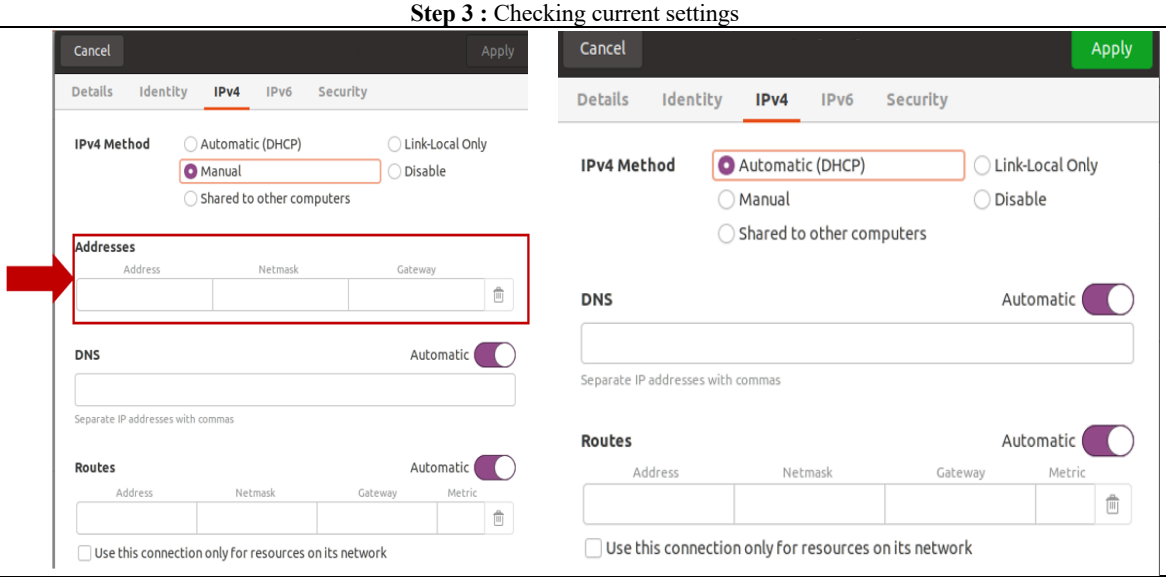
Step 1 : Opening the network setting



Step 2 : Changing the adapter settings

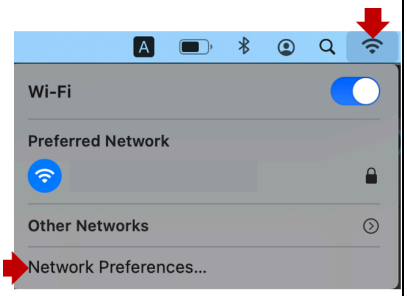


Step 3 : Checking current settings

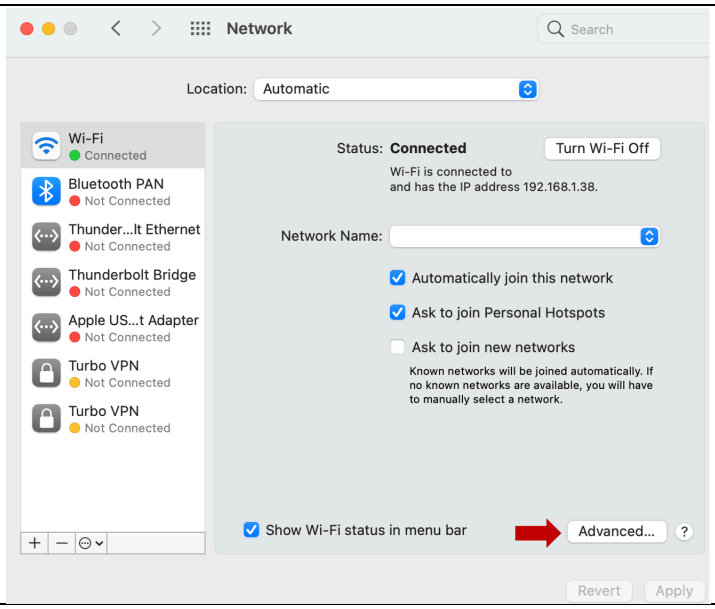


Step 4 : Setting IP address (either to automatic or static)

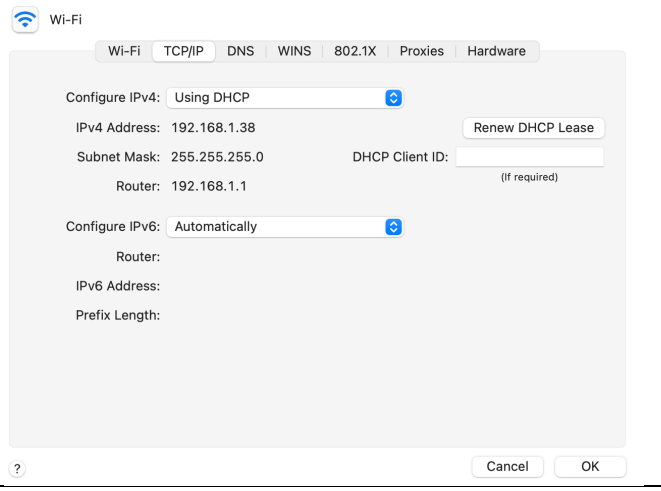
Table 6: Network configuration – Mac Os



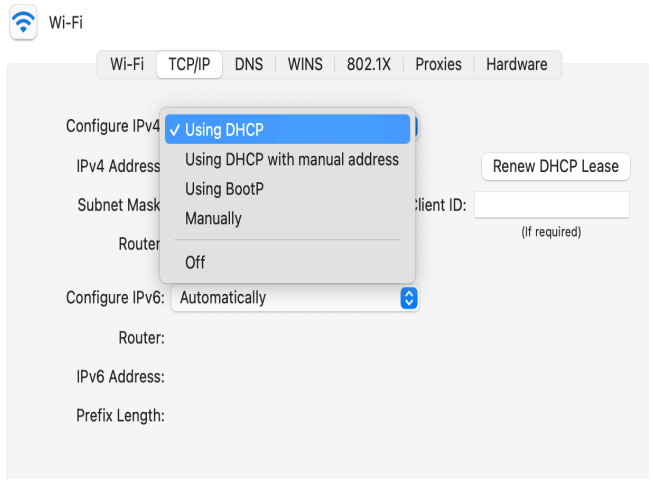
Step 1 : Opening the network setting



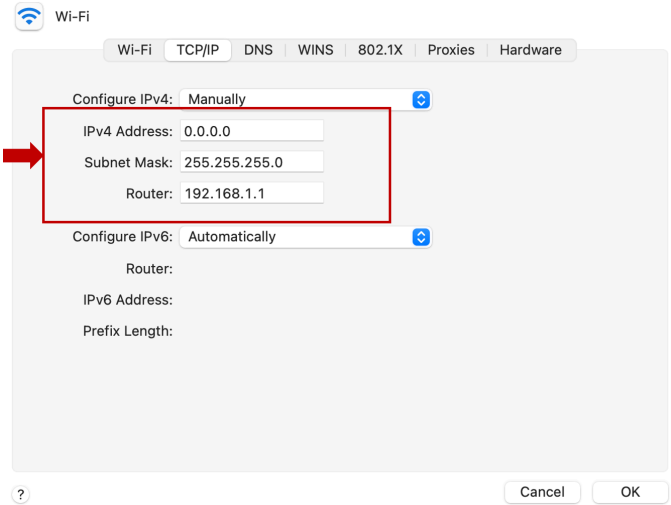
Step 2 : Changing the adapter settings



Step 3 : Checking current settings



Step 4 : Setting IP address (dynamic)

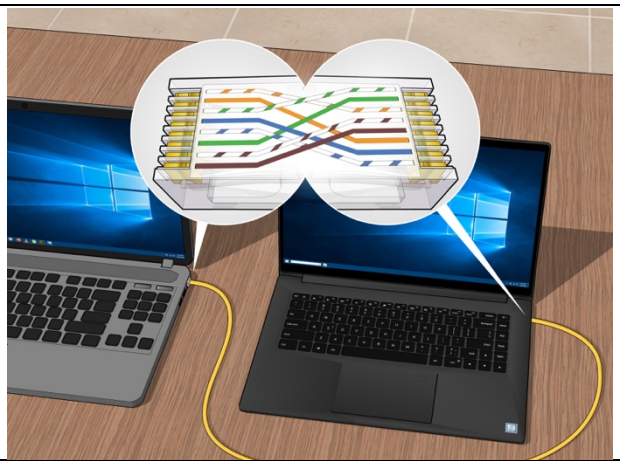
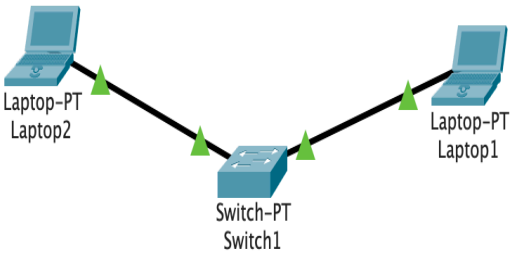


Step 5 : Setting IP address (static)

5. Connecting two Computers via ethernet cable

To connect two computers via ethernet, a crossover cable is needed. After connecting both of the cable ends to each computer, you may configure the file sharing to be able to exchange files between the two computers. If you do not have crossover cable and you have a straight-through cable, then the use of the switch is mandatory. The illustration of the connection of two computers via ethernet cable using both methods are given in Table 7. The use of switches allows not only the connection of two PCs but for multiple devices as well.

Table 7: Connecting two Computers

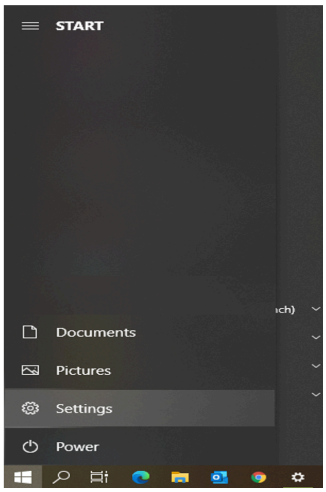
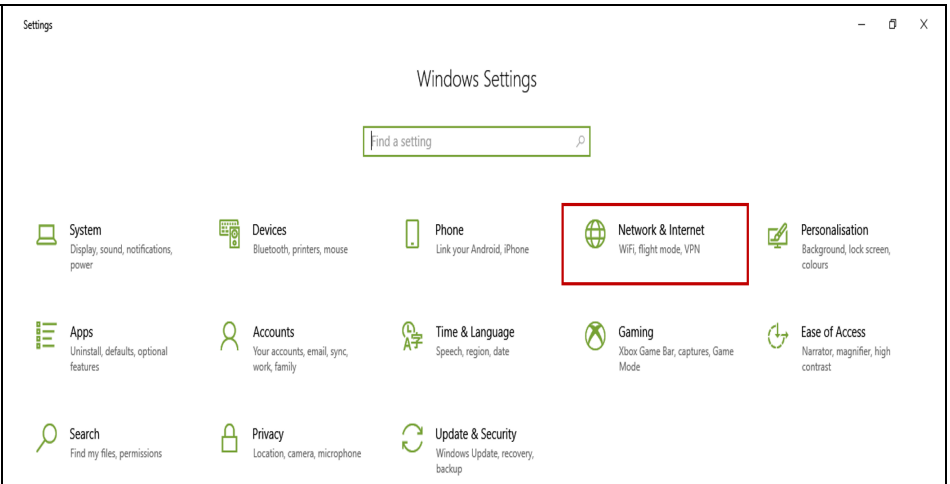
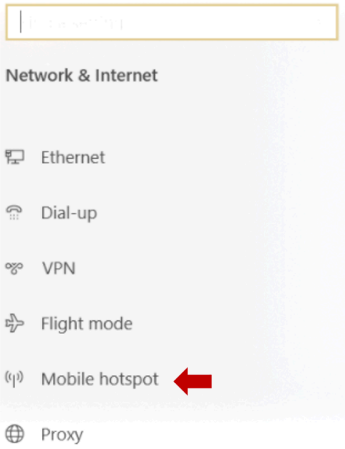
	
Method 1: Connecting two pcs with a crossover cable [4]	**Method 2:** Connecting two pcs via switch and straight-through cable

6. Access Point Configuration

Using the ethernet cables to connect the devices is the first method of creating a network, this method is known as creating a wired network. The other method to create a network is wirelessly. For this type of networks, there are two methods, one relies on the use of access points (infrastructures) which is explained in this section, the other is infrastructure-less and it is described shortly after in section 7.

