Course No. : 10202112 Networking

Title of the assignment: Ministry of Health Computer Network

Name of Student : Enas Ibraiwesh

Student ID # :18110028

Student's email : enas.ibraiwesh@htu.edu.jo

Assessor Name : Eng. Moath Sulaiman

Contents

1. Introduction:

To connect all the regional offices and the headquarters we need a computer network that provides all the needs of MoH. In this report I will explain different types of network and network devices and protocols that can be implemented in MoH.

2. Network types:

Following are types of the networks that can be used while implementing network for ministry of health.

a. Enterprise private network
b. Wide area network
c. Metropolitan area network
d. Local Area Network

a. Enterprise private network

Enterprise private network can be consider as customized network particularly built by the businesses having more than one office to interconnect them or used to connect different sites of company so that they can share all the resources.

Usage of enterprise network :

Enterprise private network is completely controlled and manage by the organization who build them it interconnect its various company sites such as production sites, offices and shops and is mainly set up to share computer resources.[1]

Benefits and constrains of EPN[2]:

Benefits:

- Security
- Centralized operations and communication
- Centralized database
- Processing speed will increase
- Help in continuity of business
- Helps in development of business
- Reduced cost
- Sharing resources

Constraints:

- Outside users cannot use network.
- Only for particular organization

b. Wide area network

WAN is a type of network that covers a large geographical area and connects via network. WAN is build by connecting smaller networks like LANs and MANs. Wide area network ensures that users residing in an area can connect or

communicate with users/ system of other area anywhere in the world. We can also consider WAN as global network, which connect each user globally[3].

Usage:

WAN is used when there is need to connect or create network between cities, states or countries it is used in internet.

Benefits and constrains of WAN[4]:

Benefits:

- Connect or create network that cover large area.
- Keep data and files updated that's because all clients on that network can access the same data this is the way it avoids having some users who has older information than others.
- Many applications that can exchange messages
- Sharing resources
- Centralized data it eliminates the need to buy email or file servers for each office. Instead, you only have to set up one at your head office's data centre.
- Sharing data
- High bandwidth leased lines are often used in WAN it gives higher bandwidth than normal broadband connection. You can get a high data transfer rate that can increase your company productivity.

Conflicts:

- Security problem WANs open the way for certain types of internal security breaches like unauthorized use, information theft, and malicious damage to files
- Require antivirus system and Require fire wall.
- High and Increased cost of setup
- Issue of server down that is why it requires full-time supervisors and technicians to maintain the network and to guarantee that your data centre will be up and operating 24/7 managers must be able to detect failures before they occur and reduce data centre downtime as much as possible because downtime is costly
- Network Disconnection issues

c. Metropolitan area network

MAN cover area that is larger than the area covered by the LAN and smaller area than the WAN.MAN is used when there is need to connect LANS of different buildings it can also span in a range of 5 to 50 kilometres in diameter it is usually owned by an association of users or by a single network provider who sells services to.[5]

Usage:

It is used in cities and or a group of buildings like a university campus.

Benefits and constrains for MAN[6]:

Benefits:

- High speed
- Sharing internet
- High security
- Less expensive
- Conversion is easy of LAN into WAN

Constraints:

- When it comes to larger area it's management become difficult.
- Hackers attack become easy
- Wires are required more than usual

d. Local area network

A local area network is used to connect computers within a limited area it also enables the sharing of resources and services like files, printers, games, applications[7].

Usage:

Residence, school, laboratory, university campus or office building.

Benefits and constrains of LAN[8]:

