Final assignment 2020-2021

NETWORKING

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CONTENTS

PART 1:

SECTHION 1: NETWORK TYPES:

PAN (Personal Area Network):

This network type specializes in connecting electronic devices within the user's immediate area and ranges from a few centimeters to a few meters and one of the most common examples in the real world of PAN is the connection between a Bluetooth earpiece and a smartphone, and it also features that it can connect laptops, tablets, printers and other computer devices and also can be PAN wired or wireless network and examples of wire connection are USB, FireWire and wireless are Bluetooth, Wi-Fi, IRDA and ZigBee and can be devices PAN share data with a few of them and often don’t include a router so it doesn't connect directly online but can be delivered to LAN and then connected to the internet [1].

LAN (LOCAL AREA NETWORK):

A network type that connects devices in a single physical location such as a building, office, or home and can be a small or large LAN network, such as a home network with a single and large user, such as an enterprise network with thousands of users or such devices in an office or school consisting of cables, access points, switches, routers and other components that enable devices to connect to internal servers, web servers and other LANs networks across the Wide Area Network and led to the emergence of virtualization has also fueled the development of virtual LANs, which enable network administrators to logically group network nodes and partition their networks without the need for significant infrastructure changes [2].
The advantages of LAN are that devices can use a single Internet connection, share files, print in shared printers, can be accessed and controlled by each other, they are used by schools, universities, companies, restaurants, cafes, shops, houses, and after the spread of Wi-Fi technology, LAN became widespread in almost every kind of environment, and wireless communication became LAN can connect every imaginable pc, printers, phones, smart TVs, speakers, and even coffee machines Refrigerators and children's toys generally have two types: 1. Client/server and 2. Peer-to-peer wherein client/server network customers connect to the server either by cables or wireless connection and can keep the range of applications on the LAN server and users can access databases and email with access to reading and writing by the network administrator and most of the large business networks, government and education are client/server LANs networks but peer-to-peer does not have a central server and cannot handle the heavy workloads of client/server, so it is smaller than it is, and also in peer-to-peer, devices share resources and data in wired or wireless communication with an adapter or router, mostly in home networks [2].

WIDE AREA NETWORK (WAN):

It is a large network that isn't linked to a single site and can facilitate communication, information sharing and other devices from all over the world through WAN, WANs networks are vital to international business but are also necessary for everyday use and the internet is one of the largest examples of WAN network in the world and is able to connect devices from multiple locations across the globe and WAN networks are the largest and most comprehensive computer networks available to date and are often created by information networks described as service providers who rent their WAN network to companies, schools, governments and the public and that they can use the network to migrate, store or communicate with other users in all countries and can be given special

access to WAN network through different links such as VPN, lines, wireless networks or cellular networks, restrictions and facilities are placed relative to the user's status and need to be met through the network and service providers will maintain the infrastructure of the network [3].

WAN and LAN are forms of the region's networks, but there is a big difference between them and WAN network varies in its reach all over the world without links to a physical site but through a rented network provider, and that the WAN network contains both LAN, PAN and MAN and if the WAN network doesn't exist, institutions will be isolated in restricted areas and local networks will be allowed to operate only within their buildings, as well as students at universities rely on them to reach universities to reach to library databases, university research or e-learning through certain applications in online education as well as shopping, banks and much more [3], but WAN network is always slower than LAN because the more distance the network becomes slower and one of the biggest and most important flaws and restrictions in the WAN network is its high cost and it is difficult to own a private WAN network and the high cost is due to the numbers of devices required to connect two places far apart and also difficult to get WAN network without ordering a special cable from the internet service provider and use their network or connect devices wirelessly using towers or satellites, they always require professional and high-end preparation and maintenance [4].

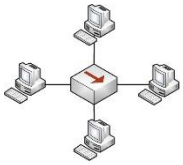
METROPOLITAN AREA NETWORK (MAN):

It is a computer network that connects computers within an urban area which can be a single large city or multiple cities and towns or any large area with many buildings and that this network is larger than a LAN network and smaller than a WAN network and that the term urban areas refers to the size and not the demographics of the area served by the MAN network and is built from the LANs network group connected and since it is smaller than wan it is more efficient where it does not have to Data to travel large distances business people, therefore, use them to combine multiple enterprise networks rather than run them by a single organization and often use fiber optic cables to form connections between LANs and extend between 5 to 50 km or wirelessly over the radio [5], wired connections are delivered via Ethernet and wireless via Wi-Fi and Bluetooth [6], its disadvantages are reduced to the difficulty of its ability to operate if the size and number of LANs increase in the size and number of LANs networks in it and also the different speed of the Internet because copper telephone wires cannot be used and copper wires affect the speed of the MAN network the cost of purchasing optical wires is high and in this network, there is a high risk of leaking data and information, unlike LAN network [7].

- Finally, I recommend that I use the LAN network for each building in all provinces and all LAN networks are connected to one WAN network for all provinces.

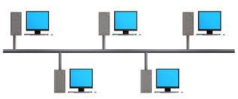
SECTHION2: PHYSICAL NETWORK TOPOLOGIES:

STAR TOPOLOGY:



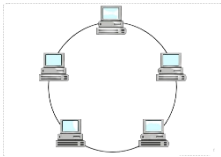
The star topology is located within the LAN network where all nodes are connected individually with a central point of contacts such as the hub or converter so in the star topology in case of cable failure will drop only one node and traffic begins from the main or central axis point so the central location controls all the associated nodes and usually, the central axis is a computer with high specifications and self-condensed and responsible for traffic access to all other nodes, However, the problems are in the central location, and if it is disabled, the network will fall, this is called signal point of failure [8].

BUS TOPOLOGY:



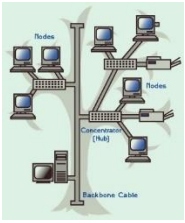
Also called line topology is a setup network where each computer and network device is connected to a single cable or spine, depending on the type of computer network card and the use of coaxial cable or RJ-45 network cable to connect them and the bus topology is characterized to work well within a small network and it is easy to connect computers and defects that it is difficult to explore and fix problems of individual devices and cannot work in large networks and need to have final connections to both ends main cable, any device that will be added will slow down the network and also in the bus there is only one device that can send data simultaneously and transmit data to only 500 meters and if a major cable is damaged, the network crashes or is divided into two parts [9].

RING TOPOLOGY:



In the ring network, each device, whether it's a workstation, server, or printer, is connected to two other devices, and this forms a loop of signals that move around it, where each data pack travels on the network in one direction, and each device that receives this information redirects it until it reaches the destination device and also has the same bus properties but closed from both directions, forming a ring and characterized by the speed of data transfer even if there are a large number of connected devices because the data flows in the direction of the bus only one so there won't be any data conflict but the main drawback is that if the main cable is damaged or there is a device malfunction, the entire network will fail because if one device weakens, it will weaken the entire network [10].

TREE TOPOLOGY:



In tree topology all computers are connected such as tree branches and in computer networks, they know it as a combination of the bus network and star-like and in the simplest form are in one path between any two nodes where it resembles the pattern of communication in the tree and is characterized mainly in flexibility and scalability better where a large number of star networks are connected using a conveyor and the main cable is the main track of the tree and other star networks such as branches and also in the case of damage to nodes other nodes aren't damaged, so it provides easy maintenance and error recognition it has the support of many hardware and software vendors, but it also has defects when the axis is damaged, the whole network will be damaged and difficult to form, and the tree network uses Ethernet protocol [11].

Comparison between star and bus topology:

Comparison in:	Star topology	Bus topology
1. **Length of cable connection used [9]**	Shorter [9]	Longer [9]
2. **How to connect devices**	All devices are connected to a central hub [12]	connected to a single cable which is known as the backbone [12]
3. **Having terminators**	Doesn't have any terminator [12]	Has a terminators at both end of the network [12]
4. **Cost of implementation and installation**	Has high implementation cost because of central hub and extra wires required for connection [12]	Less expensive than star topology [12]
5. **Data transfer speed**	Faster [12]	Slower [12]
6. **Transmission method**	The communication between nodes are done through central hub, message from sender node reaches central hub first then it is transmitted to receiver node [12]	The data from sender device to receiver device is sent directly [12]
7. **How to drop all the network**	If central hub fails then whole network fails [12]	The failure of the network cable will cause the whole network to fail [12]

SECTHION 3: NETWORKING PROTOCOLS:

NETWORK PROTOCOLS: A network protocol is a set of established rules for managing how data is transmitted between different devices on the same network. Essentially, it allows connected devices to communicate with each other regardless of their internal processes, structure, or design. Logs are the reason why you can easily communicate with people all over the world. Without the use of network protocols, local area networks (LAN) and wide-area networks (WAN) will not function as they do today [38].

OPEN SYSTEMS INTERCONNECTION (OSI) MODEL: OSI model (Open Systems Interconnection Model) is a conceptual framework for describing network system functions. The OSI model describes computing functions as a set of general rules and requirements to support interoperability between different products and software. In the OSI reference model, communication between computer networks is divided into seven different layers of abstraction: **Physical**, **Data Link**, **Network**, **Transport**, **Session**, **Presentation**, and **Application**. OSI was developed in the early days of network computing and was published by the International Organization for Standardization (ISO) in 1984. The OSI model is still used today to describe network architecture [39].

TCP/IP PROTOCOL:

TCP: TCP stands for Transmission Control Protocol a communications standard that enables application programs and computing devices to exchange messages over a network. It is designed to send packets across the internet and ensure the successful delivery of data and messages over networks.
TCP is one of the basic standards that define the rules of the internet. It is one of the most commonly used protocols within digital network communications and ensures end-to-end data delivery.
TCP organizes data so that it can be transmitted between a server and a client. It guarantees the integrity of the data being communicated over a network. Before it transmits data, TCP establishes a connection between a source and its destination, which it ensures remains live until communication begins. It then breaks large amounts of data into smaller packets, while ensuring data integrity is in place throughout the process, **TCP protocol in Transport layer** [40].

IP: The Internet Protocol (IP) is the method for sending data from one device to another across the internet. Every device has an IP address that uniquely identifies it and enables it to communicate with and exchange data with other devices connected to the internet.
IP is responsible for defining how applications and devices exchange packets of data with each other. It is the principal communications protocol responsible for the formats and rules for exchanging data and messages between computers on a single network or several internet-connected networks. It does this through the Internet Protocol Suite (TCP/IP) [40].
TCP and IP are separate protocols that work together to ensure data is delivered to its intended destination within a network. IP obtains and defines the address—the IP address—of the application or device the data must be sent to. TCP is then responsible for transporting and routing data through the network architecture and ensuring it gets delivered to the destination application or device that IP has defined [40], **IP protocol in Network layer.**

TCP/IP work:
The TCP/IP model is the default method of data communication on the Internet to enable the accurate and correct transmission of data between devices. It breaks messages into packets to avoid having to resend the entire message in case it encounters a problem during transmission. Packets are automatically reassembled once they reach their destination. Every packet can take a different route between the source and the destination computer, depending on whether the original route used becomes congested or unavailable, then TCP/IP goes through the layers in reverse order to put the message back into its original format. TCP also sends and receives packets from the network layer, handles the transmission of any dropped packets, manages flow control, and ensures all packets reach their destination [40].
The TCP/IP model defines how devices should transmit data between them and enables communication over networks and large distances. The model represents how data is exchanged and organized over networks. It is split into four layers [40].