To create a local network only an access point is needed it is like a wireless hub. If you want beside creating a local network to also be able to connect to the internet then the use of wireless router is needed instead. If you do not have an access point or a wireless router. You may turn your personal computer (Laptop) into an Access Point (AP). The condition is that the computer must have two network interfaces, one is ethernet for wired connection, the other is a wireless interface to broadcast the network data over the air emulating the AP. The steps of turning your computer into an AP are explained in Table 8.

Table 8: Steps to turn a laptop into AP in windows 10

<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Step 1 : Opening Windows settings</td><td>Step 2 : Opening network and Internet</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Step 3: Go to Mobile hotspot</td><td>Step 4: Enable the internet sharing and set the password</td></tr>
</table>

The other method is to use your smartphone as an AP. The condition is that you have either 3G, 4G or 5G connection in your phone you may share this connection with others or with your computer after setting you phone as an AP or a Hotspot, the steps of turning your phone as an AP are similar to those in the PC.

7. Ad hoc Network Creation

Unlike Windows 7, the creation of Ad hoc network in no longer done via the graphical interface but via line commands. To open the CMD prompt as administrator, press from the keyboard simultaneously on windows icon and “x” then choose run CMD as administrator. To create the ad hoc network, paste the following command in the CMD:

netsh wlan set hostednetwork mode=allow ssid=<your desired network name> key=<your desired password>, replace what is between <> with real values you want to use.

To start the ad hoc network, type this command: **netsh wlan start hostednetwork**

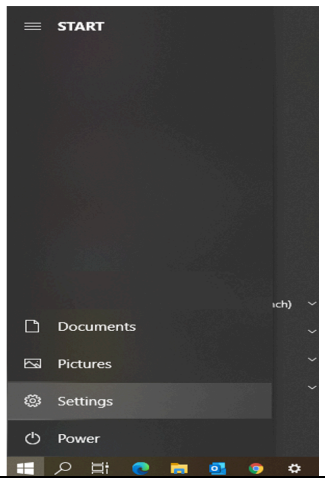
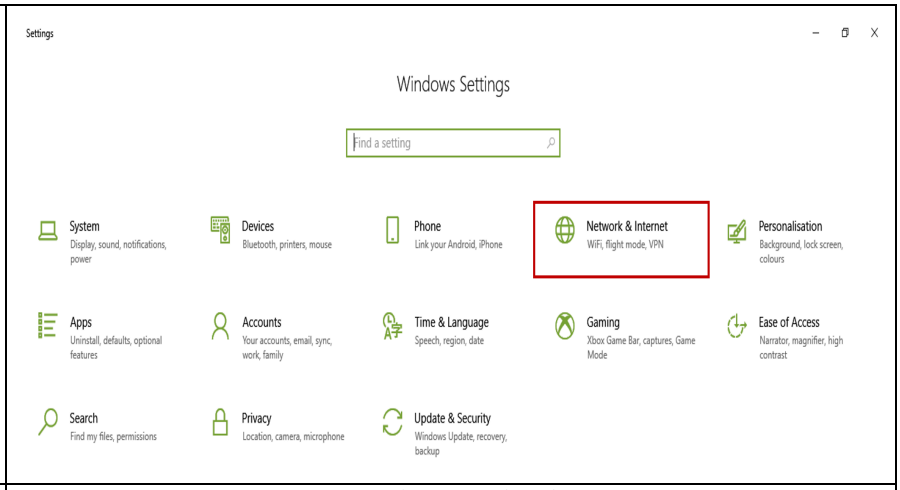
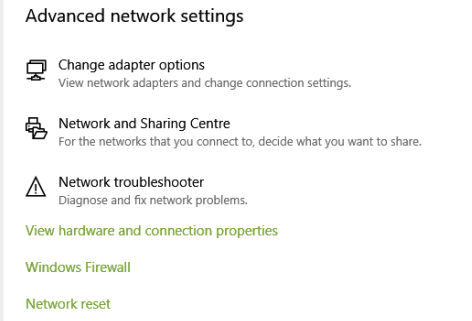
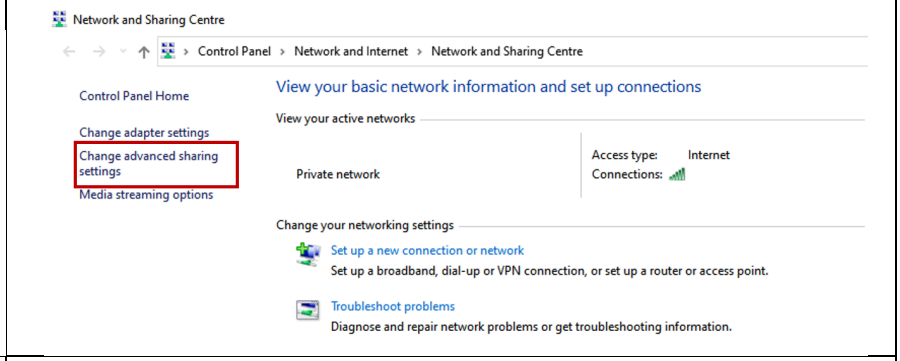
To stop it, type the following command: **netsh wlan stop hostednetwork**

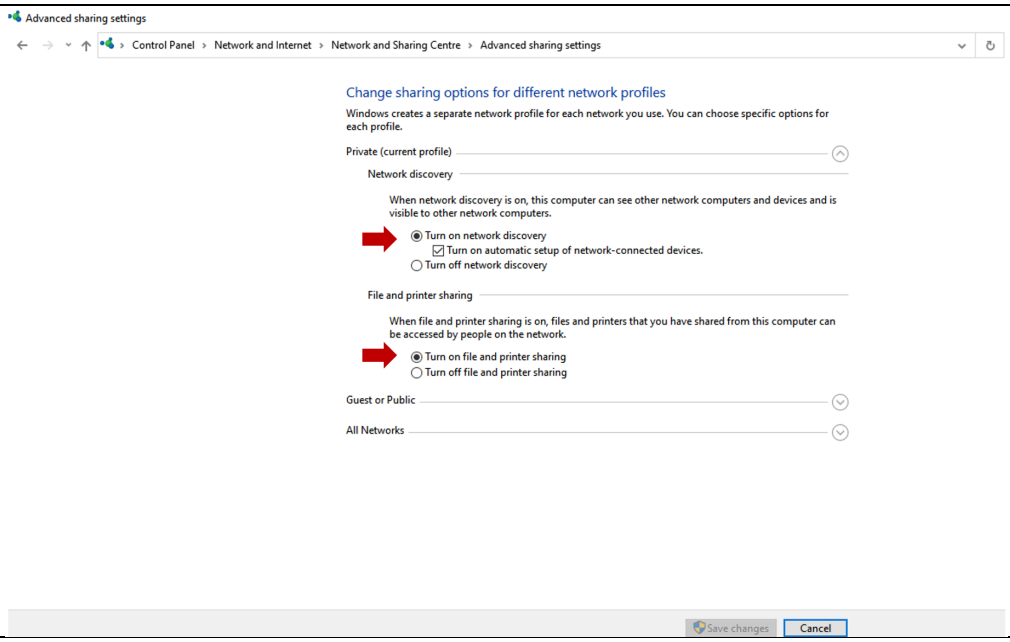
You may create the ad hoc network when you have computers with wireless interfaces, yet no wires are available nor an infrastructure (Access Point). After creating the network, you may be able to share files with other network participants (see section **8** for the details).

8. File Sharing via network

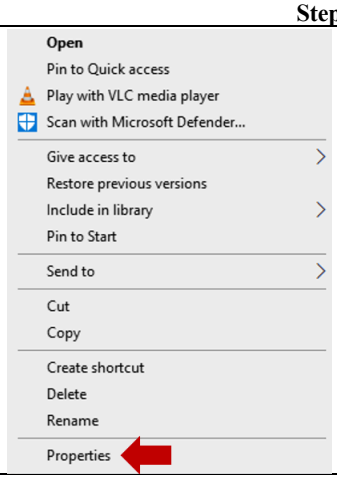
After creating the network whether wire-based or wirelessly, you need to activate the file sharing which is disabled by default. The steps of activating the file sharing on a Windows 10 computer are depicted in Table **9**.

Table 9: File Sharing Steps (Windows 10)

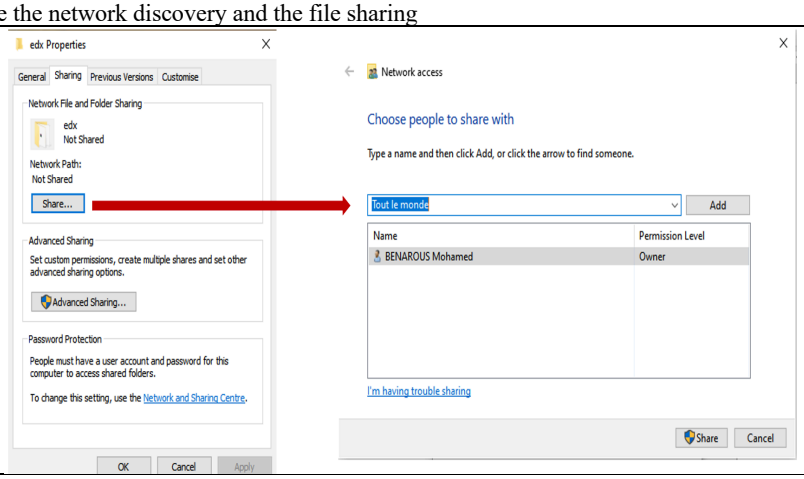
<table>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Step 1 : Opening Windows settings</td><td>Step 2 : Opening network and Internet</td></tr>
<tr><td> 
</td><td> 
</td></tr>
<tr><td>Step 3 : Change Network and Sharing Options</td><td>Step 4 : Click on advanced sharing settings</td></tr>
</table>



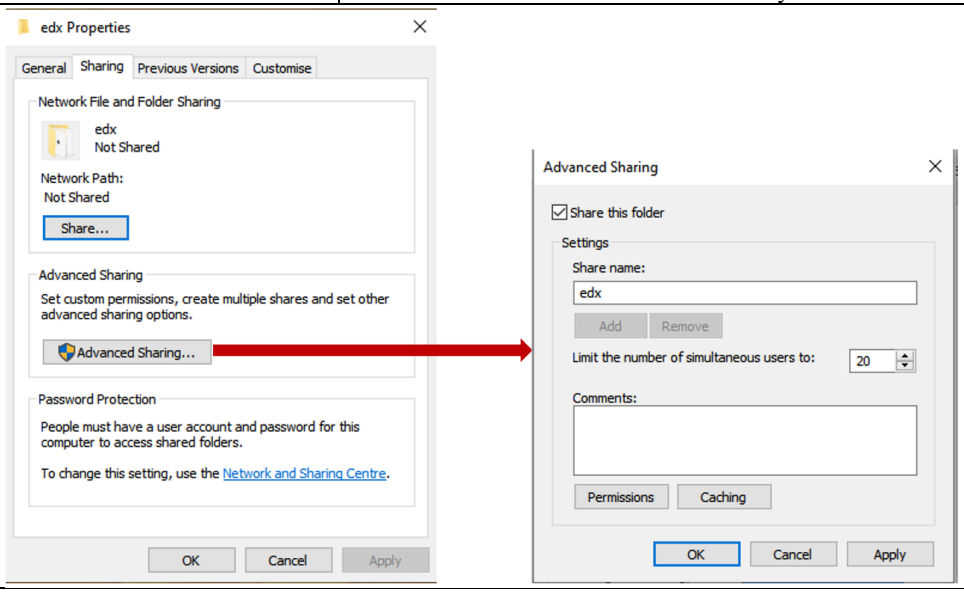
Step 5 : Activate the network discovery and the file sharing



Step 6 : Right-click on the folder to be shared



Step 7 : Set the folder to be shared with the people of your choice or to share it with everyone



Step 8 : Limit the number of simultaneous users to the shared folder to your liking

Now that the file sharing is activated, you may drop in the shared folder whatever file you want to share with others. They can see your computer from their network window as illustrated in the Figure 6. If your computer is protected with a password, you need to share it with the person you are sharing the files with to be able to enter your computer and copy the files from them. If you do not wish to share the password, then you have to disable the password protection when activating the file sharing as illustrated in Figure 7.

