



Introduction to Computer Network

CSAI 252



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Introduction to Computer networks

Chapter 1

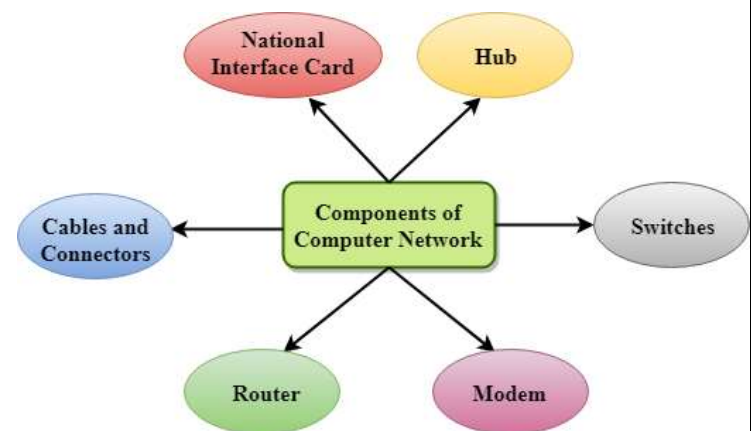
What is a Network ?

A network links two or more computers together connected with each other through wires, optical fibers, or optical links to communicate and share resources. A computer network allows computers to link to each other's resources. For example, in a network, every computer does not need a printer connected locally in order to print. Instead, you can connect a printer to one computer, or you can connect it directly to the network and allow all of the other computers to access it.



Components of Computer network:

- NIC (National interface card)
- Hub
- Switches
- Modem
- Router
- Cables and Connectors

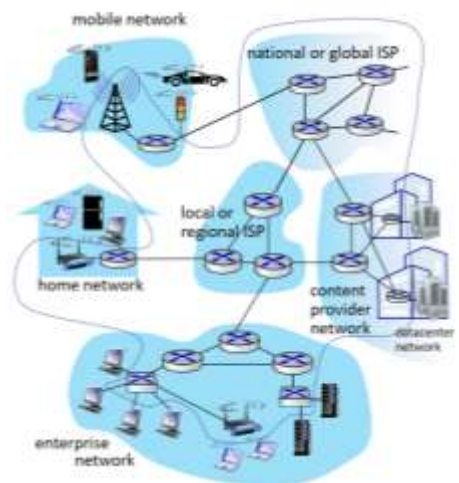


And we will talk about each one briefly later!

What is internet? (nuts and bolts view)

It is a network of networks and interconnected ISPs managed by organizations that spread the connection between:

- Billions of connected **computing devices**: which can be hosts (end systems) and running network apps at Internet's "edge" like computers, phones, servers and printers. Devices have also another name which is (network-edge devices) and (End-system devices). Servers has their own software (Apache) and often exist in big datacenters that have high abilities to keep the servers in the best conditions.
- **Packet switches**: which organize the data routes, and they are **routers** and **switches**.
- **Communication links**: which is the physical layer in the transmission that can be fiber, copper wires, radio, satellite. In each link, there is a transmission data rate that controls its performance.

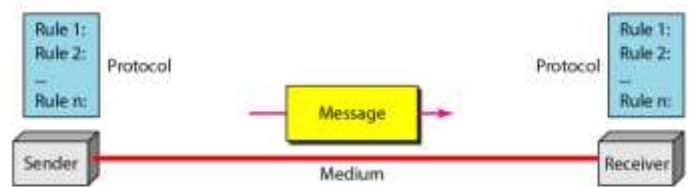


ال end devices زي أجهزة الكمبيوتر متوصلة ب switches بتنقل ال signals و متوصلة ب routers بتحدد اتجاهات ال signals دي و كل دا متوصل ببعض في local networks اللي متصلة ببعض ب Internet service providers (ISPs) كبيرة بتربط بين العالم كله عشان تخلي العالم كله مربوط ببعض و من غيرها كل منطقة هتبقى معزولة عن الثاني. كل دا متوصل بأسلاك مختلفة في الأنواع هنعرف كل تفاصيلها و الفروقات بينها في الاستخدام و الكفاءة.