The four layers of the TCP/IP models are as follows:

Data Link layer: The link layer defines how data should be sent, handles the physical process of sending and receiving data, and is responsible for data transmission between applications or devices on the network. This includes the definition of how data from devices and other communication methods should be sent. Devices in the network. It is also called the network access layer, network interface layer, or physical layer, and is a combination of the physical layer and the data link layer of the OSI model [40].

Transport: The transport layer is responsible for providing a strong and reliable data connection between the original application or device and the intended destination. At this level, the data is divided into packets and numbered to create a sequence. The transport layer determines the amount of data to be sent. The position and speed that should be sent ensure that the data packets are sent one after another without errors, and receive confirmation that the receiving agent has received the data packets [40].

Internet Layer: This layer, also known as the network layer, accepts and delivers packets for the network. This layer includes the powerful Internet Protocol (IP), the Address Resolution Protocol (ARP), and the Internet Control Message Protocol (ICMP) [40].

Application layer: The application layer refers to programs that need TCP/IP to communicate with each other. This is the level that users usually interact with, such as B. Email systems and messaging platforms. It combines the session, presentation, and application layers of the OSI model [40].

DHCP PROTOCOL:

Domain Host Configuration Protocol (application layer): DHCP is a communication protocol that network administrators can use to automatically assign IP addresses on the network. In an IP network, each device connected to the Internet needs a unique IP address. Allows network administrators to assign IP addresses from a central location and automatically send new IP addresses when the device connects from another location on the network. DHCP works on a client-server model [41].

Advantages:

Centralized management of IP addresses. Easily add new clients to the network. Reuse IP addresses to reduce the total number of IP addresses required [41].

Disadvantages:

Tracking Internet activity becomes tedious because the same device may have multiple IP addresses over a period of time. DHCP computers cannot be used as servers because their IP addresses will change over time [41].

HTTPS PROTOCOL:

HTPPs protocol: Hypertext Transfer Protocol Secure (HTTPS) is a secure version of HTTP, and is the main protocol for transferring data between web browsers and websites. HTTPS is encrypted to improve the security of data transmission. This is especially important when users submit sensitive information (such as logging in to a bank account, email, or health insurance). Any website, especially those that require credentials, should use HTTPS. In modern website browsers such as Chrome, the labels of websites that do not use HTTPS are different from them. Look for the green padlock in the URL bar to indicate that the website is safe. Web browsers take HTTPS seriously; Google Chrome and other browsers mark all websites that do not use HTTPS as insecure [42].

HTTPs Work: HTTPS uses an encryption protocol to encrypt communications. This protocol is called **Transport Layer Security** (TLS). Although it was formerly known as Secure Sockets Layer (SSL), the protocol protects communication with the so-called asymmetric public key infrastructure. Communication, this type of security system uses two different keys to encrypt the communication between the two parties. Private key: This key is controlled and kept secret by the website owner, and readers may guess it. This key is located on the Web server and is used. Decrypt the information encrypted with the public key. Public key: Anyone who wants to communicate securely with the server can use this key. Information encrypted with the public key can only be decrypted with the private key [42].

FTP PROTOCOL:

FTP Protocol: FTP (File Transfer Protocol) is a network protocol used to transfer files between computers using a Transmission Control Protocol/Internet Protocol (TCP/IP) connection. In TCP/IP data packets, FTP is considered an **application layer** protocol. The end user's computer is usually called localhost. The second computer involved in FTP is a remote host, usually a server. Both computers must be connected to the network and properly configured for FTP file transfer. The FTP service and FTP software must be installed and started on the client to access these services. Although the Hypertext Transfer Protocol (HTTP) (another protocol in TCP/IP packets) can be used for many file transfers, FTP is still widely used to transfer files in the background for other purposes, such as banking services. It is also sometimes used to download new applications through a web browser [43].

FTP work: FTP is a client-server protocol, which is based on two communication channels between the client and the server: a command channel for controlling dialogs and a data channel for transferring file content. Generally, users must log in to an FTP server, although some servers may provide part or all of the content without logging in. This mode is called anonymous FTP. When the user requests to download a file, the client initiates a dialogue with the server. Through FTP, the client can upload, download, delete, rename, move and copy files to the server [43].

CSMA/CD PROTOCOL:

Protocol is used in bus topology:

CAN communication protocol is CSMA/CD protocol in **physical layer**. CSMA stands for Carrier Sense Multiple Access, which means that each node in the network must monitor the inactivity of the bus for some time before attempting to send a message on the bus (carrier sense). When inactive, all nodes on the bus have the same ability to transmit messages (multiple access) CD stands for collision detection. If two nodes on the network start broadcasting at the same time, the node will detect the collision and take appropriate action [53]. CAN uses a non-destructive bit-by-bit arbitration technology, so even if a collision is detected, the message is still valid after the arbitration is completed. All of these arbitrations are performed without destroying or delaying the highest priority messages. To support non-destructive bit-by-bit arbitration, the logic state must be defined as dominant or recessive. The sending node must also monitor the bus state to find out whether the logic state it is trying to send is present on **the bus [53]**.

SECTION 4: NETWORK DEVICES:

REPEATER: Repeaters are network devices that amplify or regenerate an incoming signal before retransmitting it at the physical layer of the OSI model. They are used in networks to increase their coverage area. Signal boosters are another name for them. An electrical signal is attenuated when it is conveyed across a channel, depending on the nature of the channel or the technology. The length of the LAN or the service area of cellular networks is thus limited. Installing repeaters at regular intervals solves this problem [13].

HUB: A hub is essentially a multiport repeater with several ports. A hub is in the physical layer (layer 1), a hub joins many wires coming from different branches, such as the star topology connector that connects separate stations. Data packets are sent to all connected devices since hubs

cannot filter data. In other words, the collision domain of all Hub-connected hosts remains the same, they also lack the intelligence to determine the optimum routing for data packets, resulting in inefficiencies and waste [14].

SWITCH: When a device is attached to a switch, the switch records its media access control (MAC) address, which is a code embedded in the device's network interface card (NIC) that connects to the switch through an Ethernet wire. The MAC address is used by the switch to determine which associated device is sending outgoing packets and where incoming packets should be delivered. In contrast to the network layer (Layer 3) IP address, which can be assigned dynamically to a device and vary over time, the MAC address identifies the physical device [15]. When a device transmits a packet to another device, it enters the switch, which reads the packet's header to figure out what to do with it [15].
To limit the possibility of collisions between network traffic traveling to and from a switch and a connected device at the same time, most switches feature full-duplex functionality, in which packets arriving from and going to a device have access to the full bandwidth of the switch [15].
While switches do function at Layer 2, they can also operate at Layer 3, which is required to support virtual LANs (VLANs), which are logical network segments that cross subnets. Traffic must flow across switches to get from one subnet to another, which is helped by routing capabilities built into the switches [15].

ROUTER: A router is a networking device that sends data packets across a network of computers. Typically, this device is connected to two or more networks [16]. When a data packet arrives at a router port, the router examines the packet's address information to identify which port it will be routed to. A router, for example, connects your LAN to the Internet and gives you internet access [16].
When a packet arrives at a Router, it evaluates the destination IP address and makes routing decisions based on that information. Routing Tables are used by routers to identify which interface a packet will be delivered to. All networks for which routes are known are listed in a routing table. The routing table of each router is unique and is kept in the device's RAM [16].

Routing table: A routing table is a set of rules that determines where data packets going over an Internet Protocol (IP) network will be directed [17]. It is commonly presented in table format. Routing tables are used by all IP-enabled devices, including routers and switches. A routing table contains the information necessary to forward a packet along the best path toward its destination [17]. Each packet contains information about its origin and destination. When a packet is received, a network device examines the packet and matches it to the routing table entry providing the best match for its destination [17]. The table then provides the device with instructions for sending the packet to the next hop on its route across the network. A basic routing table includes information of destination, next hop, interface, metrics, and routes [17].

SECTION 5: SERVER TYPES:

INFRASTRUCTURE SERVER: An example is the **DNS server**; the domain name system is the phone book of the Internet, and DNS is responsible for finding the correct IP address for the domain name, or converting the name into an IP address when the user enters the name into a Web browser. The origin server or CDN edge server obtains website data. All of these are the responsibility of the DNS server: machines designed to respond to DNS

queries [18]. The four servers work together to send the IP address to the client in a normal non-cached DNS query: recursive resolver, root name server, TLD name server, and authoritative name server. A DNS resource (also called a DNS resolver) is a server that receives requests from DNS clients and then works with other DNS servers to find the correct IP address [18].

DNS infrastructure components: DNS infrastructure consists of 3 components. Type**: client resolver, local DNS server (LDNS)** and **authoritative DNS server (ADNS)**, of which top-level domain and root (gTLD server) are special cases. To perform a search, the client converter will query the LDNS server you configured, which will repeatedly query the required ADNS server to resolve the requested name-to-address mapping. **The DNS cost it depends on the zone and it is very low** [29]. Due to **performance optimization**, proactively monitoring the server to check availability and response time is essential for server management. Reliable network and server management software, OpManager actively monitors more than 300 key server performance indicators, such as CPU usage, disk usage, partition space usage, etc., as well as service and monitoring processes, **DNS** has **port number 53** in standard [29].

Software applications: Technitium, powerDNS, solarWinds, FusionLayer, Simple DNS Plus [31].

DNS server has custom Design **Rack Mount** System.

INFRASTRUCTURE SERVER: An example is the **DHCP** server; a network server assigns IP addresses, default gateways, and other network information to client devices automatically. To reply to broadcast inquiries from clients, it uses the standard Dynamic Host Configuration Protocol or DHCP. A DHCP server transmits the necessary network parameters to clients, allowing them to communicate successfully over the network. Without it, the network administrator must manually (static) configure each client who joins the network, which can be time-consuming, particularly in big networks. Each client is normally assigned a unique dynamic IP address via DHCP servers, which changes when the client's lease for that IP address expires [19].

DHCP works at the application layer to dynamically assign an IP address to a client by exchanging a series of messages known as DHCP transactions or DHCP conversations, **and DHCP is a software application not a hard ware** [20].

The cost of a DHCP server varies relative to the number of users, which is a **high** price compared to other servers [32].

Performance optimization DHCP servers just chug along happily in the background. A performance problem on a DHCP server could lead to some PCs being unable to lease an IP address at boot up. Although such a condition would likely be temporary in nature, it would impact your user's productivity and would cause the help desk to receive additional calls.

Many of the performance optimization techniques that you would use for optimizing a DHCP server are similar to the techniques that There are some Performance Monitor counters that are designed specifically with DHCP servers in mind [35]. DHCP server has custom Design **Rack Mount** System, DHCP has **port number 67** in standard [34].

Software application: Windows operating systems from Windows 98 to Windows 10 [33].

WEB SERVER: The web server, often known as an HTTPs server, is a piece of server software (or hardware dedicated to running a server software) that uses the World Wide Web and HTTPs to implement the

request/response model (protocol.) The HTTPs server uses the HTTP protocol to process incoming network requests from clients and serves material over the internet, the difference between HTTPs and HTTP is that HTTPs is a secure network through encryption and the HTTP doesn't contain security [21].