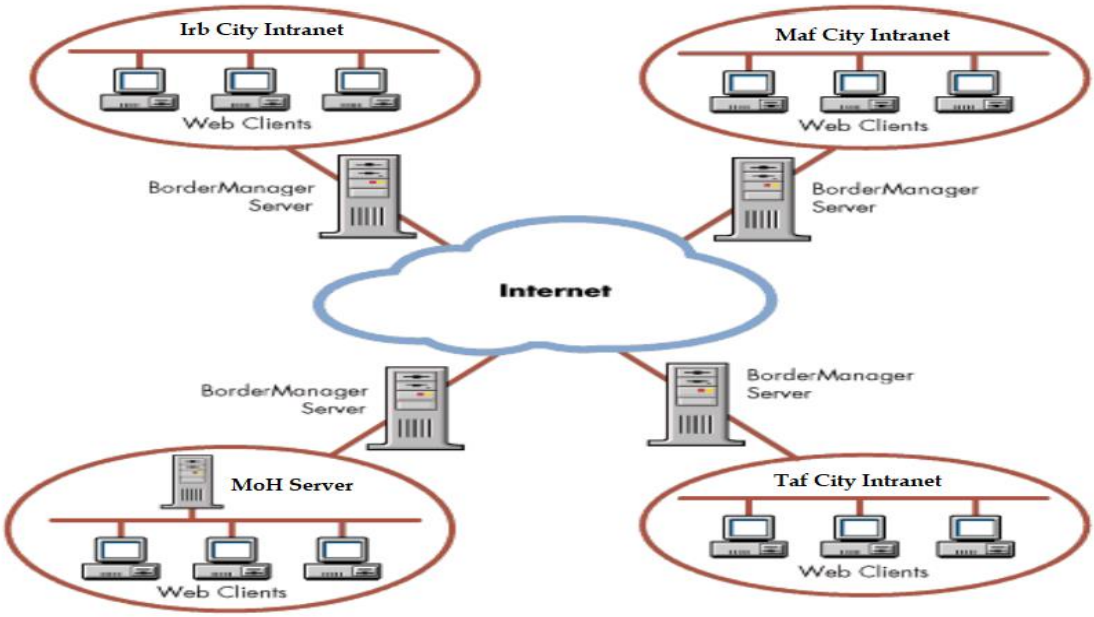
Benefits:

- Centralized IT administration Sharing resources on a network requires central administrative control, which means it's easier to make changes, monitor, update, troubleshoot, and maintain those resources.
- Resource sharing like printers and even hard disk or CD-ROM drives which makes it more cost efficient.
- Software applications sharing such as Anti-Virus and Adobe reader, word processor, spreadsheet are stored at one system and are shared for all the LAN users.
- Centralized data you can centrally manage and schedule data backups which make them more reliable.

Conflicts:

- Limitation of distance LAN covers small geographical area.

- Privacy violations it is easy to protect the network from outsiders but in LAN you can easily have access to programs and data of peers so special security measures are needed to stop unauthorized access.
- Appearance of virus in one system can spread to all the LAN users very easily also in the server based LAN architecture, if server develops some fault, all the users are affected.



3. Network Topologies:

A network topology is the layout of the network it is the way of how the nods are connected together and how they communicate.

There are two types of topologies:

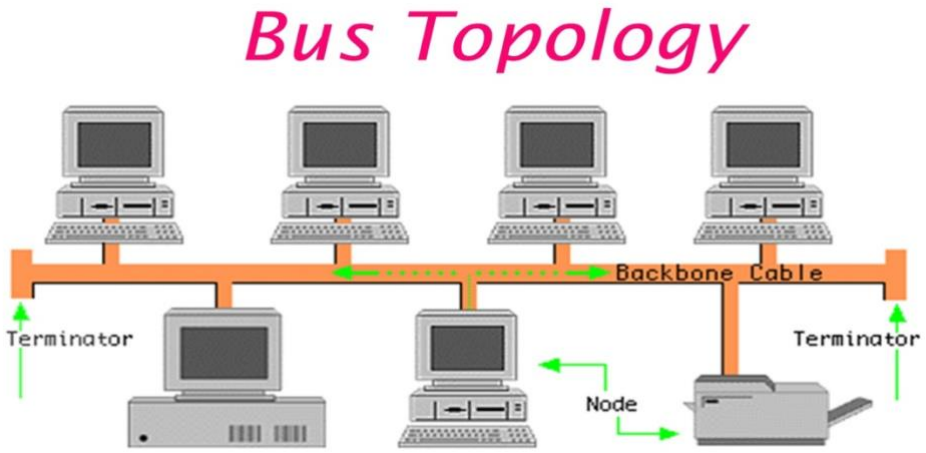
a. Physical topology: "the physical layout of devices on a network" [2]
b. Logical topology: "the way that the signals act on the network media, or the way that the data passes through the network from one device to the next" [3]