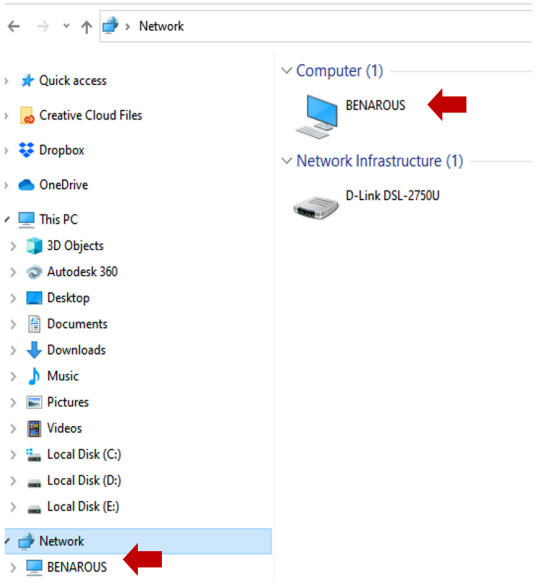


Figure 6: Network > Computer with shared folder

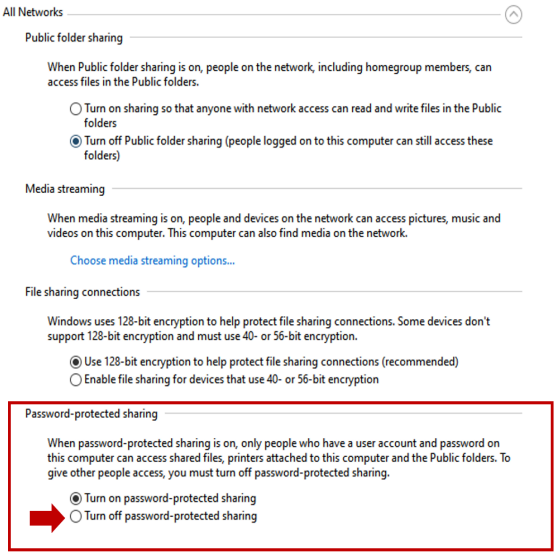


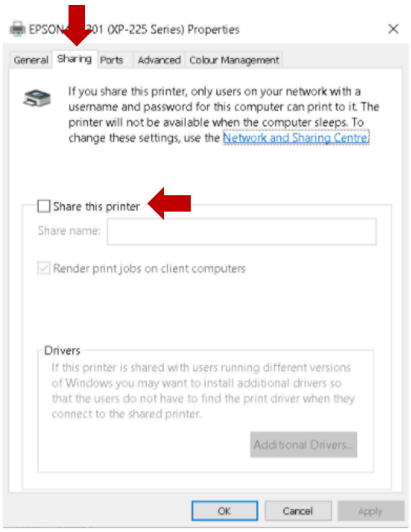
Figure 7: Disabling the password protection while activating the file sharing

Remember to disable the visibility of your computer and to turn off the file sharing upon the end of use.

9. Printer sharing via network

To share the printer over the network, the printer should be connected to a computer with a fixed IP address (see network configuration- static address- section 4). Then, repeat the steps from 1-5 from Table 9. After installing the printer driver, follow the steps illustrated in Table 10.

Table 10: Printing sharing steps

	
Step 1: Right-click on the printer's name	**Step 2:** Activate the share option

To print a document, both the printer and the computer it is connected to must be on. The users using the same network may select the printer's name to print their documents.

10. Cisco Packet Tracer guide

Cisco Packet Tracer is a powerful simulation tool provided by Cisco suitable for academic learning of networks. It has a wide variety of switches, routers, end devices made by Cisco. It simplifies the understanding of networks and give the learners the chance to get a real-world experience of networks through realistic simulations, device connections and configurations [5]. Therefore, we believe that this tool is suitable for new network learners because it allows them to try the network configurations and test if it works before the real deployment. In the following subsections, the tool will be explained and illustrated.

10.1. The tool interface

If the user is connected to the internet, a login page is prompt asking him/her to enter his/her credential. If you do not wish to create an account in the Cisco Academy Network or you do not want to log in, you may simply select to enter as a guest as illustrated in Figures **8**. Noting that if you are using the tool from an offline computer -not connected to the internet, you will directly be able to use the tool without passing by the login page.

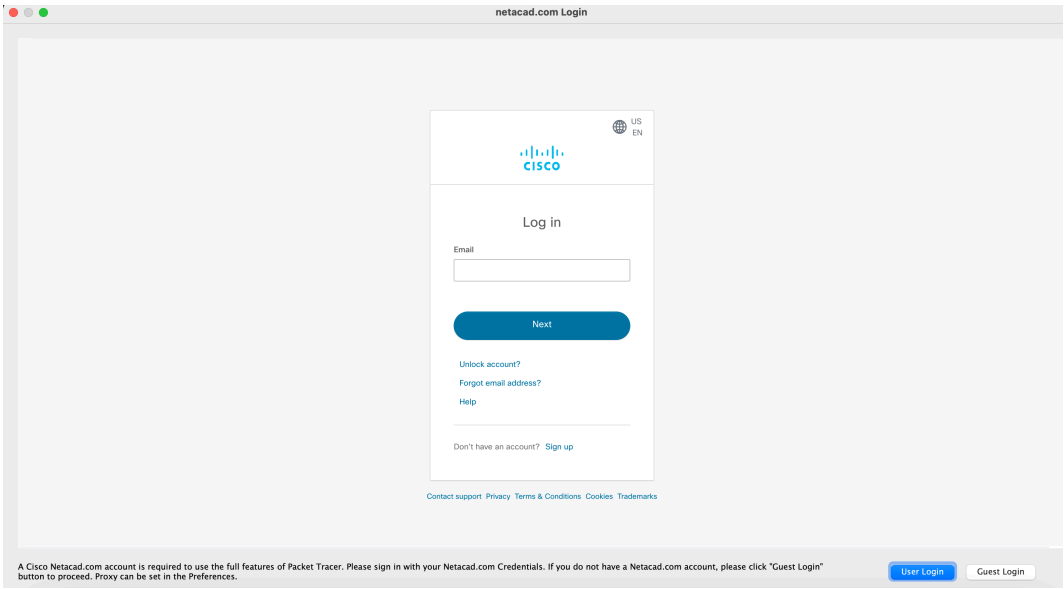


Figure 8: Cisco Packet Tracer Login interface

Upon log in, the view of the cisco packet tracer (CPT) is as illustrated in Figure 9. It has a logical and physical workspace. Our focus and use will be on the first one. The interface has many parts, we zoomed on the essential one that we are using in this guide which are the drawing panel, the simulation panel, the network components panel (see Figure 10).

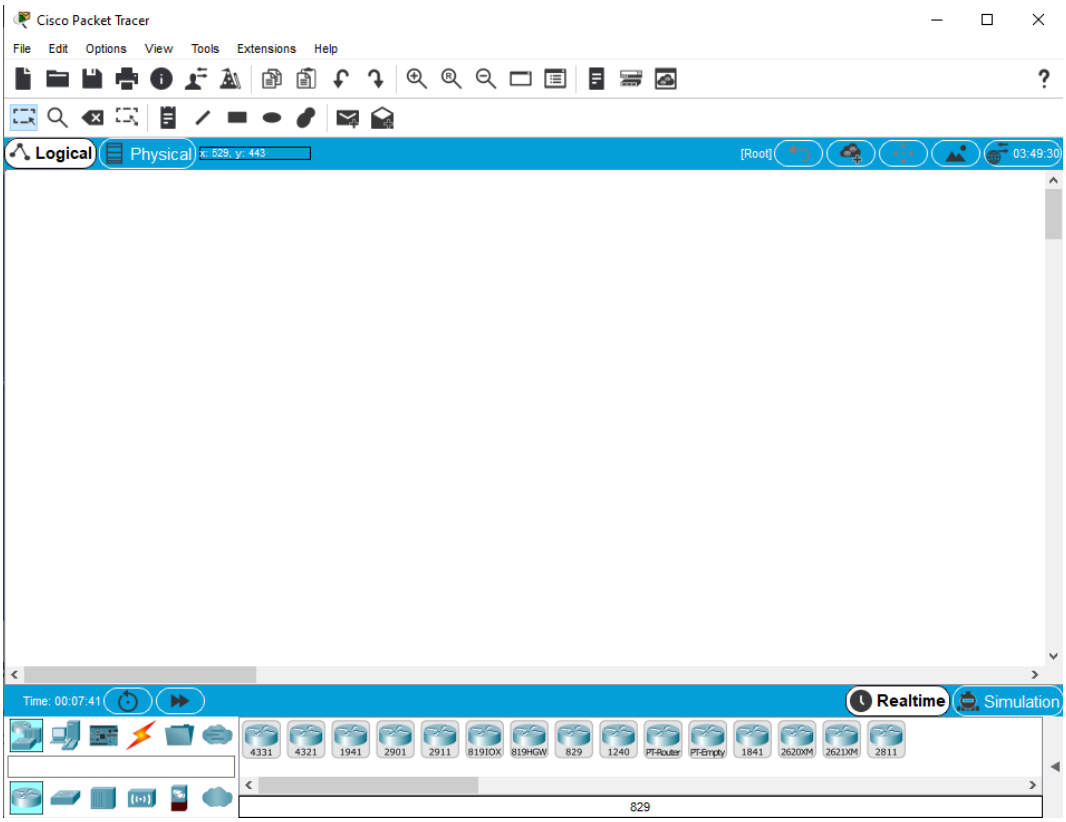


Figure 9: Cisco Packet Tracer Main interface

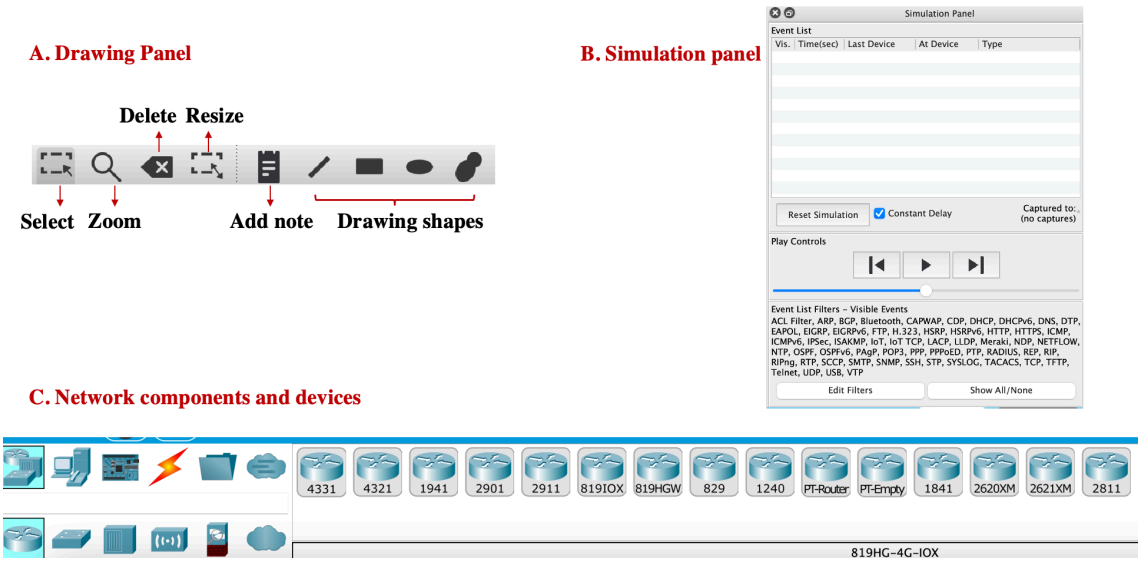


Figure 10: Zoom on CPT Logical workspace panels

10.2. Using the logical workplace

The CPT can be used for various purposes, you may use it to create, configure and test network topologies for academic studies and simulations. You may use it to design and test networks prior to their deployment. The tool has various devices with interfaces similar to real Cisco hardware and allows the user to configurate them just like it is done on physical devices. A beginner user may feel confused at the beginning about which device to choose among the various available, per example, a user who wants to use a switch will have 9 choices of switches when using CPT 3.7, to be able to choose the right device, the user is either needed to have prior knowledge about their references and appellations, or to explore the CPT tool correctly through clicking on the device and checking its characteristics and usages. To continue explaining the tool, we choose the approach “learning by application” which means we learn to use the CPT through a set of examples on configurating networks of various types and sizes. The rest of sections contains the steps needed to configure: hub-based network, switch-based network, wireless network, routers, etc.