Web applications are a mixture of server-side and client-side code. Your application may have two aspects of **performance** issues that need to be **optimized**. The client is related to the performance displayed in the web browser. This includes loading the page for the first time. Time, load all resources, run JavaScript in the browser, etc. The server side refers to the time it takes for the server to complete the request. Optimizing server performance usually comes around optimizing things like database queries and other application dependencies [44].

HTTPs has **port number 443** in standard

Web server has custom Design **Rack Mount** System

The cost of the webserver is medium compared to other servers [45].

Software applications: IBM WebSphere Application Server, F5NGINX, Official G2 Survey, Oracle WebLogic [46]

The hardware that the server needs [47]:

Large	Medium	Small
Supports up to 7500 concurrent users.	Supports up to 1000 concurrent users.	Supports up to 400 concurrent users.
1 TB of disk space for cache	**500** GB of disk space for cache	**200** GB of disk space for cache
16 CPU cores	**12** CPU cores	**8** CPU cores
64 GB RAM	**32** GB RAM	**16** GB RAM

FILE SERVER: FTP stands for File Transfer Protocol and is used primarily to transfer files between different computers via the internet [23].

if I have server hosting, I can upload files to the server via FTP, ready for others to download. I can use FTP to connect to a remote computer and once connected, others can get files (receive) or put files (send), also Many file transfers can be performed using the Hypertext Transfer Protocol (HTTP), which is another protocol in TCP/IP packets, the cost of server it depends on your own company and its size but in general **the Cost** of FTP server it's **very high compared with other servers**. FTP server has custom Design **Rack Mount** System [24].

FTP is susceptible to problems caused by unpredictable delay, packet loss, congestion, and jitter. This directly leads to **performance** loss, which is why we use **Aryaka**. Duplication (**ARRTM**) and the combined effects of delays and protocol inefficiencies. Bandwidth usage has been reduced by 60-99%, and the round-trip cycle has been drastically reduced to 95%. In addition, Aryaka's dedicated, private, and secure network minimizes latency fluctuations and maximizes available bandwidth, **FTP** has **port number 21** in standard [22]. **Software applications**: software for Windows, Linux, Mac OS, and Solaris [36].

Minimum Hardware Requirements [48]:

1GHz or Higher CPU
2 GB RAM
100GB Hard Drive
Broadband Internet Connection

MAIL SERVER**:** A mail server (sometimes called an e-mail server) is a server that processes and transmits e-mail over a network (**usually the Internet**). The mail server can receive e-mails from client computers and send them to other mail servers. The mail server can also send emails to client computers. **SMTP** is an acronym for Simple Mail Transfer Protocol and is used to send e-mail from a client to a server and from a server to other servers. When you download an email to an email program, the program connects to a server on the network called a **POP3** server. The **POP3** server uses the **POP3** protocol for communication [25]. The cost of mail server in the most expensive types does not exceed a little part from the cost of ftp server [26]. The **email infrastructure** is a system designed to ensure the delivery of any newsletters or transaction emails you send and **the cost** of email server is low compared between other servers**, SMTP** has **port number 25, POP3** has **port number 110** in standard. It usually consists of the following components: **IP address**, **mail proxy**, **feedback loop**, and **email reputation management tools** [27]. **For performance optimization**: Use out-of-the-box mail server monitoring tools to track email performance, allowing you to discover SolarWinds-related behaviors Mode® Server and Application Monitor (SAM) is designed to provide complete insight into the end user experience of Microsoft Outlook Web Access and other key webmail clients [30]. Mail server has custom Design **Rack Mount** System. **Software applications:** Microsoft Outlook, Gmail, Official G2 Survey, Front, Zoho Mail [37].

Perfect Hardware tools [49]:

- **Hard ware**
  - **32 x 3.3GHz CPU cores (Quad Intel Xeon E5-4627 3.3GHz 8-core processors)**
  - **128GB of RAM**
  - **1 x 1.2TB Intel 750 PCIe SSD drive for GreenArrow's queue and statistics**
  - **GreenArrow's PostgreSQL database is split between:**
    - **RAID 1 array of 2 x 1.2TB Intel 750 PCIe SSD drives**
    - **Two separate RAID 1 arrays, each containing 2 x 1.2TB Intel DC S3710 SSD drives**
- **System Utilization:**
  - **CPU: fully utilized at peak sending speed; this was the bottleneck of the system**
  - **RAM: fully utilized**
  - **Storage IO: never close to saturation. In fact, the entire system would not even saturate the IOPS capacity of a single 1.2TB Intel 750 PCIe SSD drive.**

SECTION 6: THE REALTIONSHIP BETWEEN THE SOFTWARE AND HARDWARE

Software: is a set of instructions, data, or programs used to operate a computer and execute specific tasks [50].

Hardware: computer hardware refers to the physical parts of a computer and related devices. Internal hardware devices include motherboards, hard drives, and RAM. External hardware devices include monitors, keyboards, mice, printers, and scanners [51].

Software and hardware are two things that depend on each other, if hardware is without software, just like I connected hardware to electricity and powered it, but this power won't do any service through the device.

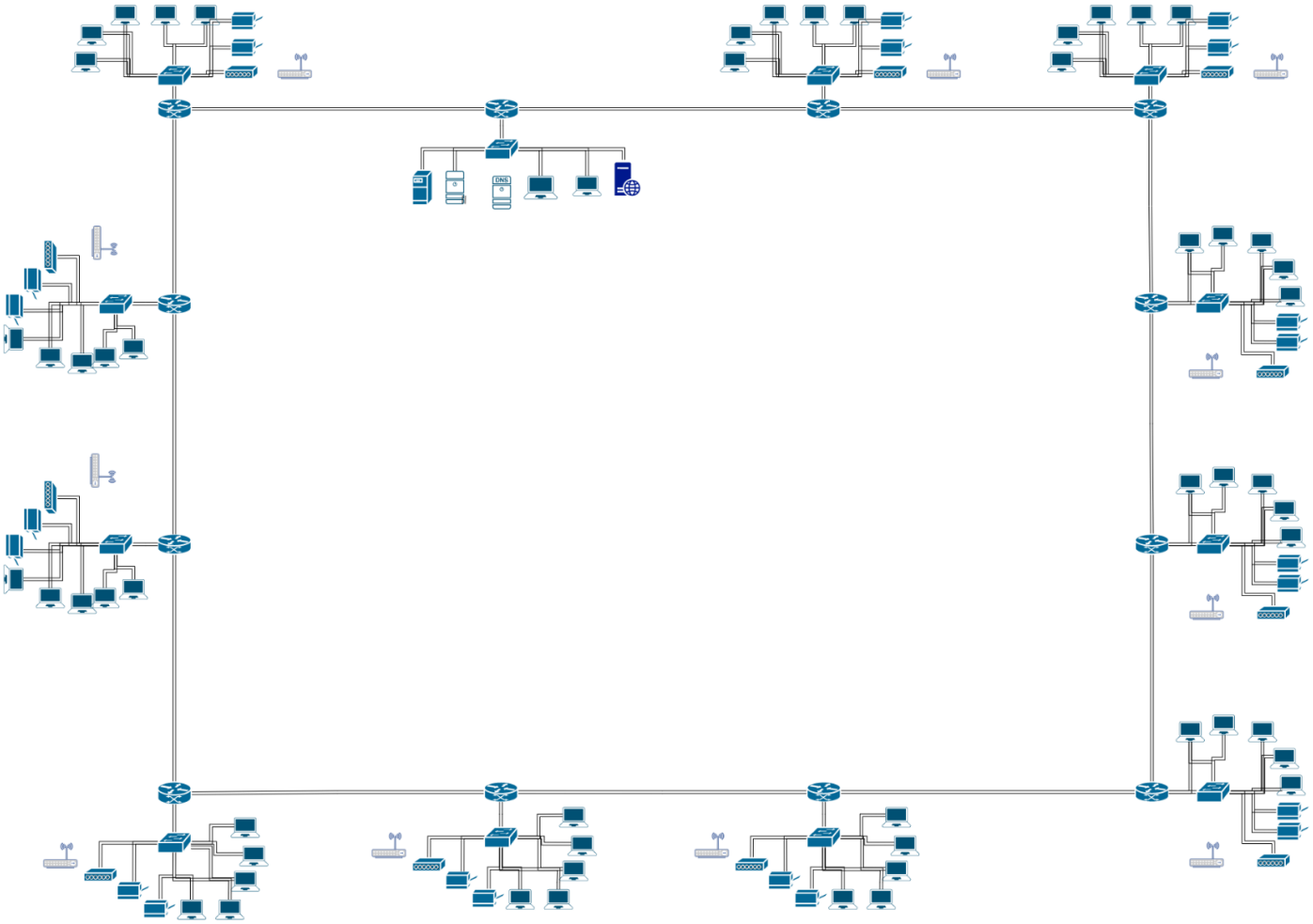
An example of a device that needs software to work is the Network Interface Card (NIC).

An example of a device that needs hardware to work is the Dynamic Host Configuration Protocol (DHCP).

PART 2:

SECTION 2.1:

1. A) DESIGN EFFICIENT NETWORKED SYSTEMS:



B) For each network I provided the following information:

- The services devices I used are: 12 router (1941), 12 switch (2950-24), 24 Printer-PT, 57 PC-PT, 11 AccessPoint-PT, 11 Generic Wireless (WirelessEndDevice-PT), 4 Server-PT, Straight Cables between (Routers and Switches) and between (switches and PCs, Printers, AccessPoints) Serial DCE and DTE cables between Routers, Place Note

- I chose (192.168.55.0/24) a classless IP addresses for subnetting that has the subnet mask (255.255.255.240), and I chose IP addresses for routers from 10.0.0.0/30 to 120.0.0.0/30 to use one of them in each network between routers.
  I did IP subnetting through these steps:
  1. We want 12 subnets, 11 subnets for one filed hospital and subnet for the headquarter
  2. We have 8 bits for the host and we will use 4 of it to distribute twelve networks
  3. number of subnets = 12
     2^x = number of subnets = $2^x = 12 \longrightarrow x = 4$
     New mask = 8N.8N.8N.4N+4H = 255.255.255.240
  4. Block size (number of hosts):
     2^y (y = number of hosts) $\longrightarrow 2^4 - 2 = 16 - 2 = 14$

  So, there are 14 hosts for each subnet and 16 hops between each subnet

Headquarter-Amman	
Subnet IP	192.168.55.0
First Valid IP	192.168.55.1
Last Valid IP	192.168.55.14
Gateway IP	192.168.55.1
Broadcast IP	192.168.55.15
DHCP IP	192.168.55.2
HTTPs and DNS IP	192.168.55.3
FTP IP	192.168.55.4
Email IP	192.168.55.5

Amman	
Subnet IP	192.168.55.16
First Valid IP	192.168.55.17
Last Valid IP	192.168.55.30
Gateway IP	192.168.55.17
Broadcast IP	192.168.55.31

Zarqa	
Subnet IP	192.168.55.32
First Valid IP	192.168.55.33
Last Valid IP	192.168.55.46
Gateway IP	192.168.55.33
Broadcast IP	192.168.55.47