Internet service providers (ISPs):

They are the devices that connect the whole world and supply it with internet. There are local ISPs for every country (In Egypt, there are five, [Vodafone, Orange, Etisalat, We, Noor]), regional ISPs for every region (e.g Middle east), and global ISPs among the continents.

Protocol: is a set of rules that organize communication between each type of device and without it they cannot transfer data. For example, http for web pages.



There are **protocols** that are used by the devices to communicate with each other and control sending and receiving of messages. (لغة التواصل بين الشبكات و انواع الداتا)

Protocols are made by Internet Engineering Task Force (IETF). Each service and program (like Skype and Facebook) have its own unique protocol which uses Request for Comments (RFC).

What is internet? (from services view)

It classifies the internet network according to the service it provides. It can be Web, streaming video, multimedia, teleconferencing, email, games, ecommerce, social media- interconnected appliances, etc.... Its importance in defining the need for every service, the used protocols, the used bandwidth and the all other features that we will learn later this semester.

Internet of things (IOT) life cycle: (((Very important question)))

- 1) Collect: collect information from sensors to use them.
- 2) Communicate: upload the collected data on the cloud.
- 3) Analyze: representing, analyzing, and classifying this data to benefit from it.
- 4) Act: taking action according to the given data. They are two types, feedback control system only for alerting the user about the change of the data, or acting and take actions automatically.

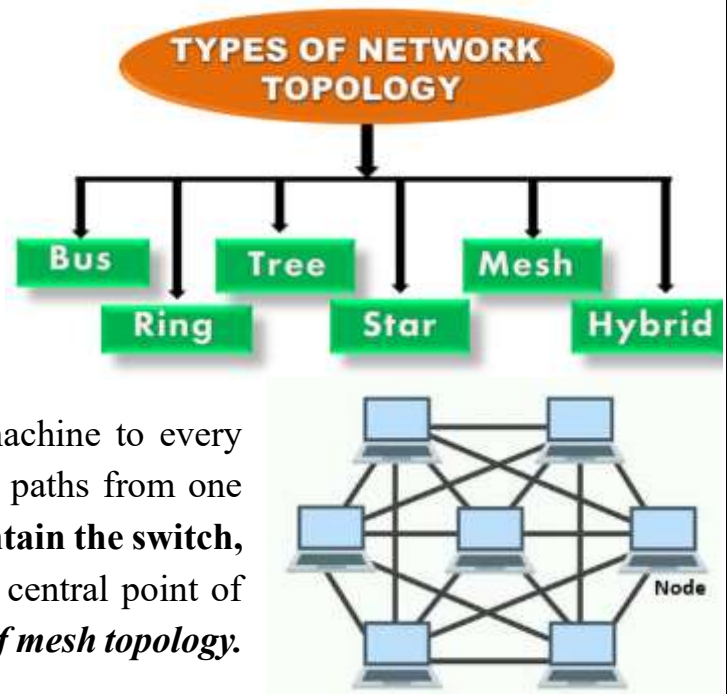
The types of networks are classified based upon the size, the area it covers and its physical architecture. (((Very important question)))

What is Network Topology?

Topology defines the structure of the network of how all the components are interconnected to each other. There are two types of topologies: physical and logical topology. **(physical architecture)**

Types of Network Topology:

Physical topology is the geometric representation of all the nodes in a network. There are six types of network topology which are Bus Topology, Ring Topology, Tree Topology, Star Topology, Mesh Topology, and Hybrid Topology.