10.2.1. Hub-based network

To connect computer with a hub in CPT, we need first to put computers and hubs in the logical workplace then to connect and configure them. As example, we connect four desktop computers with a hub and try the connection between them with ping instruction. We illustrate the steps in the following:

1- **Selecting the computers:** to put computers on the logical workplace, select on end devices then click on PC icon and again click on the white board of the workplace. Like illustrated in Figure 11 (**steps 1-3**). We repeat the same process for the rest of three computers.

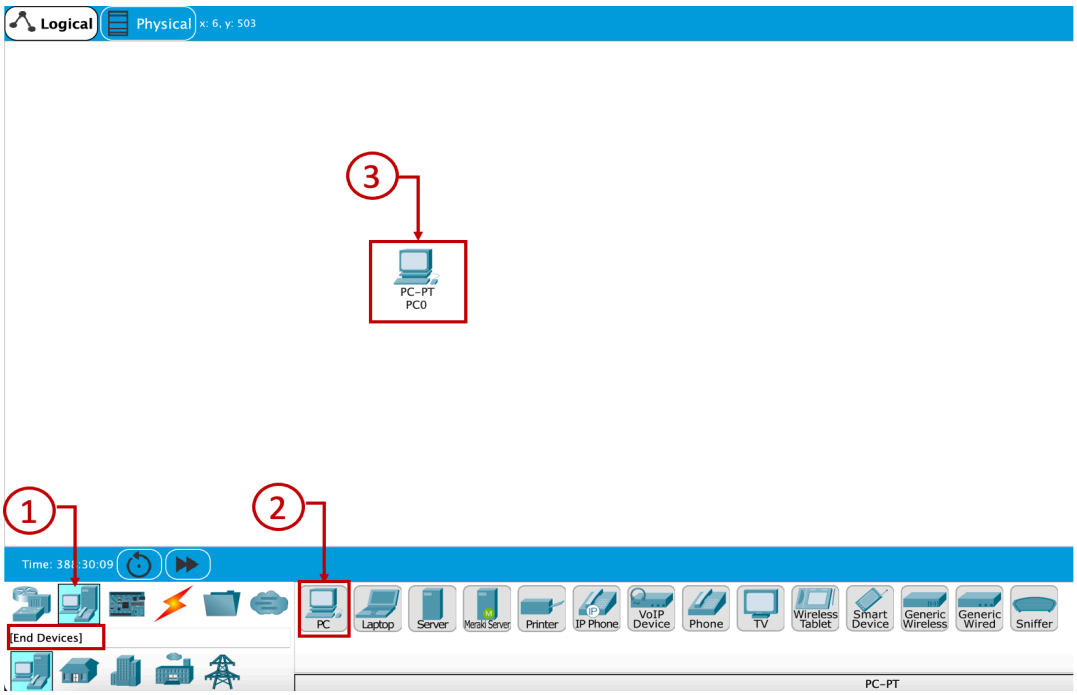


Figure 11: Steps to put a PC in the logical workplace

2- **Selecting the hub:** to put the hub in the workplace, we click on the network devices (Figure 12, step.1) then select the hub (Figure 12, step.2) and put it (Figure 12, step.3).

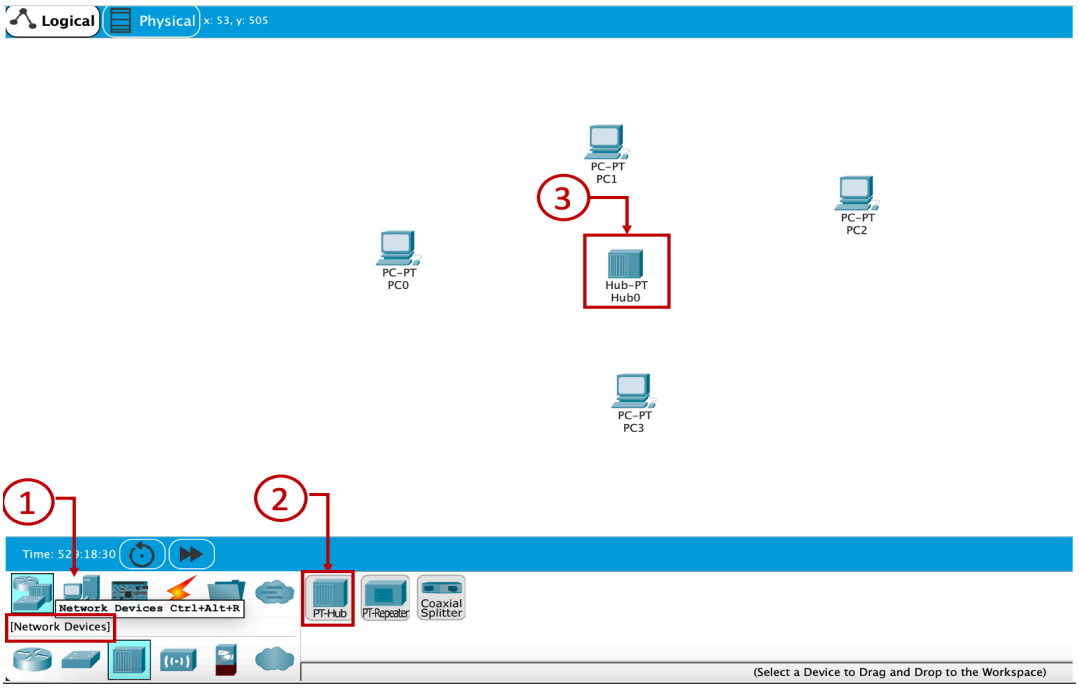


Figure 12: Steps to put a Hub in the logical workplace

Noting that the hub we selected has six Ethernet ports. To add more or reduce the number of ports, double click the Hub icon in the logical workplace, in the physical view of the prompted window, you will see the existing ports and four empty slots. To add new one Ethernet port, power off the hub, then select it from the available modules and drag it over one of the empty slots like illustrated in Figure **13.(1)**. To remove an Ethernet port, first power off the hub then select the port, drag it from the Hub and drop it in the modules section as illustrated in Figure **13.(2)**. The modules section has multiple choices of extensions, to understand which one is suitable to your needs, read the description that appears below when selecting a module.

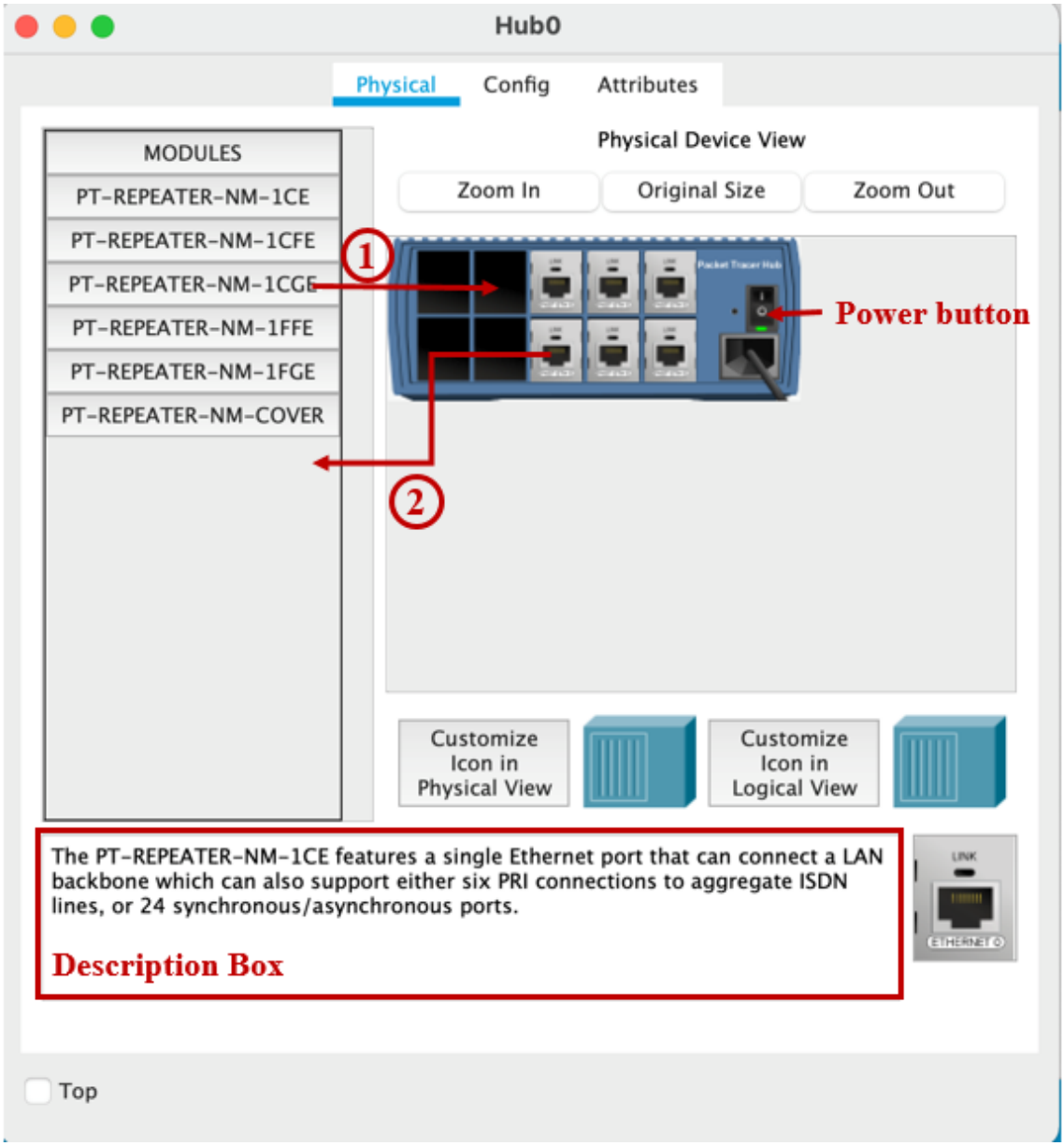


Figure 13: Adding and removing Ethernet Ports to/from a Hub

3- **Connecting the components:** To connect the devices, click on the connections tab from the network components panel, then select straight through RJ45 Cable as illustrated in Figure 14. After selecting the cable, click on one of the PCs, select the Ethernet port, then click again on the Hub and select an Ethernet port (see Figure 15). Repeat the process with the rest of the computers until you connect them all to the Hub like in Figure 16.