[2] (Webopedia.com, 2019)

[3] (Webopedia.com, 2019)

➢ **Physical topology examples:**

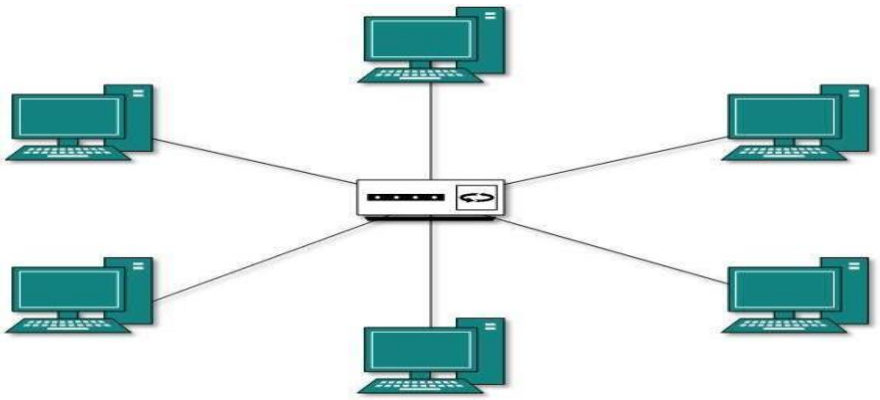
- **Bus Topology**: it is the simplest way to connect nods to form a network where each nod is connected to one cable called trunk (or backbone) so all the network traffic will flow across a single cable.
  You can use coaxial cable as the network media it can carry the signals for 500 meter the quality of the distance drops off beyond that distance if the coaxial cable used is thin we use drop cable and T-connector to connect the nods to the cable but if you use a thick coaxial cable then you would use a vampire clamp to connect the nods to the cable. Coaxial cables have different lengths you can use a barrel connector to extend the length there is a phenomenon of bus topology called bounce-back which means that the signal transmitted over the cable returns when it reaches the end of the cable and that cause unnecessarily traffic over the network that's why you install a device called terminator at both ends of the cable to absorb the signal and to prevent bounce-back.



(Anon, 2019)

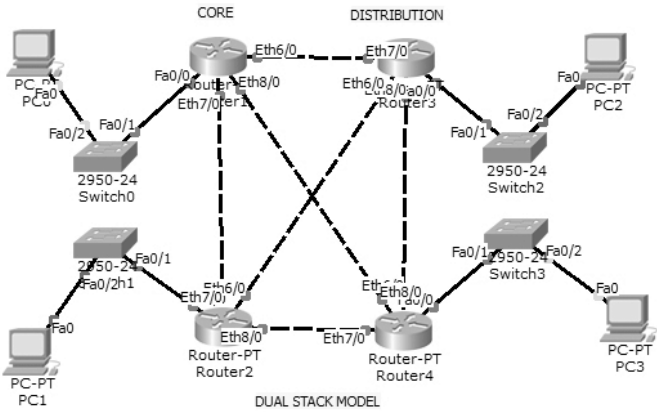
This is ideal for small networks since it is inexpensive and easy to setup and expand but if the central cable malfunctions then the whole network shutdown and it is not great for large networks it is also hard to detect and troubleshoot fault at individual station.[9]

- **Star Topology**: it looks like an octopus and the body of it is a hub which is a connection box for all the wires it has a port for each node on the network you can use a switch instead of a hub the cable used in it can be UTP or the unshielded twisted pair cable you can also use the RJ45 or the Ethernet cables Star Topology is easy to expand and manage also troubleshooting is easy and if one computer goes down the rest of the network will not be affected but it is fully dependant on the hub and the entire working of the network depends on the hub or the switch so if the hub goes down the whole network shuts down and if there are many nodes and the cable is long then the network may slow down[10].