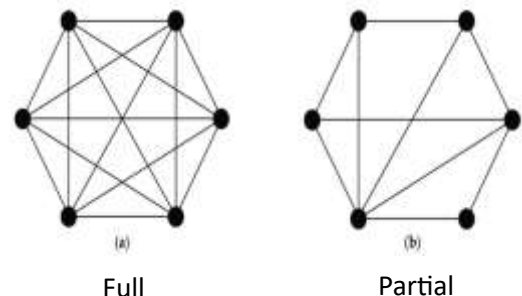


- 1) **Mesh Topology:** In this type of topology, you'll find that there's a path from every machine to every other one in the network. There are multiple paths from one computer to another computer. It **does not contain the switch, hub or any central computer** which acts as a central point of communication. *The Internet is an example of mesh topology.* **(Very important)**

كل ال end devices متوصلة ببعض من غير أي switch في النص.

- Mesh topology can be formed by using the formula: $Number\ of\ cables = \frac{n \times (n-1)}{2}$, where n is the number of nodes (devices) representing this network.
- Types of mesh network topology:

- **Full Mesh topology:** بنوصل كل جهاز كمبيوتر بكل الأجهزة اللي موجودة في النيتورك فبتبقى توصيلة كاملة
- **Partial Mesh topology:** بنوصل أجهزة كمبيوتر معينة للأجهزة اللي بتتواصل كثير في النيتورك بحيث يكون كل الأجهزة تقدر تتواصل مع بعضها بس مش لازم كل جهاز يكون متوصل بكل الأجهزة عشان نقل التكلفة



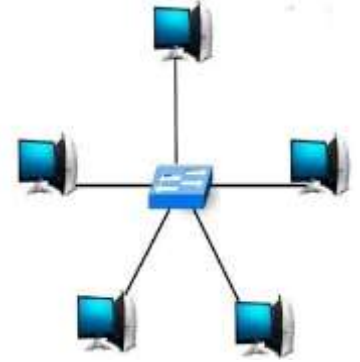
Advantages	Disadvantages
بيقدر يتحمل داتا كثير في نفس الوقت عشان كل الكمبيوترز يقدروا بيعتوا لبعض في نفس الوقت (Big data capacity)	التكلفة عالية جدا عشان بنستخدم توصيلات كثير و دا بيخليها مش فعالة و اقل تنفيذا (High cost)

لو كمبيوتر واحد باظ النيتورك مش هتتاثر عشان في كذا طريق تقدر الداتا تنتقل بين كل جهازين (Reliable)	بتاخذ وقت كثير في البناء و صعوبة في التنفيذ (Hard infrastructure)
لو عايز ازود جهاز جديد مش هضطر اقطع الدائرة كلها عشان اوصله (Easier Reconfiguration)	أوقات بيبقي في توصيلات زيادة ملهاش لازمة بتزود التكلفة علي الفاضي (Redundant connections)
لو في أي كونكشن باظت بقدر اكتشف فين المشكلة عادي (Fault detection and isolation are easy)	

2) Star topology:

Star topology is an arrangement of the network in which every node is connected to the central hub, switch or a central computer. This topology offers an advantage that if a cable does not work, only the respective node will suffer, the rest of the nodes will work smoothly. All data or messages that one node sends to other passes through the central hub.

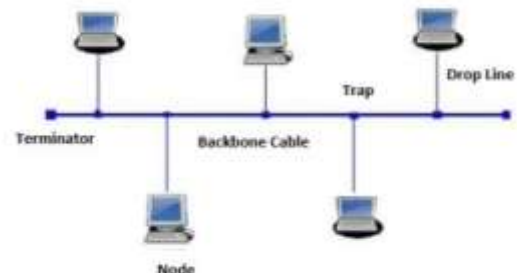
كل الأجهزة متوصلة بسيرفر مشترك بينهم بيتحكم في كل حاجة في التوصيلات