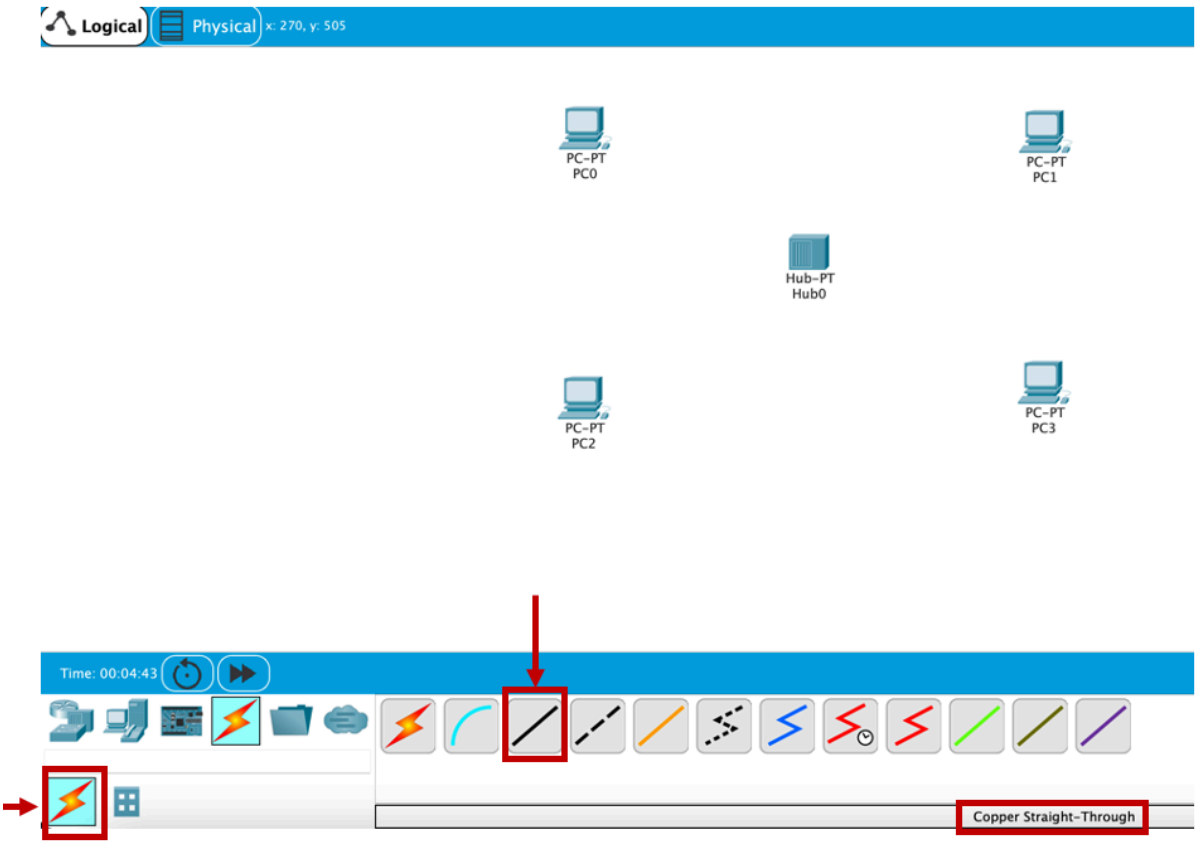


Figure 14: Selecting the RJ45 Straight-through Cable

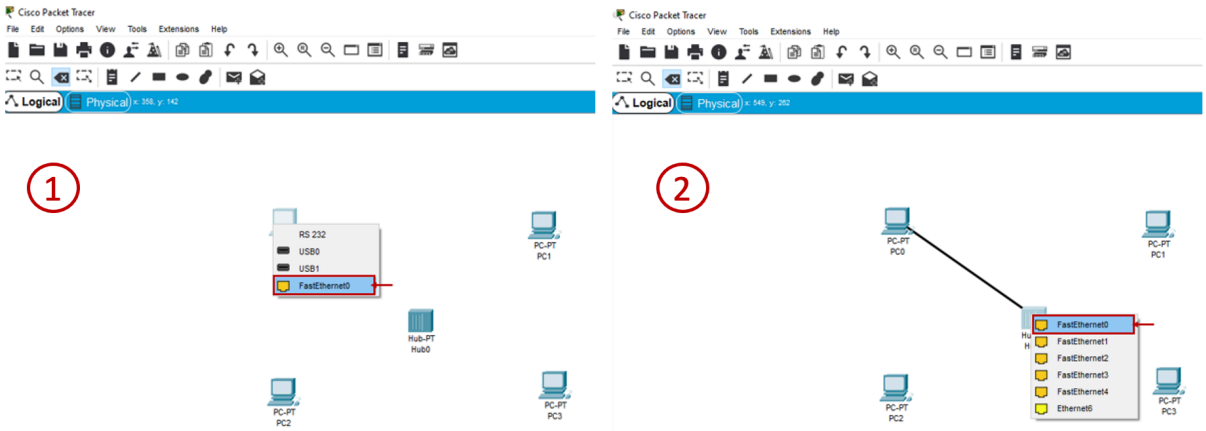


Figure 15: Connecting PC to Hub

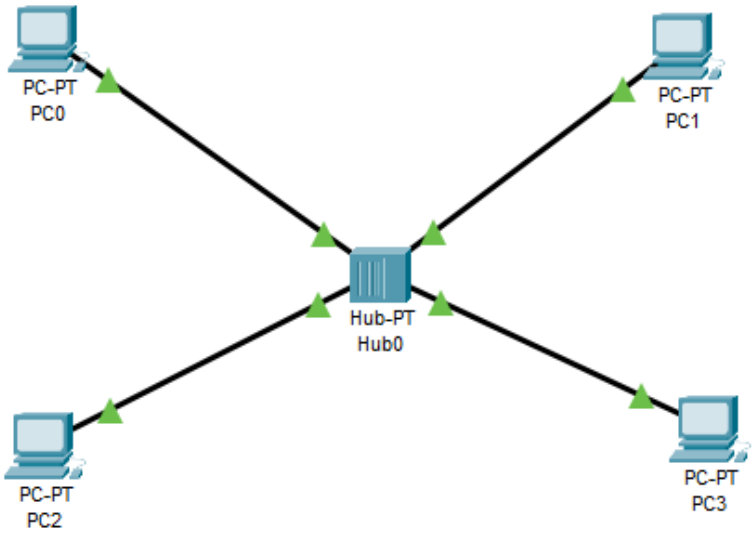


Figure 16: Example of Hub-based Network

4- **Configuration of PCs:** Now that the devices are connected and the network is created, the configuration is needed. We have two choices, the first is to configure the IP address in each computer in static way, conditions to respect are that the IP address is unique, correct in format, non-reserved one. Second choice is to use DHCP dynamic addressing where each computer is automatically assigned with a unique IP address by the simulator. To configure the computers, double click on the PC icon from the logical workspace, then go to the "config" tab in the prompted windows, from the left menu, go to network interface, click on it and under IP configuration you may select either DHCP or Static addressing where you have to enter the IP address and the network mask. For this example, we use the DHCP protocol (See Figure **17** for the steps).

5- **Testing the connectivity**: To test the configuration and the connectivity, we use the ICMP protocol (ping). To send the ping from one pc to another, click on the sender PC, then in Desktop Tab, select "command Prompt". In terminal, type ping <IP of destination>. To see the sent packet, either follow the sent and received packets from the Terminal (Textual mode, see Figure **18**) or use the graphical mode by clicking on simulation tab and run it or pause it as per your needs see Figure **19**.

Note: ICMP stands for Internet Control Message Protocol [6].