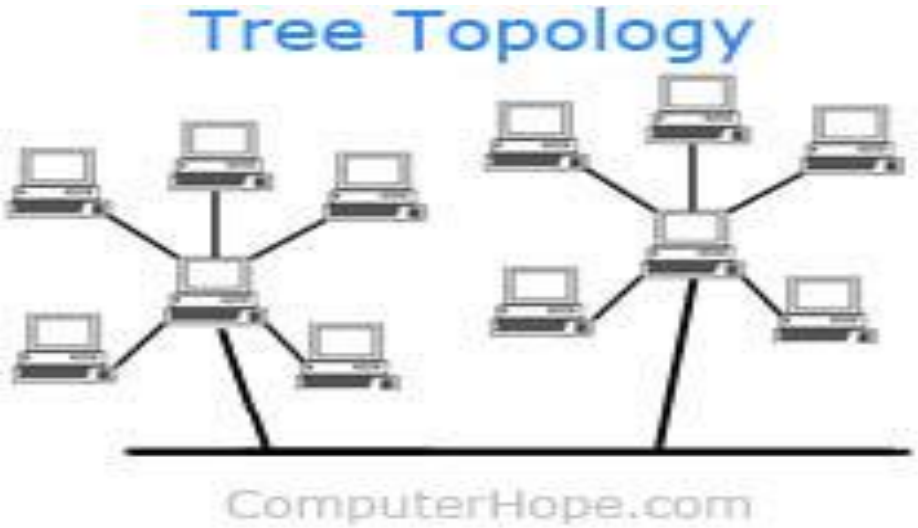
(Bing.com, 2019)

- **Mesh Topology**: it a topology where infrastructure nodes such as bridges, switches and other connect directly dynamically and non-hierarchically to each other and cooperate with one another to efficiently route data from and to clients.[11]
  Mesh topology can manage high amounts of traffic because multiple devices can transmit data simultaneously also if one device fails that doesn't cause the network to fail but implementing mesh topology costs a lot also it takes a lot of time to build and maintain and the chance of connection redundant is high. [12]



(Google.com, 2019)

- Tree topology: it is a star-bus topology tree networks are hierarchicalif one nod gets damaged other nods wont be affected and it has easier maintenance and fault finding but it is backbone forms the point of failure.[13]



Mesh Topology	Tree Topology

Architecture/ organization: It is a kind of network, which allows every system in the network to communicate directly with every other system every nod is connected with the other nods. **Routing Methodology:** Often used across long distances. Information transfer can happen in different ways, depending on the other topologies **Complexity:** it is used in bigger networks and it is not simple **Expansion:** it is easy to add network devices **Reliability:** If any one of the device fails network will not fail and it is able to manage traffic in high amount but Maintenance in mesh topology is time consuming and difficult. **Cost:** Implementing mesh topology will result in high cost. **Cabling concerns:** Can use twisted pair and coaxial cable. Also incorporates Fiber optic cabling over long distances	**Architecture/organization:** Tree topology is the hybrid of the bus and star topology. Its structure looks like tree having branches. Tree topology is mostly used in the corporate sector while organizing the computer network. **Routing Methodology: :** a transmission from any station Propagates throughout the medium and can be received by all other stations. **Complexity:** same as in mesh topology it is not simple **Expansion:** The simplest to install and extend extra Stations in a daisy chain manner so it is easy to expand **Reliability:** Easier maintenance and fault finding and If one segment is damaged, other segments are not affected but the backbone forms the point of failure a lot of maintenance is needed **Cost:** Cable cost is high **Cabling concerns:** Coax - Twisted Pair – Fiber it requires large amount of cables.