Irbid	
Subnet IP	192.168.55.48
First Valid IP	192.168.55.49
Last Valid IP	192.168.55.62
Gateway IP	192.168.55.49
Broadcast IP	192.168.55.63

Madaba	
Subnet IP	192.168.55.64
First Valid IP	192.168.55.65
Last Valid IP	192.168.55.78
Gateway IP	192.168.55.65
Broadcast IP	192.168.55.79

Jarash	
Subnet IP	192.168.55.80
First Valid IP	192.168.55.81
Last Valid IP	192.168.55.94
Gateway IP	192.168.55.81
Broadcast IP	192.168.55.95

Ajloun	
Subnet IP	192.168.55.96
First Valid IP	192.168.55.97
Last Valid IP	192.168.55.110
Gateway IP	192.168.55.97
Broadcast IP	192.168.55.111

Mafraq		Karak		Ma'an		Tafelah	
Subnet IP	192.168.55.112	Subnet IP	192.168.55.128	Subnet IP	192.168.55.144	Subnet IP	192.168.55.160
First Valid IP	192.168.55.113	First Valid IP	192.168.55.129	First Valid IP	192.168.55.145	First Valid IP	192.168.55.161
Last Valid IP	192.168.55.126	Last Valid IP	192.168.55.142	Last Valid IP	192.168.55.158	Last Valid IP	192.168.55.174
Gateway IP	192.168.55.113	Gateway IP	192.168.55.129	Gateway IP	192.168.55.145	Gateway IP	192.168.55.161
Broadcast IP	192.168.55.127	Broadcast IP	192.168.55.143	Broadcast IP	192.168.55.159	Broadcast IP	192.168.55.175

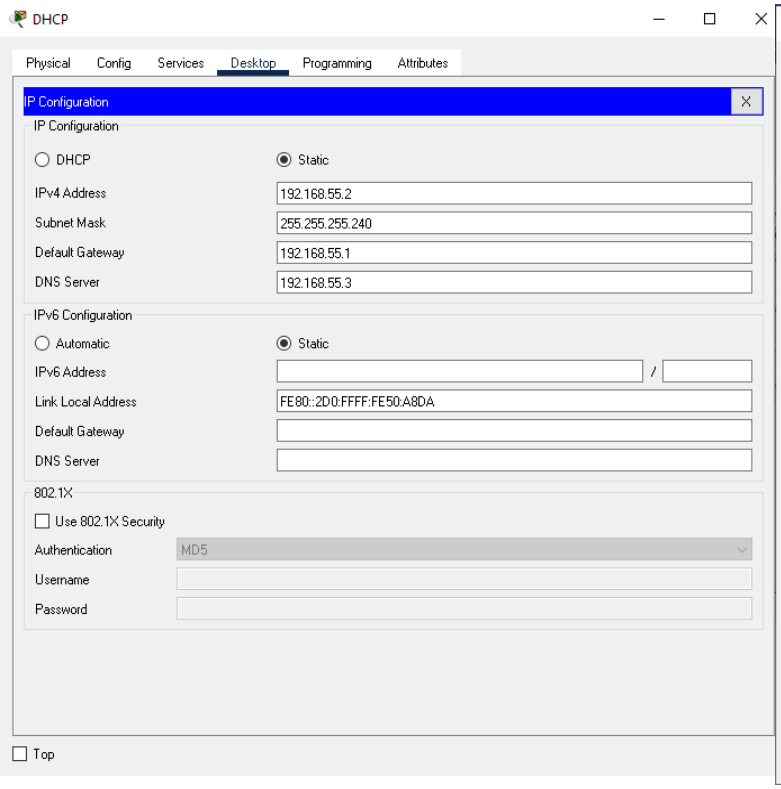
Aqaba	
Subnet IP	192.168.55.176
First Valid IP	192.168.55.177
Last Valid IP	192.168.55.190
Gateway IP	192.168.55.177
Broadcast IP	192.168.55.191

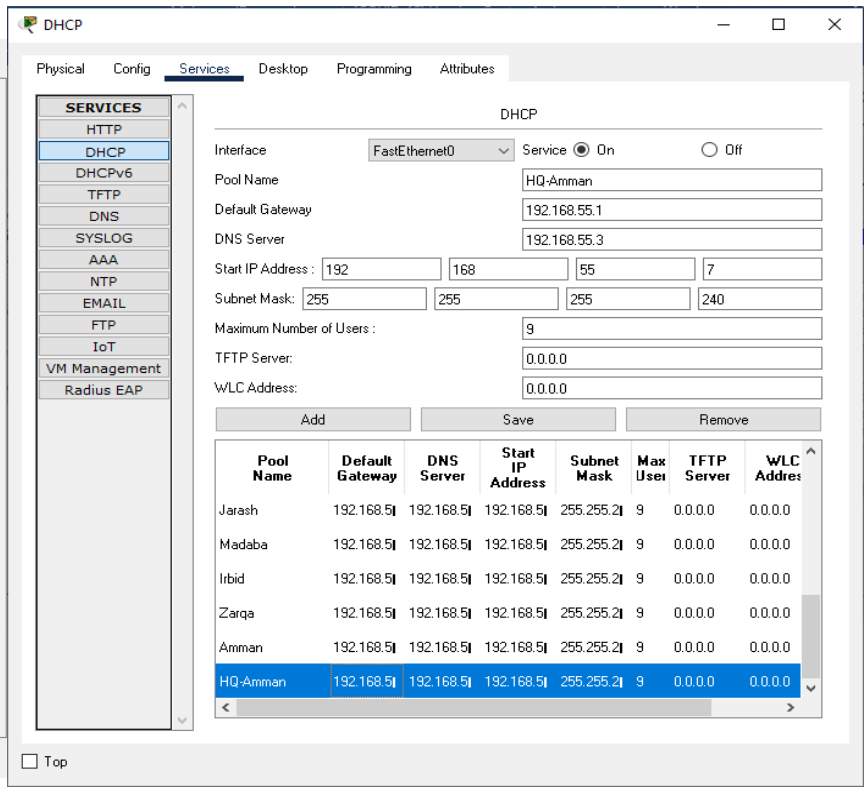
Routers	IP address	First Valid IP	Second Valid IP	Subnet Mask
Router Network-1	10.0.0.0	10.0.0.1	10.0.0.2	255.255.255.252
Router Network-2	20.0.0.0	20.0.0.1	20.0.0.2	255.255.255.252
Router Network-3	30.0.0.0	30.0.0.1	30.0.0.2	255.255.255.252
Router Network-4	40.0.0.0	40.0.0.1	40.0.0.2	255.255.255.252
Router Network-5	50.0.0.0	50.0.0.1	50.0.0.2	255.255.255.252
Router Network-6	60.0.0.0	60.0.0.1	60.0.0.2	255.255.255.252
Router Network-7	70.0.0.0	70.0.0.1	70.0.0.2	255.255.255.252
Router Network-8	80.0.0.0	80.0.0.1	80.0.0.2	255.255.255.252
Router Network-9	90.0.0.0	90.0.0.1	90.0.0.2	255.255.255.252
Router Network-10	100.0.0.0	100.0.0.1	100.0.0.2	255.255.255.252

Router Network-11	110.0.0.0	110.0.0.1	110.0.0.2	255.255.255.252
Router Network-12	120.0.0.0	120.0.0.1	120.0.0.2	255.255.255.252

C)

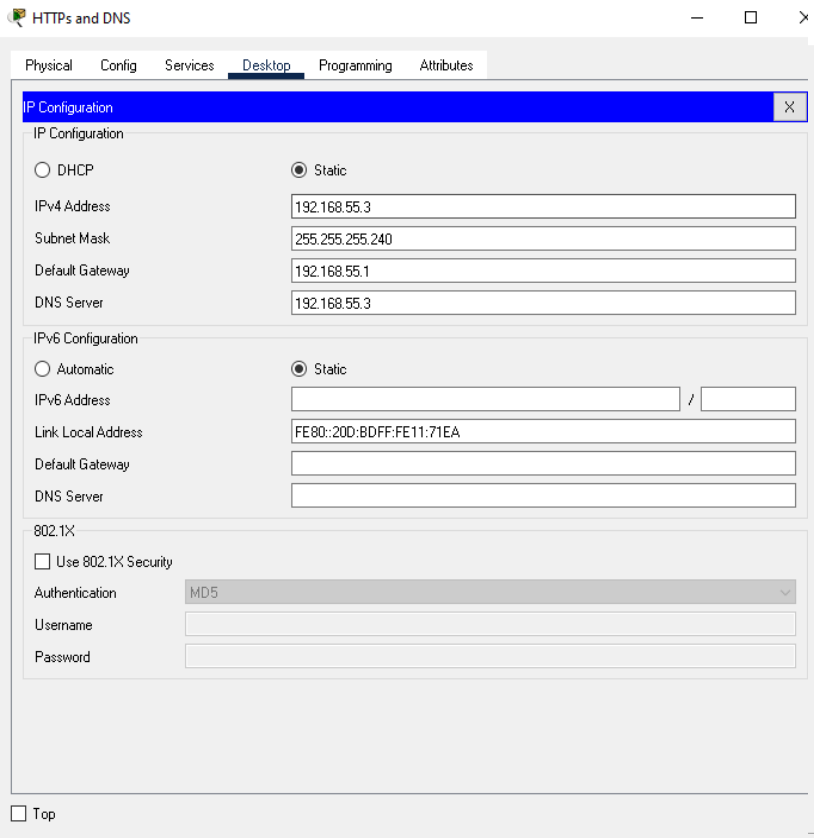
1- **DHCP server:**

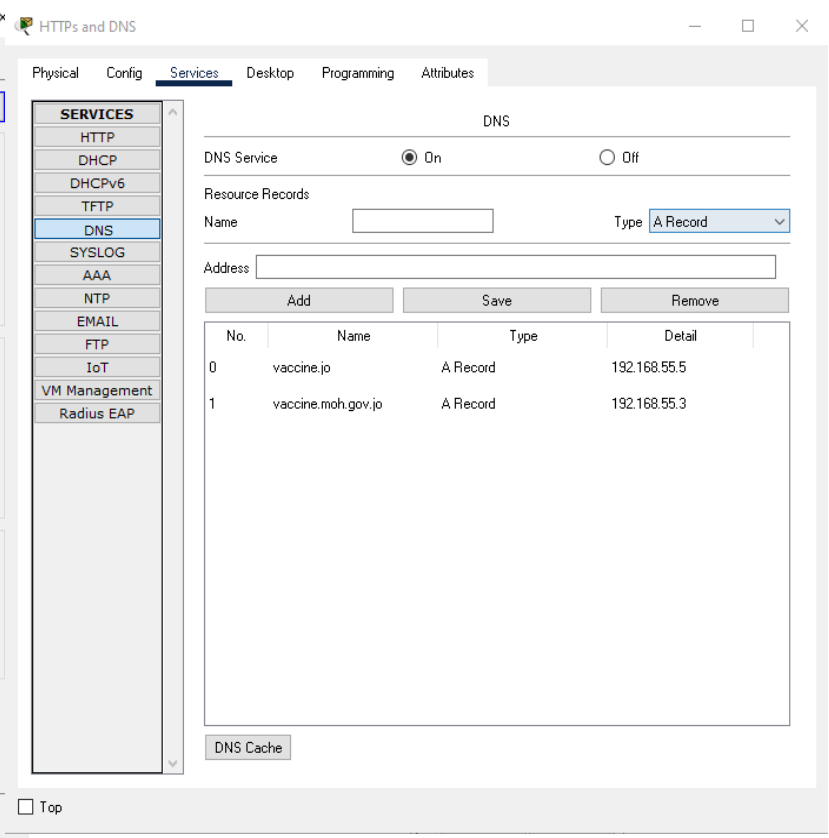




At first, I gave the DHCP server Ip address that I had already booked in the subnet of static Ip addresses, and then I clicked on the DHCP server, then on icon desktop and then on Ip configuration icon, and I entered the IP (192.168.55.2) in the static in the right place and entered the subnet mask for the network (255.255.255.240), the Gateway for this network (192.168.55.1) and the Ip address that I have also booked for DNS (192.168.55.3).
I clicked on the services icon and on the DHCP icon, in the first I turned it on and put a pool name in the name of my first network, HQ-AMMAN and Gateway for HQ-AMMAN, which is (192.168.55.1), and Ip address for DNS server (192.1. 68.55.3) Ip addresses in this network start from (192.168.55.7) I have booked it 7 for static and put the standard subnet mask for all networks (255.255.255.240), I pressed add and then I repeated the process for all other networks but I booked only 5 static Ip and eventually I pressed the serverPool and made sure that all its values are equal to zero so as not to give any Ip address and don't affect the other pools and in order for DHCP to do properly I activated the rely agent on all routers so that they do not delete the message broadcast and transmitted to unicast that must go out and go to and from DHCP server.