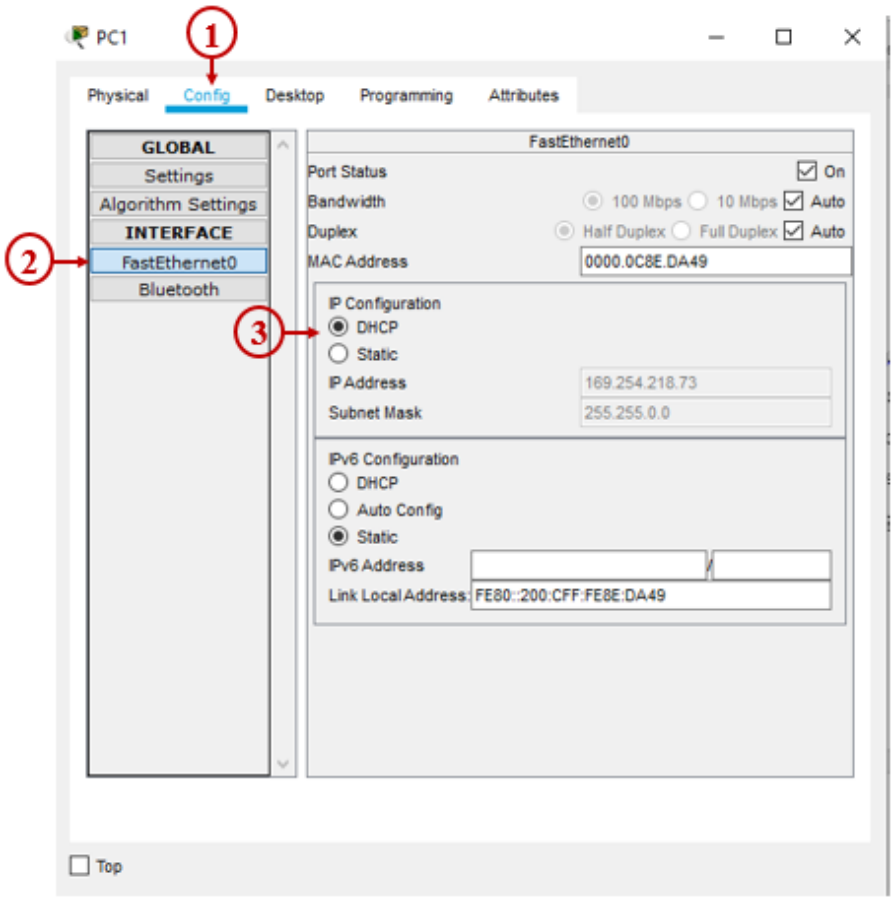


Figure 17: Network Configuration for PC

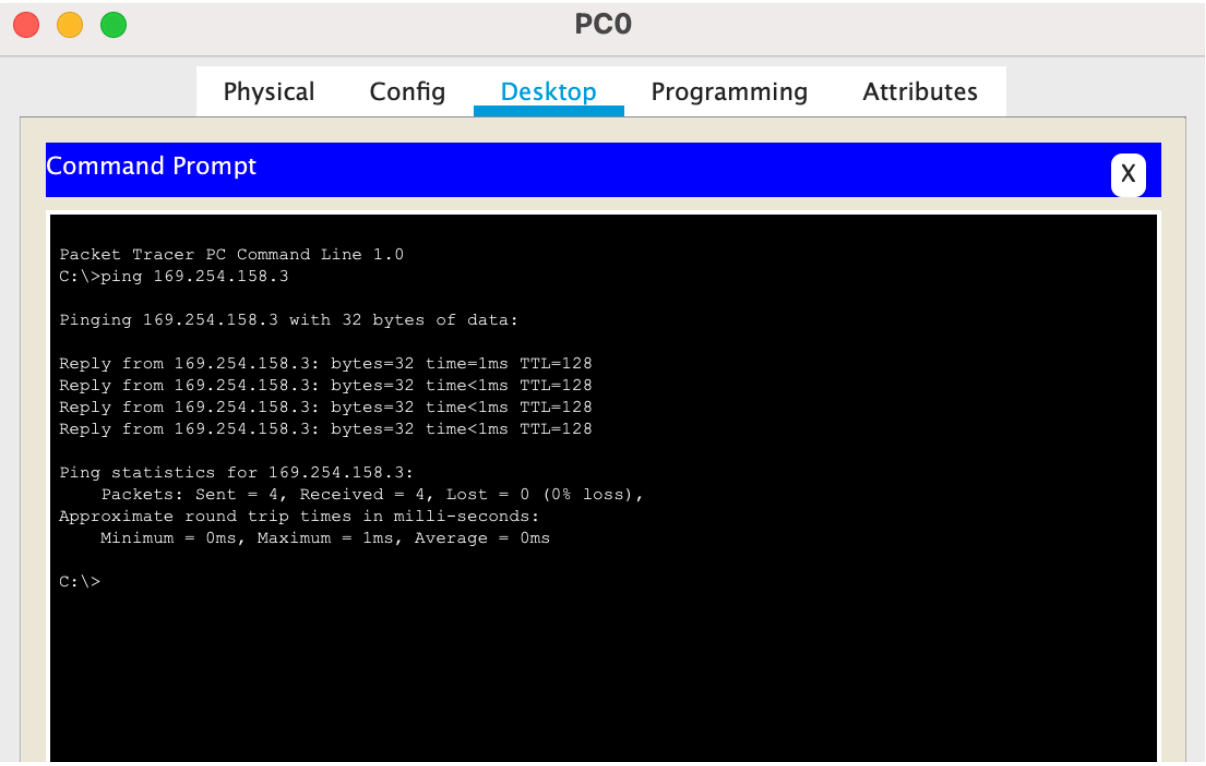


Figure 18: Ping textual mode

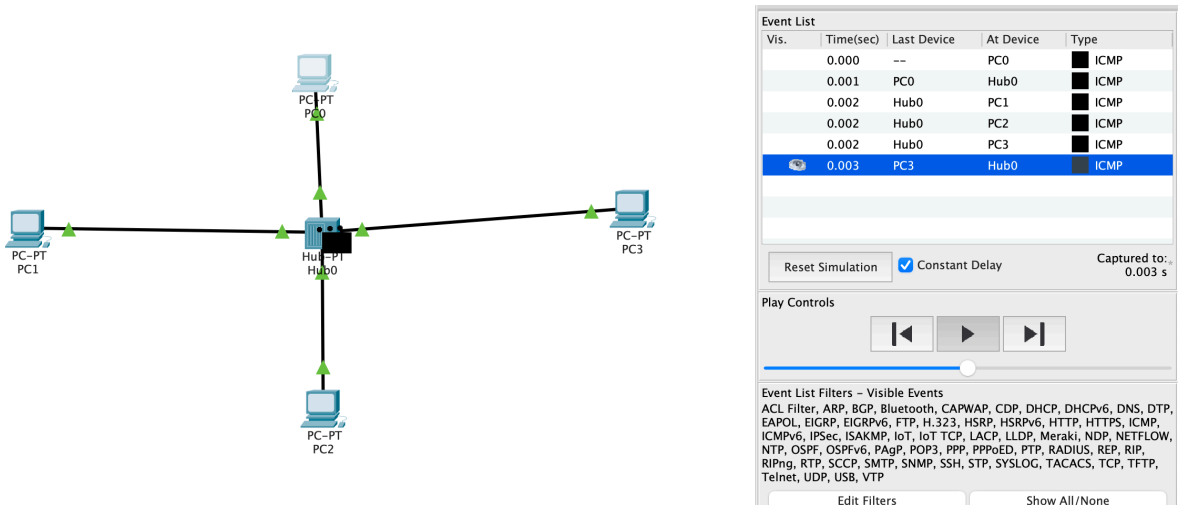


Figure 19: Ping graphical simulation mode

10.2.2. Switch-based network

Similarly, to how we formed the network using the hub. In this section, the network is created by connecting the devices using a switch. For ease of explanation, we form as an example a network containing two computers and a switch. This time we choose to configure the IP addresses statically. The steps of selecting the PCs are the same as the example above. To use a switch instead of a hub, follow the steps in Figure **20**. Figure **21** depicts the created network. The computers are configured to use the IP addresses 192.168.1.20 and 192.168.1.21, respectively. Figure **22** illustrates the configuration steps which are to double click the PC icon, then in desktop tab, select IP configuration and lastly enter a correct IP address and subnet mask.

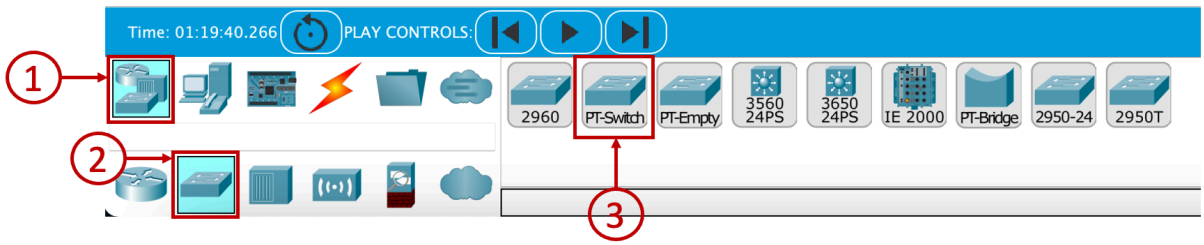


Figure 20: Selecting and using a switch

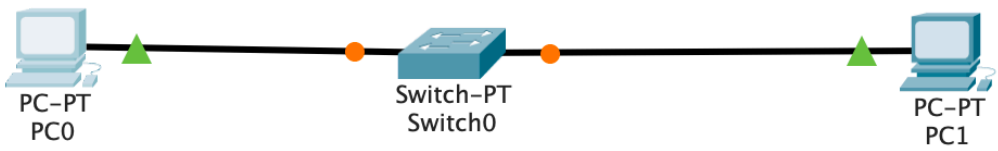


Figure 21: Example of Switch-based Network

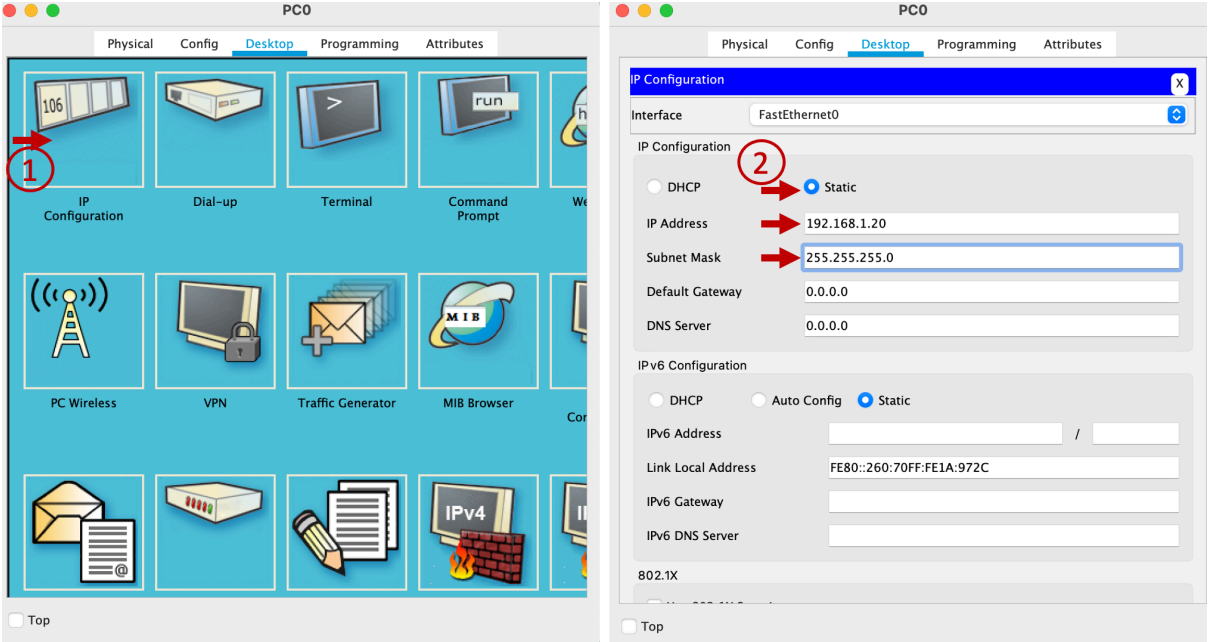


Figure 22: Steps to configure the IP address statically.

10.2.3. Access point configuration

To configure an access point, we explain the steps on the following example: select two laptops and insert them in the workplace (See Figure 23). Add to each laptop a wireless network interface like illustrated in the Figure 24. Select and insert an access point (see Figure 25 for the steps to follow). Then, configure the access point by setting a password (see Figure 26 for the steps). Noting that in this case, the Laptops must be configured to use this password (see Figure 27 for the steps). Similarly to the previous examples, the connectivity is tested by using the "ping" instruction and the result is illustrated in Figure 28.