- **Logical topologies:**

Ethernet: It is a bus primarily based broadcast network it will operate at ten Mbps or one hundred Mbps or on top of computers on an Ethernet will transmit whenever they need to. If two machines transmit at the same time, then their packets collide. Then the transmitting computers just wait for a random amount of time and retransmit their signal it transmits the information in the form of an Ethernet frame, or packet the frame consists of a group of bits organized into many fields. These fields embrace address fields, a data field and an error checking field that checks the integrity of the bits in the frame to make sure that the frame has arrived intact. Ethernet contains a set of rules (protocols) embedded in every local area network interface that may decide whoever computers on the network will have access to the information on the medium.[14]

Token ring: It uses a special three-byte frame referred to as a "token" that travels around a logical "ring" of workstations or servers. This token passing will be a channel access methodology providing fair and equal access for all stations, and eliminating the collisions of contention-based access method in it each laptop is a repeater to boost signals.[15]

4. **Network Devices:**

- NIC: Network Interface Cards it connects the computer with the network and it is a hardware that is installed on the mother board the data will be transformed into an electrical signal then it will be sent to the network via the network card These days network cards are software configured Modern NICs provide functionality to computers such as support for I/O interrupt, direct memory access (DMA) interfaces, data transmission, network traffic engineering and partitioning.[16]

- Firewall: firewalls are basically used to protect computers and other devices from intrusion and hacking and it filters content which is being transmitted firewall goes hand in hand with IPS (Intrusion Prevention System) the difference between them is that IPS is limited to attacks that identify themselves as one but firewalls are used in a network to screen the information that tries to enter from the outside. It is also used to prevent outside information and applications to access and extract the private and sensitive data from the network.
  Firewall techniques:[17]
  1- A packet-filtering firewall examines packets in isolation and does not know the packet's context.
  2- A stateful inspection firewall examines network traffic to determine whether one packet is related to another packet.
  3- network- and port-address translation (NAT)
  4- virtual private network (VPN) support

- Switches: Switches are used to connect Personal Computers, access points, servers, printers and any other hardware device depending on the requirement. Switch is the central point of connection, which share information or data directly. It is more like a network hub but avoids the limitation of network hub a hub works by sending the data to all the ports on the device but a switch transfers it only to that port which is connected to the destination device and that is because it has a built-in learning of the MAC address of the devices connected to it and that results in the transmission of data signals being well defined in a switch so the network performance is consequently enhanced. As well as in a network hub when the number of devices increases the speed of transmission becomes slow while in switch number of devices does not affect the speed or security as well.[18]

- Router: Router is used to connect different networks. Router routes the data in the form of packet among computer networks it behaves like dispatcher and it is used to direct the data traffic. It selects the best route on the computer network, so that information can travel on the computer network in optimized manner it does that by reading the header of the packet the header has a logical address which is the IP address after the address is determined, it searches in its routing table to know how to reach the destination and then forwards the packet to the higher hop on the route it could be the final destination or another router.

The two ways through which a router can receive information are:

- **Static Routing: t**he routing information is implemented in the routing table manually this way is time consuming and prone to errors it also needs manual updating.
- **Dynamic routing:** it is more practical especially for larger environments it uses routing protocols the reason why it uses these protocols is to enable the other routers to transfer information about to other routers, so that the other routers can build their own routing tables such as Routing Information Protocol (RIP) which sends the completed routing table for all active interfaces every 30 seconds it works well in small network but it is not efficient in larger networks because it has a maximum hop count of 15 by default if there is more hop count it will be unreachable.

  It can also use Open Shortest Path First (OSPF) which is used to find the best path for packets and when a change occurs to a routing table, the router multicasts the information to all the OSPF hosts in the network so that all of them have the same routing table information.

  In addition to that routers can provide quality of service (QoS) for specific types of network traffic it is also known as traffic shaper what it does is that it assigns priority to every device on the network also it manages the bandwidth that the device is allowed to consume based on its mission.[19]

Switches will connect personal computers of an office and router will be used to connect switches with each other.

5. Networking protocol:

HTTPS: shortened for Hypertext Transfer Protocol Secure and is an extension for HTTP this protocol is an application protocol (layer 7 protocols) and it uses the port 443 this protocol makes the communication between your browser and the website server encrypted and secure so that the information can only be accessed by the user and end server[20].