2- **DNS server:**

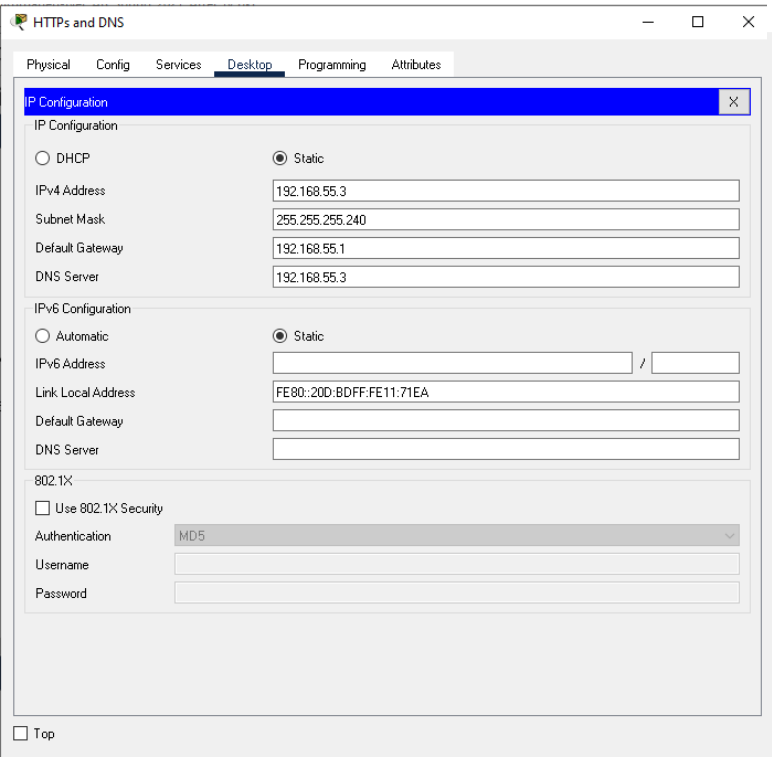


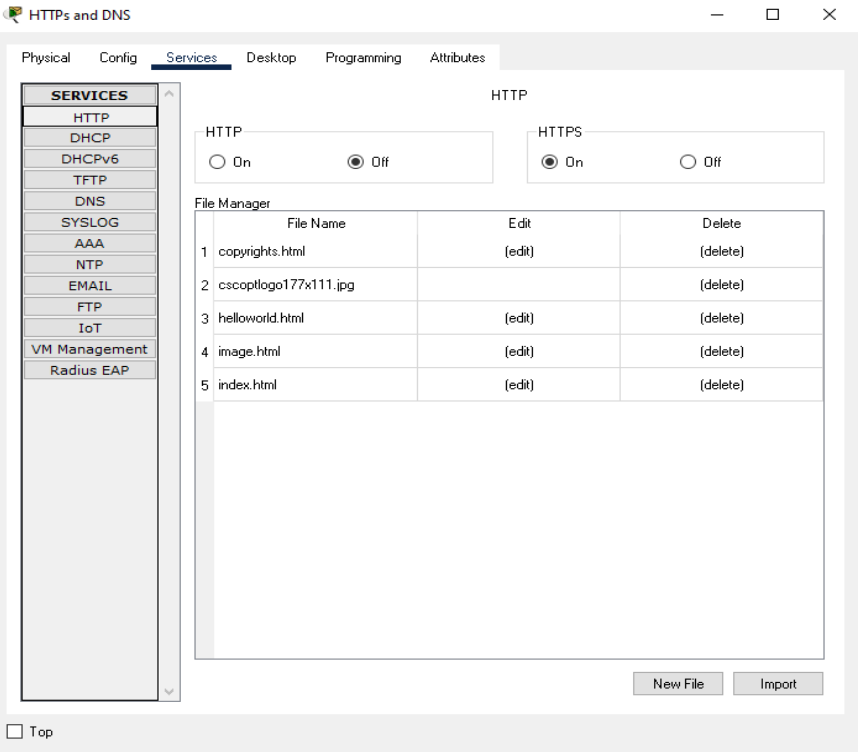


At first, I gave the DNS server Ip address that I had already booked in the subnet of static Ip addresses, and then I clicked on the DNS server, then on icon desktop and then on Ip configuration icon, and I entered the IP (192.168.55.3) in the static in the right place and entered the subnet mask for the network (255.255.255.240), the Gateway for this network (192.168.55.1) and the Ip address that I have also booked for DNS (192.168.55.3).

I clicked on the services icon and on the DNS icon, in the first I turned it on and put a name in the name label of my first network to turned Ip of the website in the website server (HTTPs) (192.168.55.3) to the name of website (vaccine.moh.gov.jo), with added Ip address for it (192.1. 68.55.3) and I pressed add as a record, I added another record for the DNS server with all steps I previously said it but in different IP address which I booked to email server (192.168.55.5) to mapping it to name for the domain (vaccine.jo) from email server and pressed add as a record

3- HTTPs server

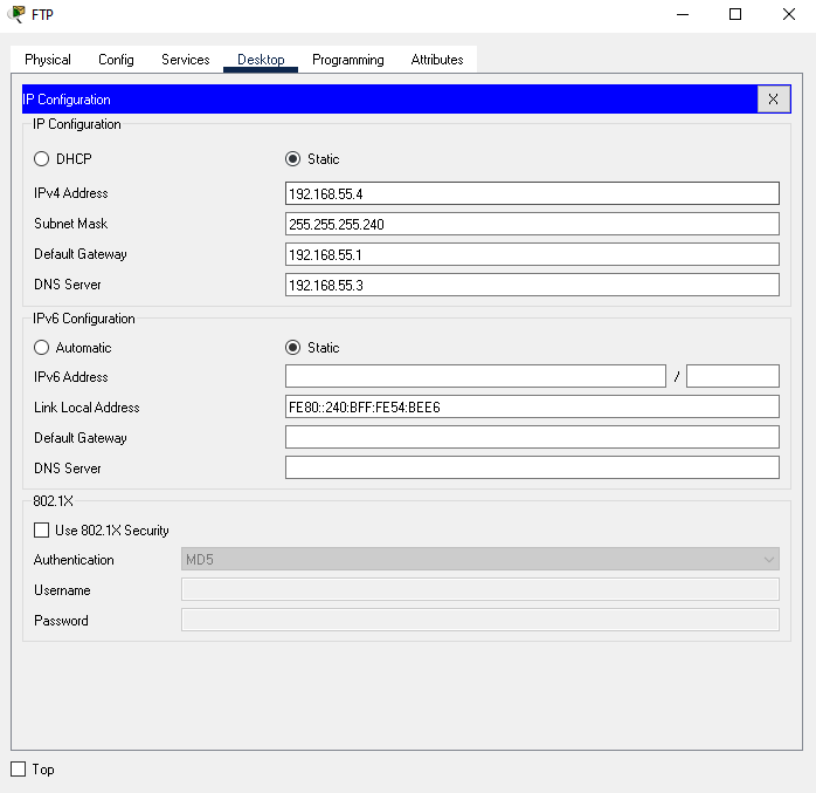


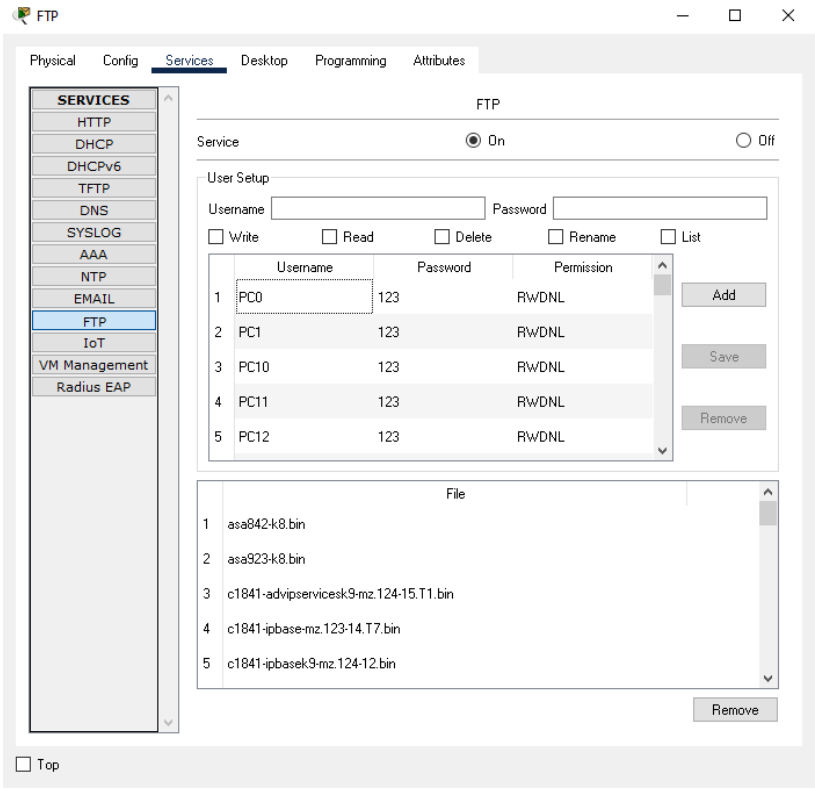


At first, I gave the HTTPs server Ip address that I had already booked in the subnet of static Ip addresses, and then I clicked on the HTTPs server, then on icon desktop and then on Ip configuration icon, and I entered the IP (192.168.55.3) (I booked also the same IP for the DNS) in the static in the right place and entered the subnet mask for the network (255.255.255.240), the Gateway for this network (192.168.55.1) and the Ip address that I have also booked for DNS (192.168.55.3).