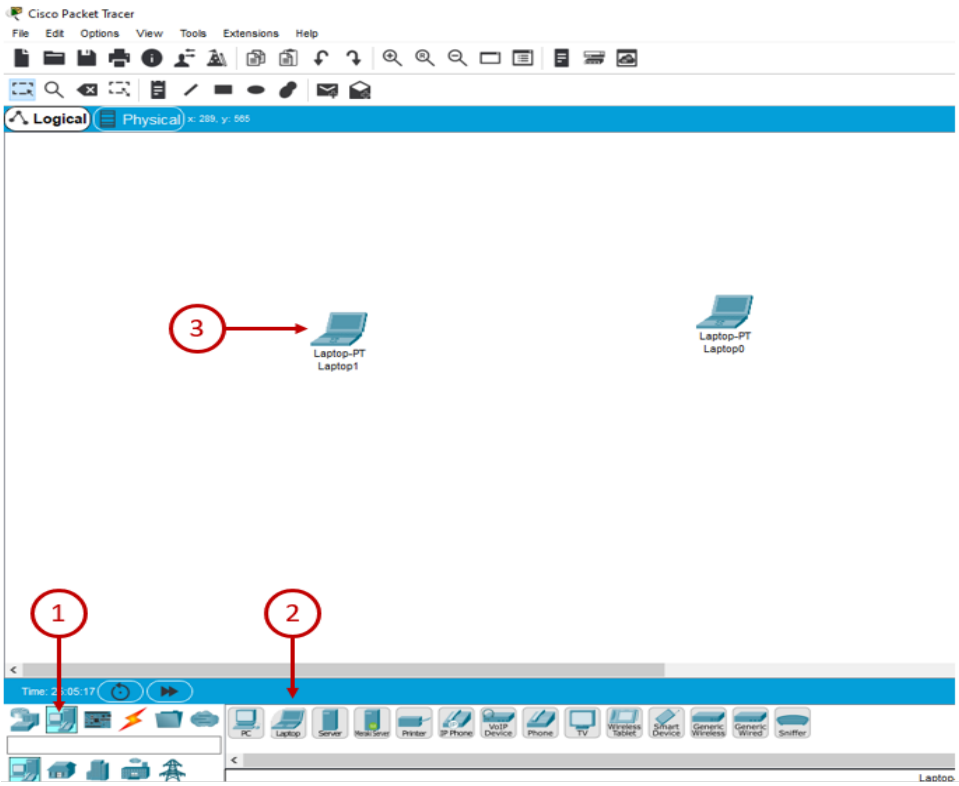


Figure 23: Inserting and Using Laptops in CPT

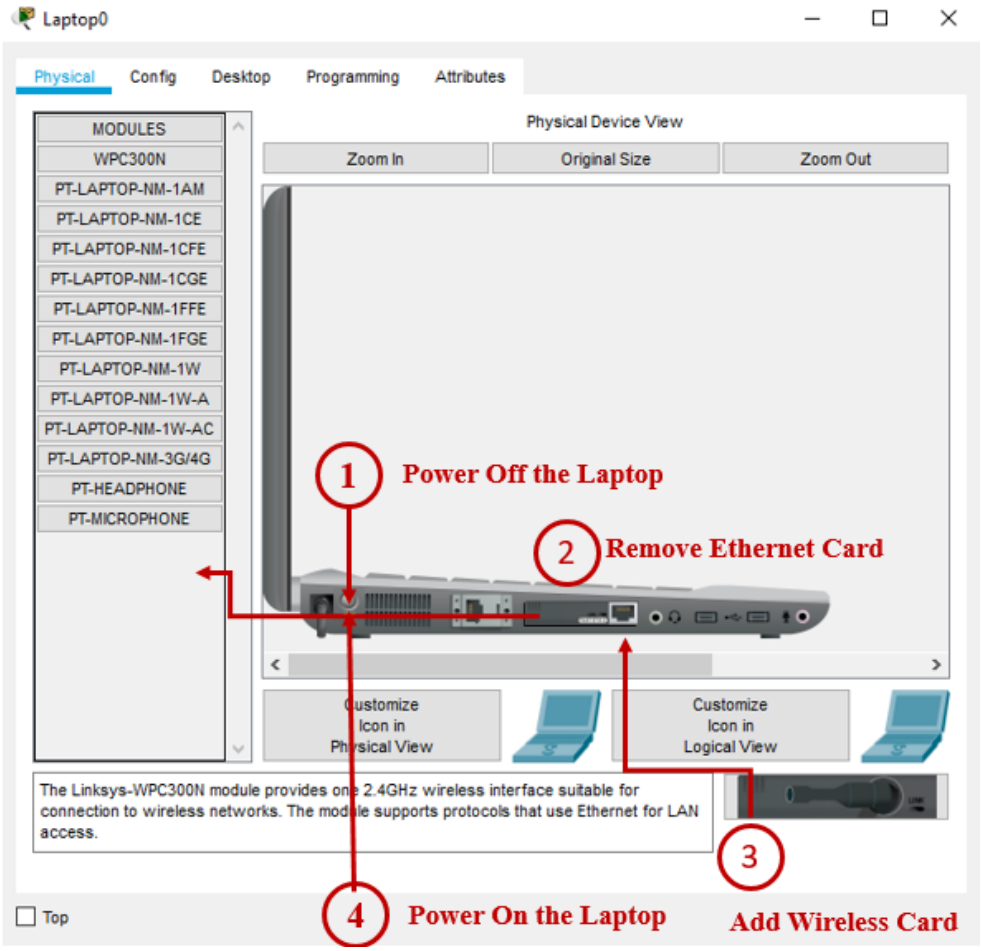


Figure 24: Adding a wireless network interface to laptop

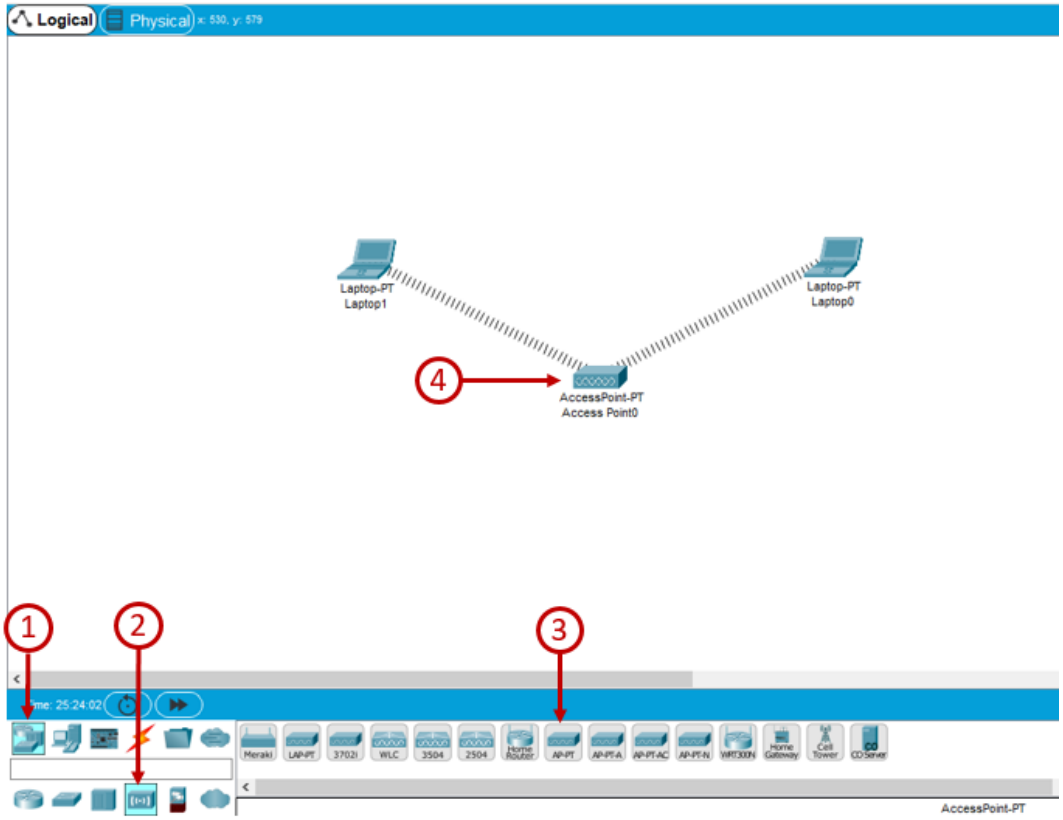


Figure 25: Adding and using access point

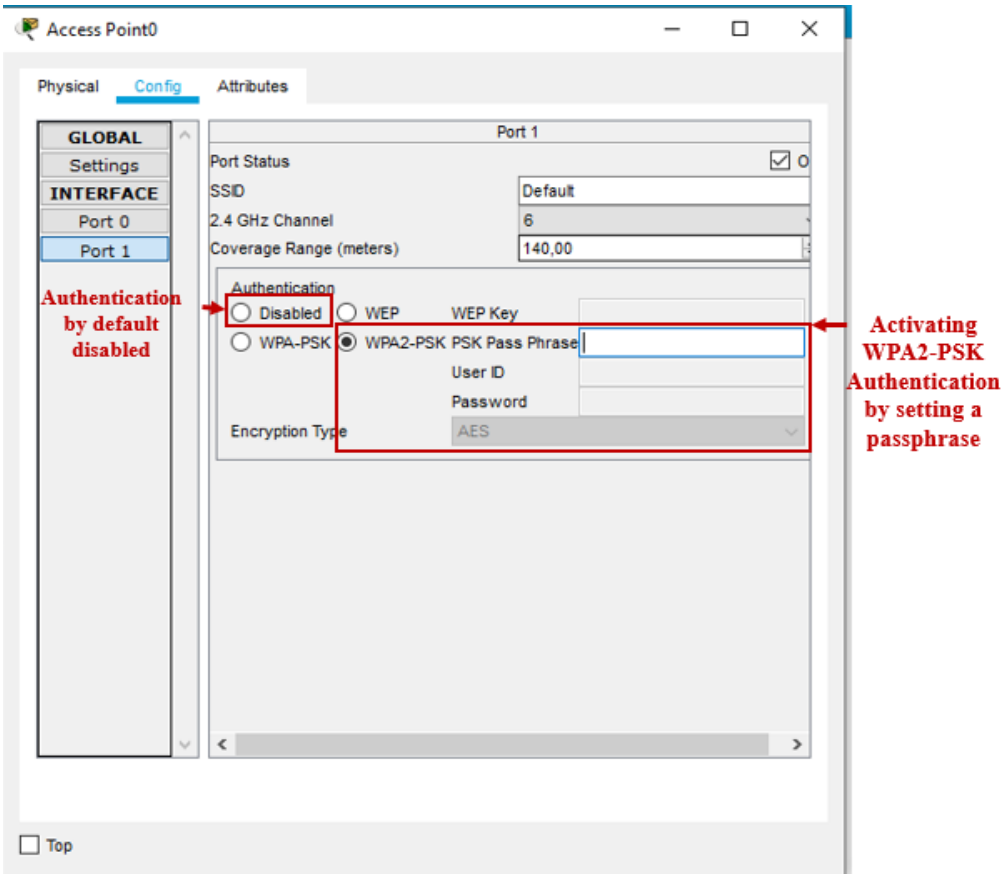


Figure 26: Access Point authentication configuration

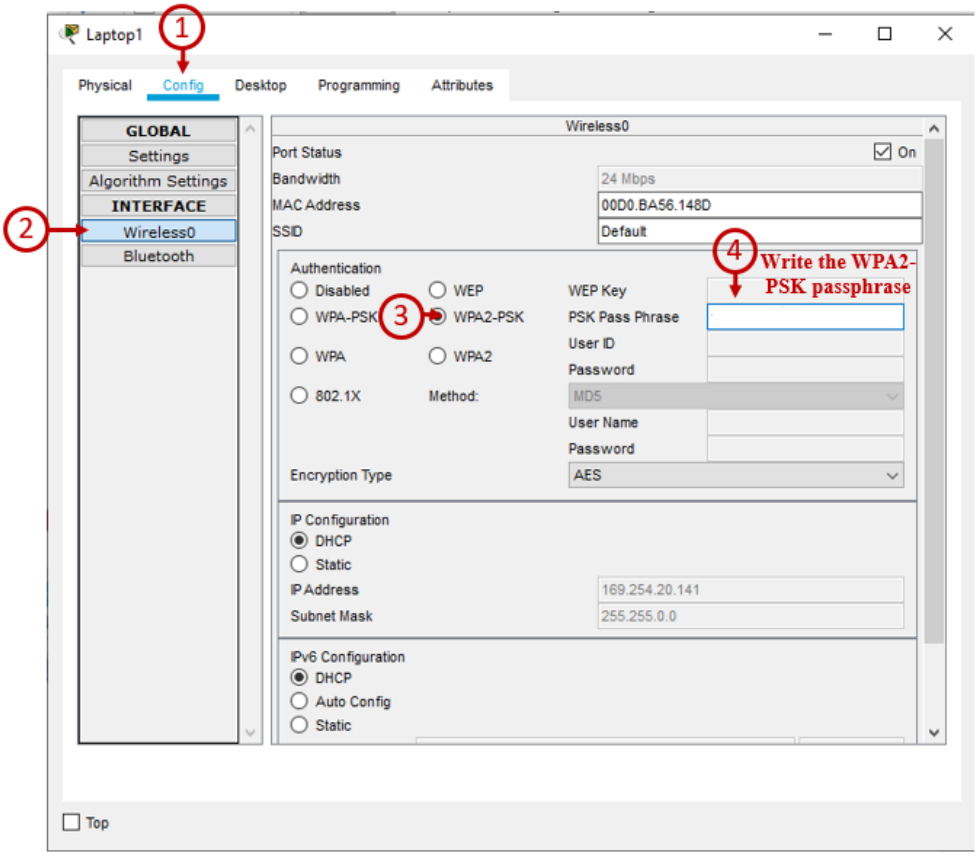


Figure 27: Laptop authentication to Access Point

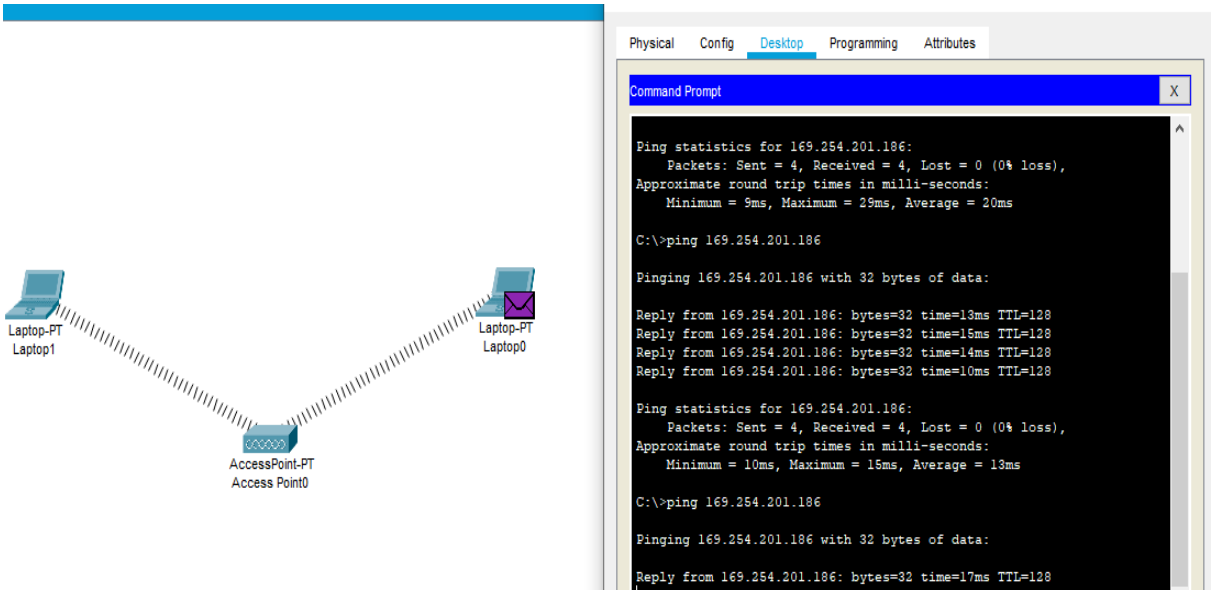


Figure 28: Connectivity Testing using Ping

10.2.4. Router configuration

There are two methods for the router configuration, the first is by using CLI (Command Line Interface), the second is by using the graphical interface. To configure a router, we explain

the steps on a simple example where a router has two interfaces each connected to a PC, like illustrated in Figure 29.

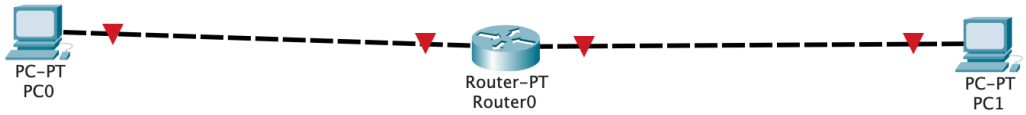


Figure 29: Router configuration Example

The steps to select and insert a PC is similar to those explained in section **10.2.1.** while the step to select and insert a router are depicted in Figure **30**. For the connection, we use a cross-over RJ45 cable following the cable use cases rules summarized in Section **3**, Table **3**. The connection steps are the same as in section **10.2.1.** except for the cable type which is cross-over instead of straight-through.