TCP: Transmission Control Protocol this is a transport layer protocol (layer 4) it connect the application layer to the internet layer .TCP and Internet Protocol work together where the internet protocol identifies the logical location of the remote node and the TCP transports and makes sure that the data is delivered to the correct destination TCP divides the data into multiple packets then after it reaches its destination the IP layer hands it back to the TCP layer to reassemble the packets. TCP is connection-oriented so it ensures a connection is established and maintained until the exchange between the application/servers sending and receiving the message is complete. [21],[22]

IP: internet protocol this is a network layer protocol (layer 3) one of its main job is routing which is delivering the package from host to the destination host based on their IP addresses which is a unique address for each nod it has two versions (IPv4) , (IPv6) IP is a connectionless protocol, which means that there is no continuing connection between the end points that are communicating IP does not guarantee reliable packet delivery over a network TCP is responsible to do so after the TCP divides the data into packets Internet Protocol encapsulate them into IP packets which means it adds information to it such as data load and IP header that information is for the internet protocol to know the destination.[23]

SMTP: Simple Mail Transfer Protocol it is an application layer protocol (layer 7)it also uses TCP port 25 SMPT is a protocol used to send emails and it is usually used with POP3 or IMAP those protocols are responsible of retrieving email The SMTP protocol has one problem: it understands only 7-bit ASCII characters. And that's why you cann't use SMTP to send binary data such as graphics or programs so then we use Multipurpose Internet Mail Extensions (MIME) it provides a standard by specifying a set of encryption rules and header extensions to the net standard message specification. These rules will encode messages with text, graphics, and even sound into 7-bit ASCII. [24,25]

POP3: Post Office Protocol version 3 it is an application layer protocol (layer 7) and its on port 110 it is a receiving email protocol it receives and holds emails for individual until the pick it up as soon as you download it POP3 is designed to delete mail on the server right away but some implementations allow users or an administrator to choose the mail they want to be saved for some period of time. Internet Message Access Protocol (IMAP) is an alternative for POP3 the difference is that IMAP provides the user more capabilities for retaining e-mail on the server and organizing it in folders on the server.[26]

FTP: File Transfer Protocol it is an application layer protocol (layer 7) it uses two separate ports control port 21 and data port 20 it is used to upload, download, delete, rename, move and copy files on a server a user usually needs to log on to the FTP server but some servers make some or all of their content available without login, also known as anonymous FTP you can start an FTP session in active or passive mode the difference between them is In active mode the server initiate a data connection back to the client and starts transferring data but in passive mode the server uses the command channel to send the client the information it needs to open a data channel this is also known as "firewall-friendly" mode FTP doesn't encrypt its traffic anyone who can perform packet capture on the network can read usernames, passwords, commands and data you can avoid this problem by using FTPS, which is more secure. In addition to that there is the SSH File Transfer Protocol. Or you can use Secure Shell, SSH.[27]

DNS: Domain Name Service it is an application layer protocol (layer 7) and uses port 53 it allows you to locate a website using a name like com, net and org instead of using the IP address that the computer uses to locate a website Web browsing and most other internet activity rely on DNS to quickly provide the information necessary to connect users to remote hosts. People who give access as well as governments, universities and different organizations usually have their own assigned ranges of IP addresses and an appointed domain name; they additionally usually run DNS servers to manage the mapping of these names to those addresses.[28]

DHCP: Dynamic Host Configuration Protocol it is an application layer protocol (layer 7) it is a network management protocol it is used on UDB networks it dynamically assigns IP configuration to the devices on the network if the network doesn't have a DHCP server then IP addresses must be manually assigned to the devices on that network or it will assign to itself an APIPA address a devices who has APIPA can't communicate outside its local subnet for some devices on the network you can reserve an IP address for it like printers.[29]

6. **Servers:**
    - Web server
    - mail server
    - FTP server
    - Infrastructure servers
    - Database server

Web server: it is used to receive HTTP requests and it accepts them then sends HTTP answer to the client the request and response can be HTML pages which are exchanged on the internet or the requests can be files like, wav, image and raw files as for the application Apache HTTP Server it is an open source server and that means there is no licensing fee and you can edit the underlying code to tweak performance and contribute to the future development of the program it runs on UNIX, Windows, Linux, Mac OS although it runs on all of them it is usually used with Linux operating system in addition to that it is really secure and powerful server to success in Apache you need to have an understanding to what it can do, increasing its power by adding extra Apache resources and transforming raw logging data into information you can see and use.[30]