I clicked on the services icon and on the HTTPs icon, in the first I turned HTTPs on and turned HTTP off, then I go to DNS server and convert Ip address of HTTPs into a name I choose as domain (vaccine.moh.gov.jo) and IP address (192.168.55.3) in steps I mentioned in the DNS server explanation.

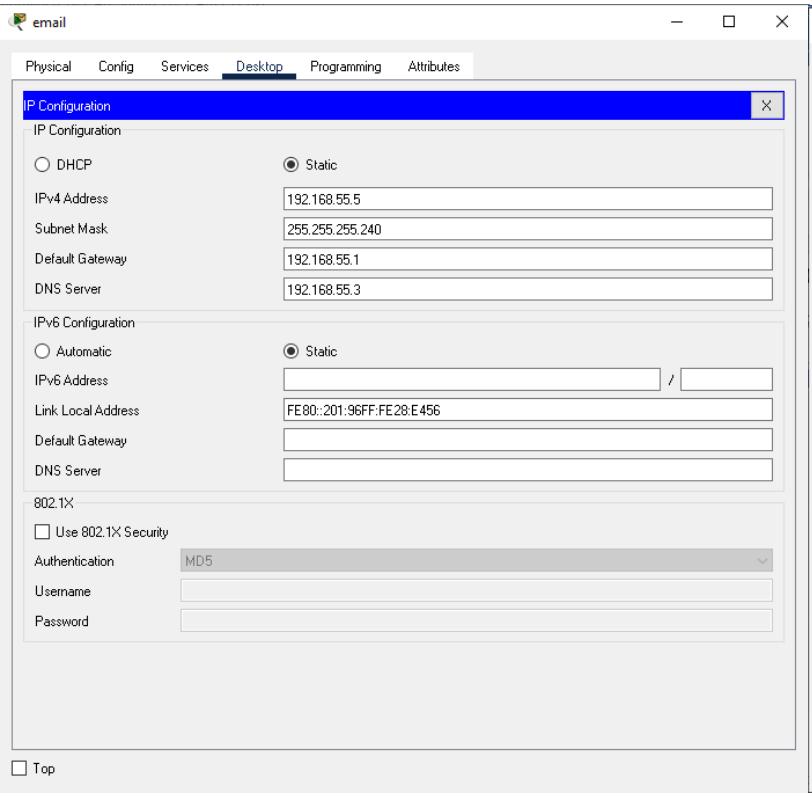
4- FTP server

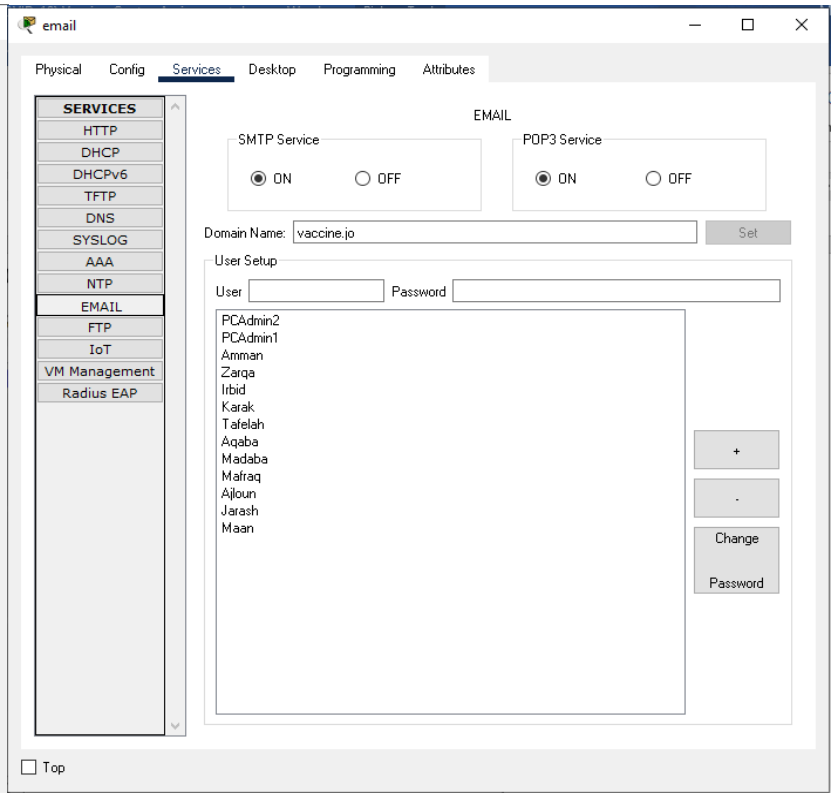




At first, I gave the FTP server Ip address that I had already booked in the subnet of static Ip addresses, and then I clicked on the FTP server, then on icon desktop and then on Ip configuration icon, and I entered the IP (192.168.55.4) in the static in the right place and entered the subnet mask for the network (255.255.255.240), the Gateway for this network (192.168.55.1) and the Ip address that I have also booked for DNS (192.168.55.3). I clicked on the services icon and on the FTP icon, in the first I turned FTP server on, I need to create an account for each PC I have in the network and give them all the capabilities so that they can share them between each other over the network, so I first put usernames like (PC0) and password like (123) and I run all the capabilities like: write, read, delete, rename and list and click add, and I repeat this process to create an account for all devices with changing the name of the device every time

5- Email server:





At first, I gave the Email server Ip address that I had already booked in the subnet of static Ip addresses, and then I clicked on the Email server, then on icon desktop and then on Ip configuration icon, and I entered the IP (192.168.55.5) in the static in the right place and entered the subnet mask for the network (255.255.255.240), the Gateway for this network (192.168.55.1) and the Ip address that I have also booked for DNS (192.168.55.3). I clicked on the services icon and on the Email icon, in the first I turned SMTP and POP3 services on, then I go to DNS server and convert Ip address of Email into a name I choose as domain name (vaccine.jo) with IP address (192.168.55.5) in steps I mentioned in the DNS server explanation.
Referring to email server and the services box, I will put the domain name (vaccine.jo) unified for all devices that can send the email and I chose only 13 PC devices, (one per network and two for administrators) and I put the names of the provinces for all devices except administrators I have put them the name (PCAdmin1 and PCAdmin2) but all devices have the same password which is (123) with clicking on a press (+) to add user

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2.

A) **Router:** Because it's had ability to connect two different networks

B) **DHCP server:** I used this server for devices to get IP addresses, because my network is large, it’s too complex to give the networks IP addresses in static, so I used dynamic routing protocol to distribute IP addresses automatically

C) **DNS server:** to mapping IP addresses to names and the opposite is true

D) **HTTPS sever:** to be able to use the hospital website from all the employees.

E) **FTP server:** to used it to upload, download, rename, delete the files from all employees.

F) **Email server:** to send and receive emails between all the employees.

G) **Switch:** to make devices see each other and connect all devices in LAN network and to stop the collision domain in the network.

H) **PCs:** To use it by employees to do their works.

I) **Printers:** to print data to papers.

J) **Access point:** To provide a connection point for the wireless.

K) **Generic wireless:** to connect other devices through the network wirelessly

L) **Serial:** To link routers to each other.

M) **Copper straight – Through:** To connect different devices together like switches with PCs and Router with switch.

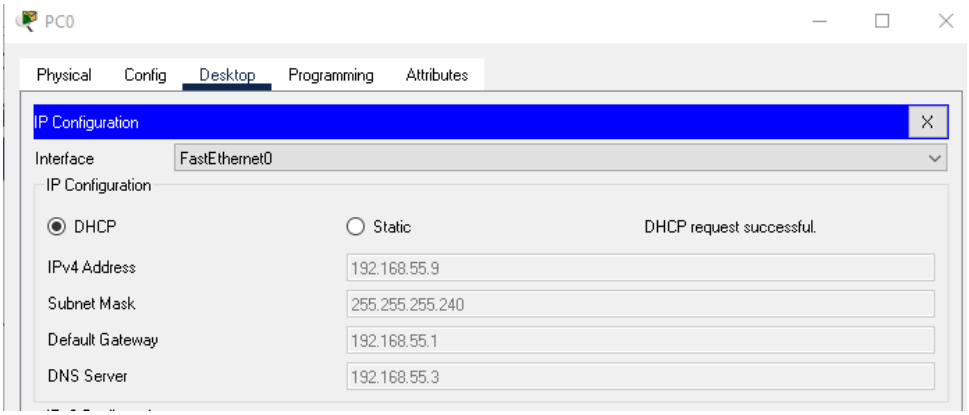
3.

What to be tasted	Tools or commands used for testing	Expected results
1) IP configuration using dynamic	Using DHCP in IP configuration in the PC instead of static	DHCP request successful
2) Connectivity between PCs	Command (ping + IP address for the device I want to communicate with) in the command prompt	Reply from IP address of PC that I want to communicate with
3) Interfaces identified on the router and make sure the router sees all the networks through Rip	The first command is (enable) and then (show running-config) In the CLI in the router	interface + the name of interface and the Ip address + mask and a lot of results it depends on the interface like: clock rate, duplex auto, speed auto and Rip information like: the number of versions, no auto summary and the IP addresses for the networks between routers only.
4) Networks seen by router	The first command is (enable) and then (show ip route) In the CLI in the router	All the networks that the router sees will appear through IP addresses and subnet mask for each other, and Indicate the L letter next to ip addresses to express the word Local, the letter C is express of the word Connected, the letter R is express of the word Rip

5) PC,s ability to access a particular website	With one of the PCs given ip address, access the web browser and write in it (https:// + ip address for https server or the name you have defined in DNS server and click on GO)	Cisco Packet Tracer website must appear with sentence (Welcome to Cisco Packet Tracer. Opening doors to new opportunities. Mind Wide Open)
6) Make sure the mapping process from the DNS server	With one of the PCs given ip address, access to the command prompt and write command (nslookup + any name I have identified in DNS server)	I'll see the name and IP address to the website I ordered in the nslookup
7) Number of routers in the distance between the current PC and DNS server	Access to the command prompt in this PC and write command (tracert +any IP address represents a particular destination)	A set of IP addresses will appear and their speed
8) Ensure the capabilities of devices that have created an account on it through the FTP commands, for example file uploading capability	First, I will create a new file so I will go to any PC that has taken IP address and go to "text editor" and write any data I want and then I will save it by a specific name and example (file1.txt) and then I will go to command prompt and write (ftp+ ip address for FTP server) and then write command (put + file name which is file1.txt)	Will print a sentence (transfer complete and with file size in bytes)
9) Test of send an email between two PCs	First I have to go to any pc I have and go to the email icon and then click on the Configure Mail and put the name in its correct place and a name I have written earlier in the email server and for example (PCAdmin1) and email address is made up of name and domain name and so on (PCAdmin1@vaccine.jo) the incoming and outgoing mail server will be similar in my case because the message will enter and exit the email server (192.168.55.5) and finally I will put the user name and password as I put it in the email server (PCAdmin1 and Password	Initially, (Send Success) will be printed below in the sender and the receiver (PCAdmin2) will receive the message that was in its direction and will deliver it in the (Mail Browser) in the (Receive) and print a sentence in the below (Receive Mail Success)