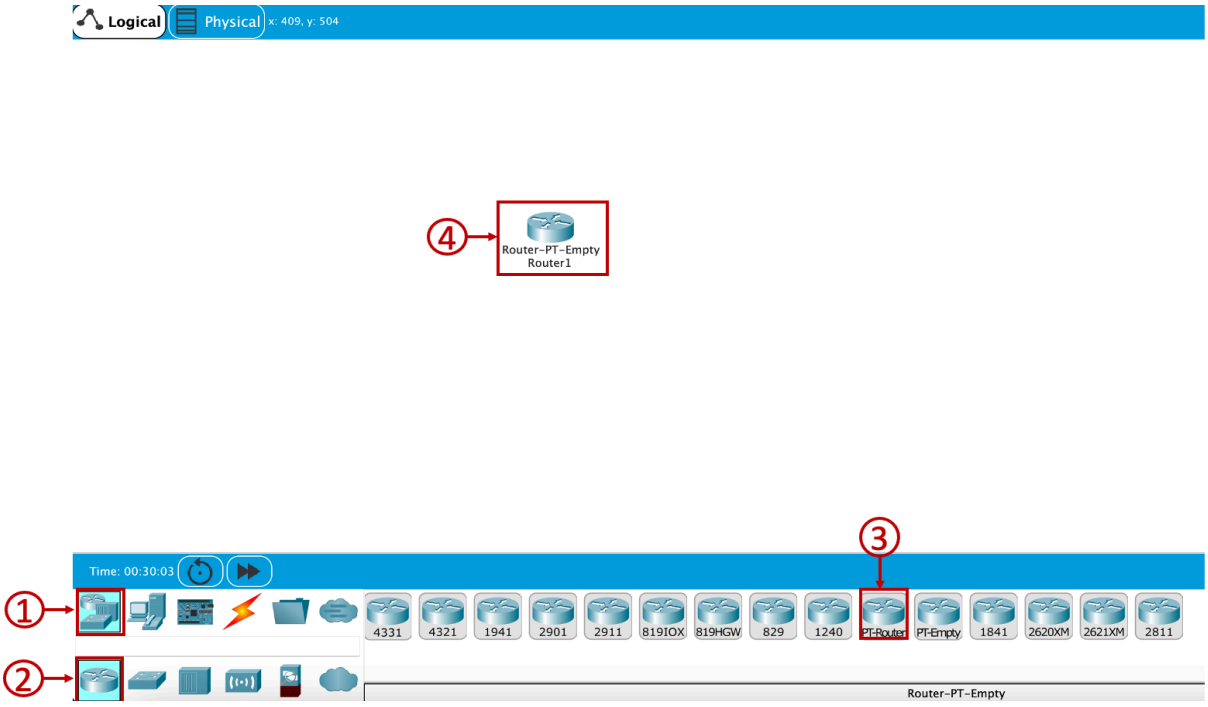


Figure 30: Inserting and using a Router

The router configuration interfaces (Graphical and CLI) are illustrated in Figure **31**. For the graphical interface, the user needs to set the IP address for each network interface and its subnet mask. To configure the router using the CLI, type the following commands [6]:

```
Enable
Configure terminal
interface FastEthernet0/0
ip address <ip address> <subnet mask> example : ip address 192.168.4.1 255.255.255.0
no shutdown
```

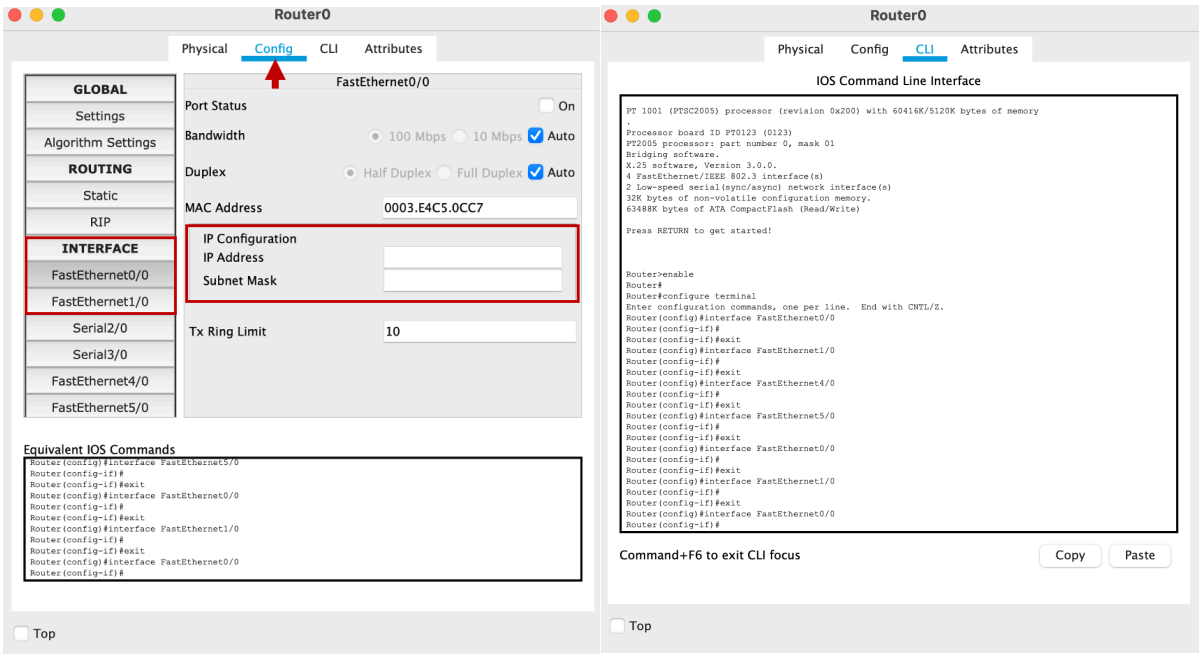


Figure 31: Router configuration, graphical mode on the left, CLI on the right

Change the gateway in the computer configuration to the address IP of the router interface its connected to and set the IP addresses of the PCs to static addressing, see the example in Figure 32.

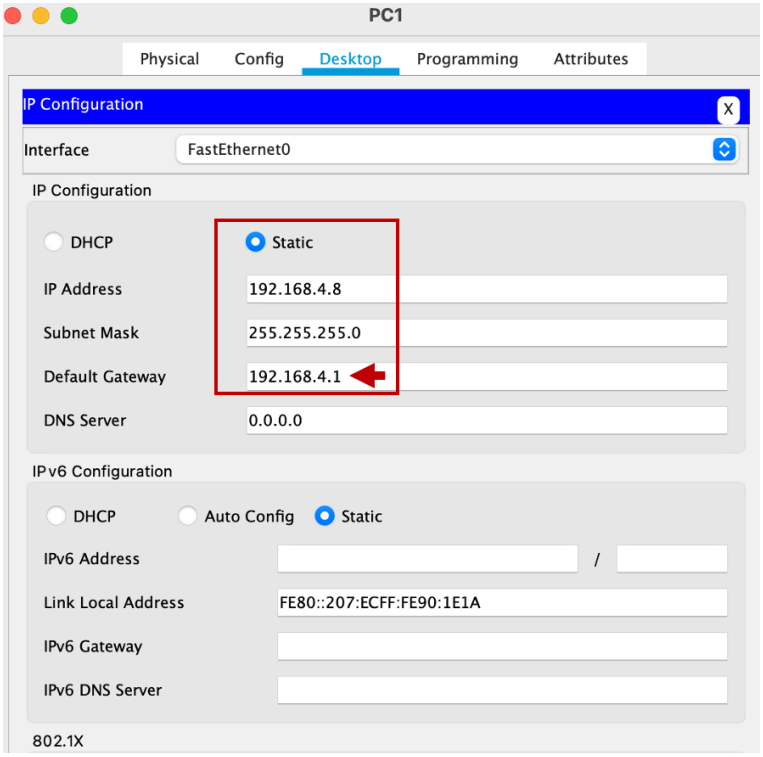


Figure 32: PC IP address configuration to use router interface (gateway)

Once the configuration is done, proceed to the connectivity testing phase by sending ping from PC0 to PC1 as illustrated in the previous subsections.

11. Activity Sheet

Activity 1

Follow the tutorial given in section 4 and change the network configuration of your computer from dynamic to static by assigning a unique IP address to it.

Activity 2

Share internet from your mobile phone to your computer by setting it as a hot spot (access point).

Activity 3

Turn your computer into an access point and share internet to your colleagues. Follow instruction in section 6 to do the activity.

Activity 4

Create ad hoc network and share files with your colleagues, follow the instructions given in sections 7 and 8.

Activity 5

Create a network and share the printing service amongst its computers. Noting that you only have one printer, the printer does not have network interface. See section 9 for guidelines.

Activity 6

Using CPT, connect two computers and test the connectivity between them using ping.

Activity 7

Using CPT, create the following network topology and test connectivity using ping. The topology is composed of two local networks (LN) connected by a router, in each LN there are four computers connected to a switch. The first network addressing is 192.168.5.0/24 while the second is 192.168.15.0/24. Visualize the exchanged messages in the graphical mode and simulation panel.

Activity 8

The same questions above on the following topology. The network is composed of three routers, one connected to a local network LN1, and the second connected to local network LN2 while the third connects the routers of LN1 and LN2. LN1 is composed of a switch and three computers. The network address is 192.168.7.0/24. LN2 is composed of four laptops connected

to an access point, the network address is 192.168.1.0/24. Use the drawing panel to add labels and to shade in different colors the local networks.

Activity 9

Using the CPT, create a network of computers and connect them to a printer. Test connectivity using ping.

Activity 10

Using the CPT, create a ring topology network composed of six computers. Test connectivity using ping.

12. Conclusion

We presented a tutorial like natured guide to cover the basic knowledge about networks. Although this guide helps students create networks and configure them, it is still not enough to develop advanced skills. Practice is key to mastering skills, therefore, students are invited to configure networks of different topologies either in real world or in simulation environment so as to get a wider idea of the possible issues to encounter and the ways to tackle them. furthermore, we advise them of getting certified trainings for their long-term professional plans. These certificates not only allow them to get hands-on experience on real devices but also help them acquire different levels of advanced networking concept which will help them in their professional journeys. Some of the useful certificates in a non-exhaustive listing are: Cisco Certificate [7], CompTIA Network+ [8], Huawei [9], Juniper Networks Certified Associate [10].

References

[1] C. CALECA, "Cablage de Réseau Ethernet," 02 04 2006. [Online]. Available: https://sitelec.org/cours/caleca/pc/cablage_reseau.html. [Accessed 18 08 2021].

[2] D. Labroche, "T568A vs T568B : Quelle est la Différence entre un Câble Droit et un Câble Croisé," 15 11 2018. [Online]. Available: https://cutt.ly/qQMzOftb3. [Accessed 18 08 2021].

[3] "Guru 99," [Online]. Available: https://www.guru99.com/difference-between-straight-through-crossover-cables.html. [Accessed 18 08 2021].

[4] "WikiHow," WikiHow, [Online]. Available: https://cutt.ly/KQ9JXoV. [Accessed 20 08 2021].

[5] "packet-tracer," Cisco Network Academy, [Online]. Available: https://www.netacad.com/courses/packet-tracer. [Accessed 26 08 2021].

[6] J. Postel, "Internet Control Message Protocol," RFC792, 09 1981. [Online]. Available: https://datatracker.ietf.org/doc/html/rfc792. [Accessed 24 09 2021].

[7] G. khaled, "TP.6 Mise en oeuvre du logiciel Packet Tracer,"Universite Larbi Ben M'hidi Oum El Bouaghi Departement De Mathematiques et Informatique" , Oum El Bouaghi , 2020.

[8] "Cisco training certifications," Cisco, [Online]. Available: https://www.cisco.com/c/en/us/training-events/training-certifications/certifications.html. [Accessed 16 09 2021].

[9] "CompTIA Network+," Comptia , [Online]. Available: https://www.comptia.org/certifications/network. [Accessed 16 09 2021].

[10] " HCSA-IP Network," Huawei, [Online]. Available: https://partner.huawei.com/university/weben/cert/cert.html?certId=CRE201701221601. [Accessed 16 09 2021].

[11] "Juniper Networks Certified Associate," Juniper, [Online]. Available: https://www.juniper.net/us/en/training/certification.html. [Accessed 16 09 2021].