Mail server: the application for mail server is hMail it is a free email server for windows it is an open source server it has a lot of features such as anti-spam, anti-virus and Built-in support for SSL it supports SMTP, POP3 and IMAP. [31]

FTP server: FileZilla PRO Server is an open source and free server application for Windows you can choose which ports the program should listen on the number of users that can be connected to your server at the same time and the number of CPU threads the server can utilize, and timeout settings for connections, transfers, and logins it also has the ability to adjust the transfer and socket buffer size it is heavily optimized for speed and you can also adjust the pace of your transfers. FileZilla also has security features such as supporting FTPS and SFTP and it can prevent unencrypted FTP it also can auto-banning an IP address if it fails to login after so many attempts. [32]

Database server: Microsoft SQL it has a main function of storing and retrieving data as requested it uses TDS which is an application layer protocol, used to transfer data between a database server and a client it supports different data types, including primitive types such as Integer, Float, Decimal, Char and it also allows user-defined composite types (UDTs) to be defined and used. SQL Server buffers pages in RAM to minimize disk I/O. Any 8 KB page can be buffered in-memory the set of all pages that are now buffered is called the buffer cache the amount of pages that will be cached in memory is decided by the amount of memory available to SQL Server buffer cache is managed by the Buffer Manager the main mode of retrieving data from a SQL Server database is querying for it. SQL Server main interface tool is Management Studio (SSMS) (previously known as Enterprise Manager) and it supports 32-bit and 64-bit environments. Examples of some features of SQL: XML data type support, dynamic management views (DMVs), full-text search capability and database mirroring there are many types of ms SQL but the most suitable here is Standard which is made for small and medium organizations. Also supports e-commerce and data warehousing it license costs around 4,000 USD which is good especially that the mail, FTP and web servers software all had free license. [33],[34]

Infrastructure server: using Microsoft servers you can have active directory (AD), DNS and DHCP on the same server active directory interact closely DHCP and DNS active directory: It authenticates and authorizes all users and computers in a Windows domain kind network—assigning and implementing security policies for all computers and installing or updating software. the DHCP maintain the IP addressing of nods such as computers, servers and routers and DNS helps the clients locate resources using simple names instead of IP address but download DHCP server role on the domain controllers you need to do some further configuration Windows Server provides a similar capability features and operative mechanism of a regular server operating system it is generally capable of providing server-oriented services, such as the ability to host a website, user management, resource management across users and applications, messaging, security and authorization it is not expensive these protocols and topology will provide efficient utilization for the network. [35]

7. Inter-dependencies of Workstation hardware with relevant networking software:

The main network hardware is Network interface card and for network software we have network operating system; drivers and application the hardware and software communicate with each other's using protocols. Network interface card enables computers to be combined together in a network usually a local area network those computers communicate with each other using a specified protocol for transferring data packets the network interface card acts as a translator letting machine mutually send and obtain data on a LAN however to run network devices you need a network software which is an operating force that instructs all network computers and hardware to operate together Software is the electrical signals (a set of on/off signals) which tell those devices what should be done and when it helps users accessing network resources and

devices also it helps enabling network visualizations an example on software is network operating system (NOS) it allows computer devices to connect with the network and for protocols they are a set of rules that allows the communication between the software and hardware so we can conclude that the hardware and software are dependent on each other. [36]

8. **Recommended for MoH:**

I would use LAN for branches and then connecting these branches to form a WAN using cables leased from orange i decided to use WAN because of the large distance between the branches i will use tree topology where switch would be the centre hub for the star topology in LAN because it provides zero collision and routers will connect the four LAN together tree topology will provide connection between all computers and it is suitable for networks with branches in LAN i will use access point to provide wireless access to the internet i will also use a load balancer which will efficiently distributing incoming network traffic i will also use the servers mentioned before to enable sharing files between all offices and send and receive emails also it will enable all offices to have access to the MoH https website so the web server will use https, mail server will use SMTP and POP3, file server will use FTPS and DNS and DHCP will both be used on the same server they will help with assigning IP protocols dynamically but i will reserve an IP address for the printers and the servers and giving a domain name for https website instead of using the IP address.

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