	123) and I click save, I will repeat this process on the other device that will receive the message and then I will go to the compose mail box and write in to the name with the domain name for the other device to which receive the message (PCAdmin2@vaccine.jo), will go and the subject is the main idea of the message and below it the message I want is written and then click on send	

1) Depending on the previous table:



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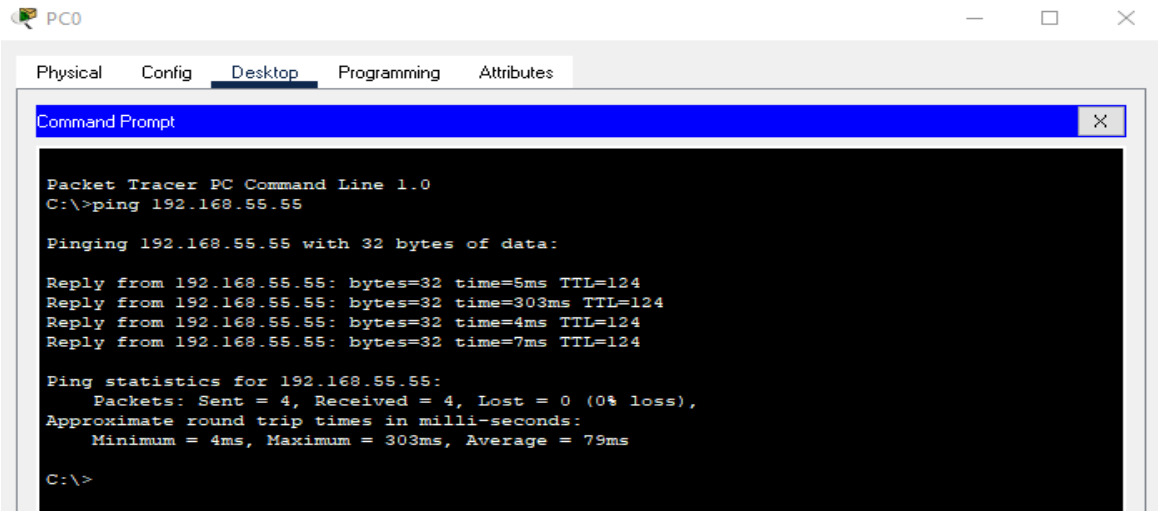


3) Depending on the previous table:

Router11

Physical Config CLI Attributes

IOS Command Lin

```
!
!
interface GigabitEthernet0/0
 ip address 192.168.55.17 255.255.255.240
 ip helper-address 192.168.55.2
 duplex auto
 speed auto
!
interface GigabitEthernet0/1
 no ip address
 duplex auto
 speed auto
 shutdown
!
interface Serial0/0/0
 ip address 120.0.0.2 255.255.255.252
!
interface Serial0/0/1
 ip address 10.0.0.1 255.255.255.252
 clock rate 2000000
!
interface Vlan1
 no ip address
 shutdown
```

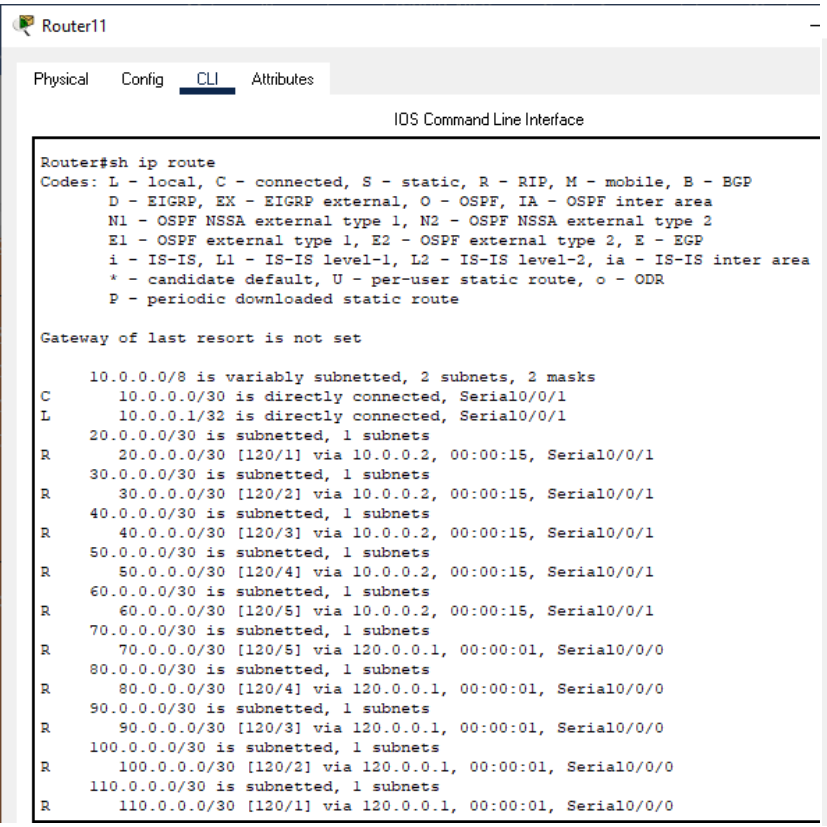
Router11

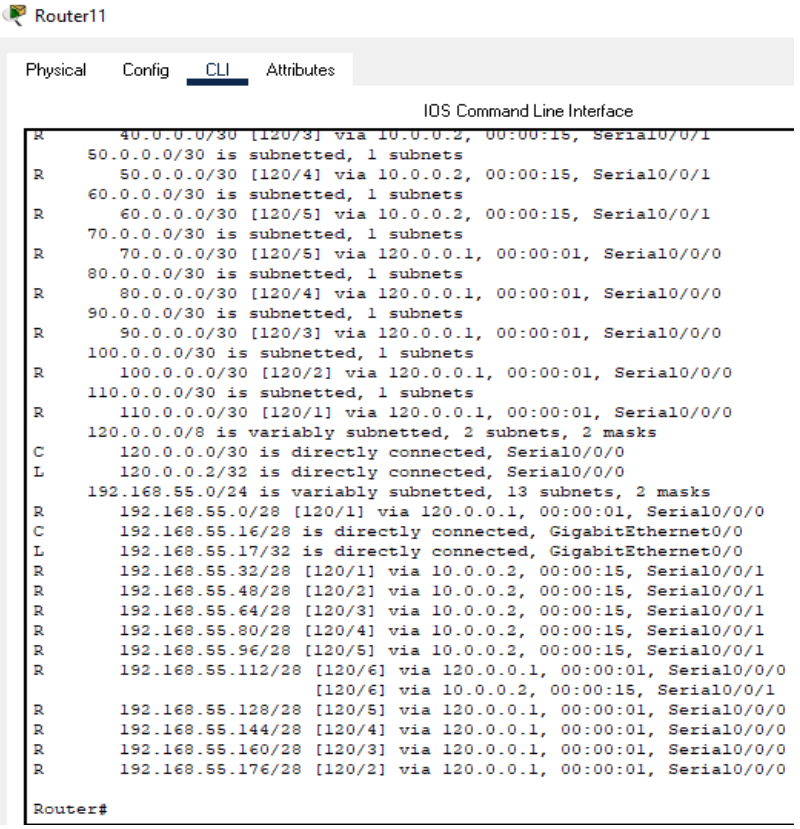
Physical Config CLI Attributes

IOS Command Line Interface

```
 no ip address
 shutdown
!
router rip
 version 2
 network 10.0.0.0
 network 20.0.0.0
 network 30.0.0.0
 network 40.0.0.0
 network 50.0.0.0
 network 60.0.0.0
 network 70.0.0.0
 network 80.0.0.0
 network 90.0.0.0
 network 100.0.0.0
 network 110.0.0.0
 network 120.0.0.0
 network 192.168.55.0
 no auto-summary
!
ip classless
!
ip flow-export version 9
!
```

4) Depending on the previous table:





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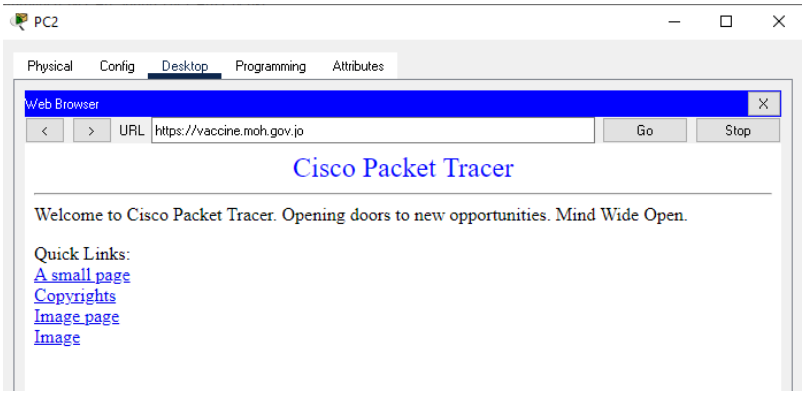

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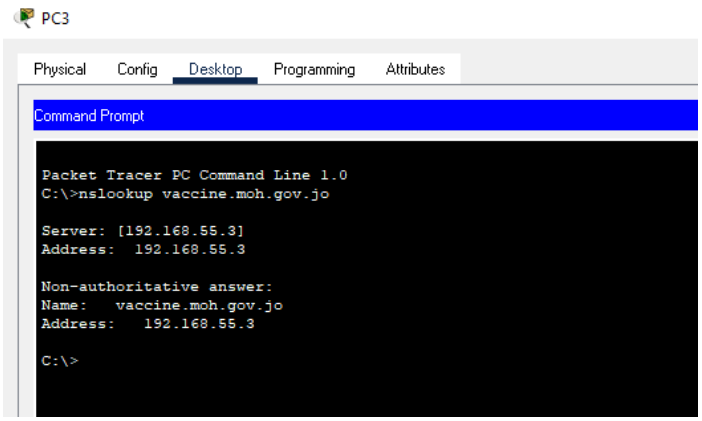

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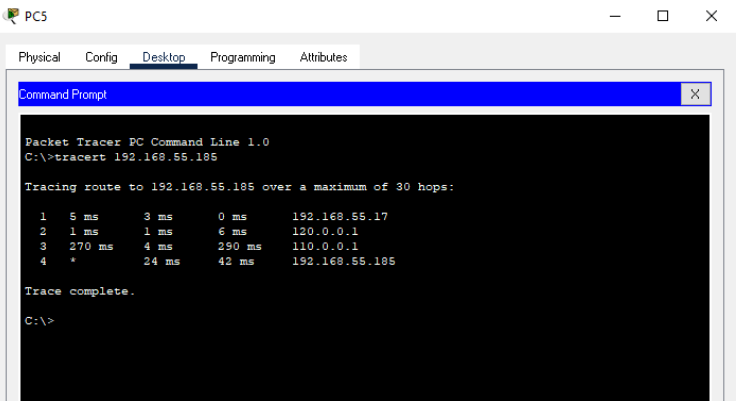

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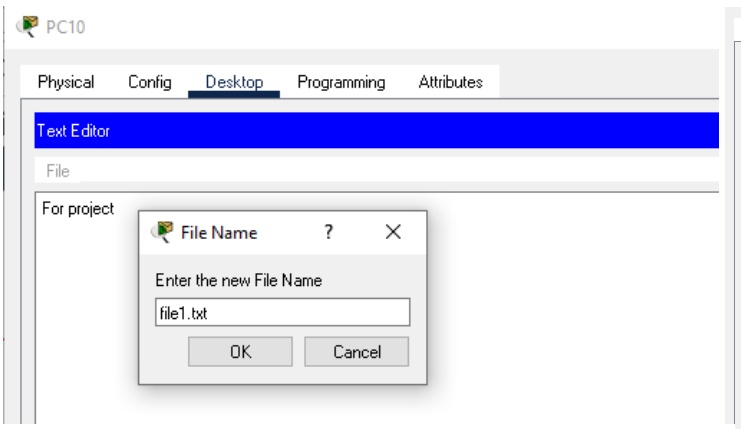

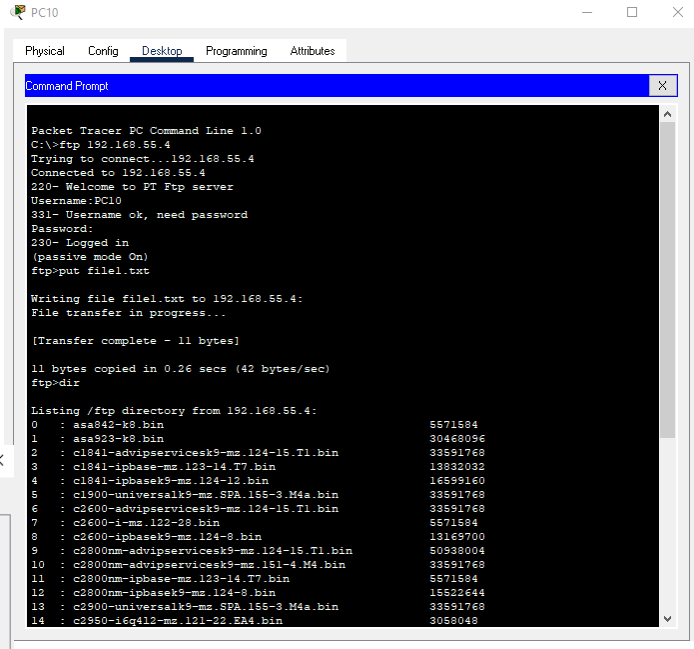

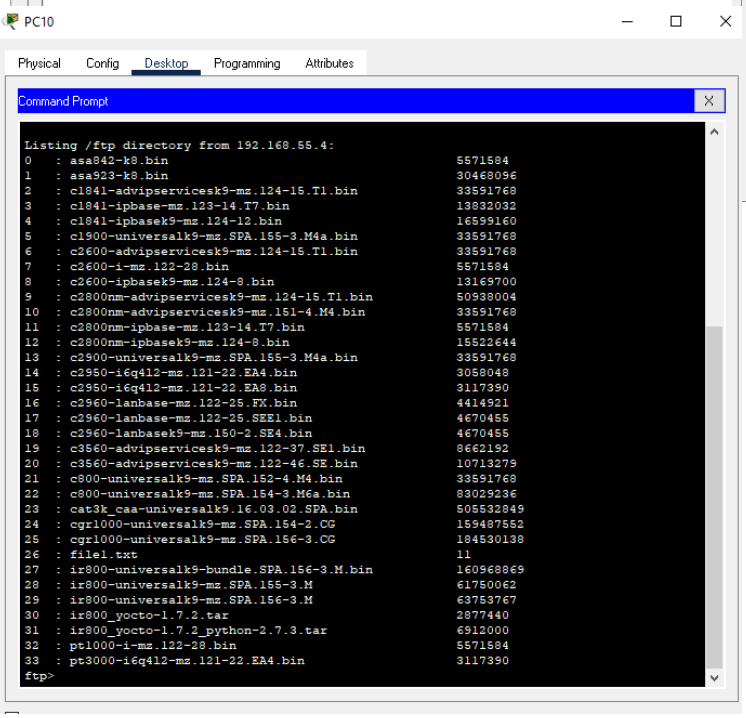

9) Depending on the previous table:

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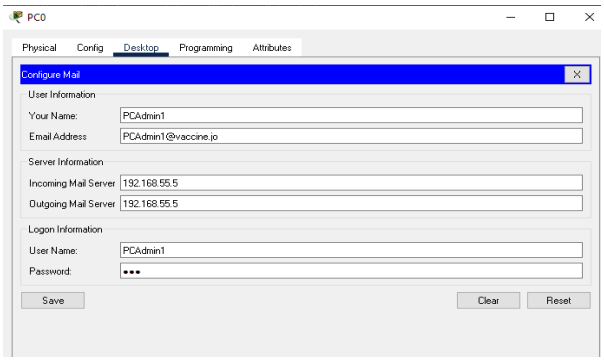

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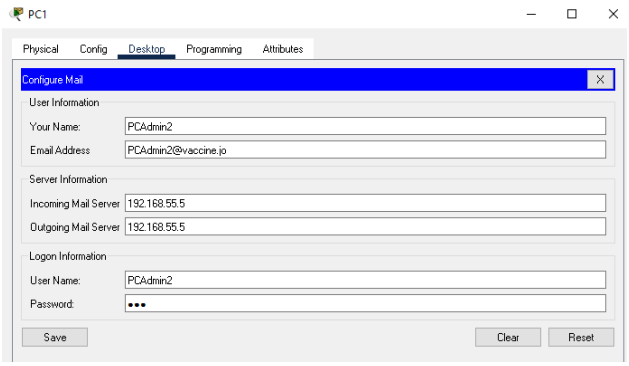
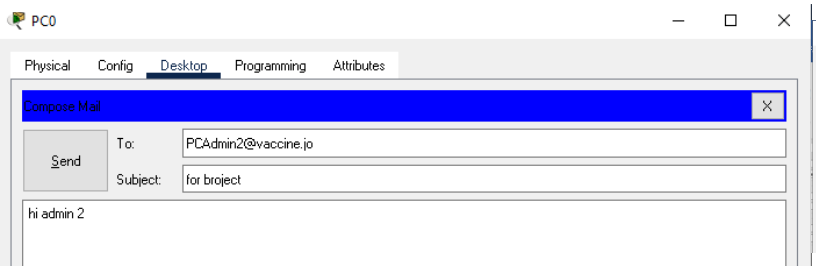
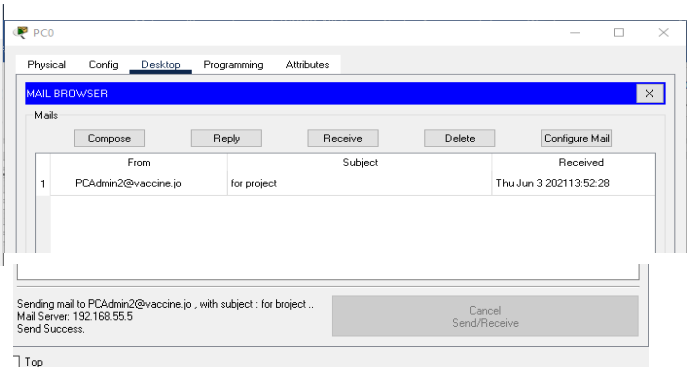


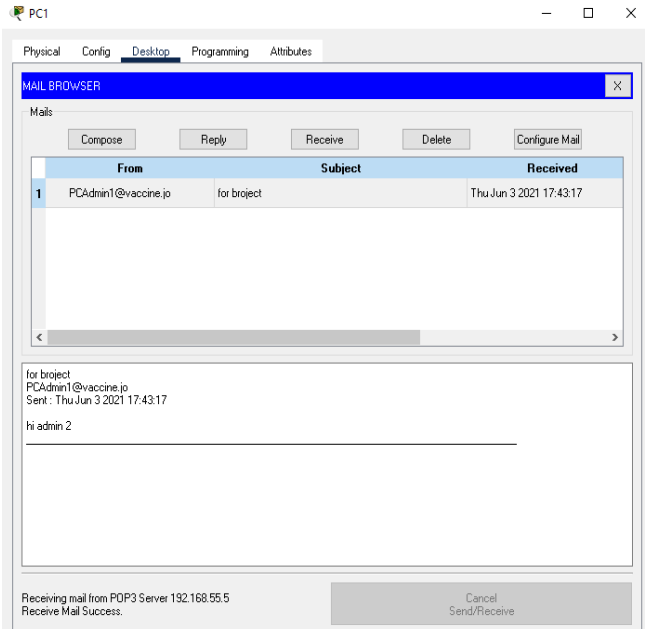
C.



D.



E.



4. MAINTENANCE SCHEDULE

On the weekends we maintain the devices mentioned in the hardware box that have certain problems during the week, but for servers cannot stop working on the weekend I will choose one day of each month to stop the operation of the servers and do rapid maintenance for them and check the storage space and cooling system, also I will make sure that the software on the devices is correct and this every week, and routers I will check every month and make the necessary updates for software and if there is any hardware malfunction for servers as well

SECTION 2.2:

1. IMPLEMENT A NETWORKED SYSTEM

In the packet tracer file

2. CONDUCT VERIFICATION:

I did it in (2.1 – 3) in the table

3. RECORD THE TEST RESULTS

I did it in (2.1 – 3) in the table

4. RECOMMEND POTENTIAL ENHANCEMENTS AND INVESTIGATE

Until I develop my network, I will develop switches for hospital-related matters, the Covid 19 will not remain forever there, for example switch mode for each radio and switch section for the analysis department, switch for operations and switch for the pharmacy and emergency department and so on for all departments and hospitals in all provinces and add PCs and printers as well as improving the quality of the internet and using fiber wires to communicate on the network faster than accessing the site and transferring files over the network, also put server as a backup for the database for fear of any cable from the network crashes and the network outage on everyone and the loss of some information backup is done for the data, And that I will use servers for DHCP because rip routing protocol can only give them ip addresses

The development of hardware servers and some devices that have high pressure in terms of RAM, Hard disks and Network card and that the reason I choose fiber is that it bears the pressure of users and does not waste the signal inside it no matter the length of the wire, and that I will change the password for all devices, activate encryption Double, and Turn off guest networks and servers in each maintenance period to increase protection and add firewall to the network and activate all its characteristics and eventually to keep using TCP/IP and not use UDP

5. THE SIGNIFICANCE OF UPGRADES AND SECURITY REQUIREMENTS

Why security is important?

Deploy active devices: Use software to prevent malicious software from entering or running on the network, prevent users from sending or receiving suspicious emails, prevent unauthorized use of the network, and prevent network users from accessing known websites [52].
Deploy passive devices: For example, use devices and software that report unauthorized network intrusions or suspicious activities by authorized users [52].
Use active devices: Devices that help identify potential security vulnerabilities that network workers need to address [52].
practices: Even if the software and hardware are configured to be secure, user operations may cause security vulnerabilities. Cybersecurity personnel is responsible for training organization members on how to protect themselves from potential threats [52].

My network does not contain all the security systems that I will need in a hospital like this, I have only used TCP/IP protocol and HTTPs that contain a protection system but there is no firewall and internet proxy because

hospitals have important information, especially patient privacy and personal information and may be sensitive and any hacking of the system and the extinguishment of hospital devices will lead to the death of some people, and I mentioned things about security in the **pervious section (Part2- 2.2 – 5)**

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