Advantages	Disadvantages
سهل في التنفيذ و التركيب (Easy infrastructure, installation and configuration)	لو السيرفر باظ السيستم كله هيقع و هيزود تكلفة تغيير السيستم جدااا (Central hub dependent)
لو في كمبيوتر بايظ الفرع بتاعه بس اللي بيتاثر و مش بياثر علي الشبكة كلها (Reliability)	تكلفته ممكن تبقي عالية عشان يستخدم switch او central hub (High cost dependent on the central hub)
تكلفته اقل بكثير اوي عشان بيستخدم اسلاك اقل (Low cost because of less wiring)	بيحصر عدد ال connections اللي متوصلة فيه و كفاءتها علي حسب كفاءة ال central hub (Central hub connection handling)
اقدر أكون و اعمل شبكات معزولة و اوصلها ببعض (Fault detection and isolation are easy)	بتحتاج إمكانيات عالية (Requirement of additional equipment)
لو عايز ازود جهاز جديد مش هضطر اقطع الدائرة كلها عشان اوصله (Easier Reconfiguration)	الاسلاك بتبوظ بسرعة عشان السيستمز كبيرة (Cables prone to damage)
اقدر اتحكم في أي حاجة عايز اتحكم بيها من السيرفر (Controlling configuration by the hub)	
سرعات اعلي في نقل الداتا (Higher data transfer rate)	

3) Bus topology:

The bus topology is designed in such a way that all the stations are connected through a single cable known as a backbone cable. Each node is either connected to the backbone cable by drop cable or directly connected to the backbone cable. When a



node wants to send a message over the network, it puts a message over the network. All the stations available in the network will receive the message whether it has been addressed or not.

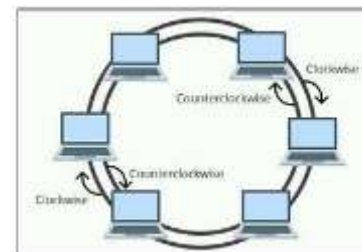
كل الأجهزة متوصلة بكابل رئيسي و لما بتوصل مسدج علي السيستم بتوصل علي الكابل الرئيسي و كل الأجهزة اللي متوصلة فيه تقدر تستلمها حتي لو هي متوجهة لجهاز واحد معين

The most common access method of the bus topologies is **CSMA (Carrier Sense Multiple Access)**. CSMA is a media access control used to control the data flow so that data integrity is maintained, i.e., the packets do not get lost. طريقة لحفظ الداتا من انها تضيع

Advantages	Disadvantages
التوصيلات سهلة و رخيصة (Low cost and simple wiring)	التوصيلات كثيرة (Lot of wiring)
سرعة نقل البيانات كويس نسبيا (Moderate data transfer speed)	تشويش الإشارة (Attenuation)
لو في توصيلة باظت مش بتبوظ النيتورك كلها (Reliable)	تداخل المسدجات في بعض (Signal and message interference)
بتشتغل كويس علي النيتورك الصغيرة (Small network efficient)	إضافة أجهزة جديدة هيادي لضعف النيتورك (Reconfiguration difficult)
	مش بتشتغل كويس في النيتورك الكبيرة (Large connection inefficient)
	لو النيتورك فيها مشكلة صعب احدد فين المشكلة بالظبط (Fault detection and troubleshooting are hard)
	لازم اضافة نهايات في الكابل الرئيسي (Terminators are required for both ends of the main cable)

4) Ring topology:

A ring topology is a network configuration in which device connections create a circular data path. In a ring network, packets of data travel from one device to the next until they reach their destination. It is like a bus topology, but with connected ends. The data flows in one direction (**unidirectional**). The node that receives the message from the previous computer will retransmit to the next node.



كل الأجهزة متوصلة بشكل دائري بحيث ان الداتا تخش تلف علي كل الأجهزة اللي في طريقها لحد ما توصل للجهاز اللي هي مبعوتاله بالظبط

Advantages	Disadvantages
كل الداتا بتتبع في اتجاه واحد و دا ببقل تصادم ال packets	الداتا بتلف علي كل الأجهزة اللي في النيتورك لحد ما وصل ال destination بالظبط

(Reducing collisions) سرعة نقل الداتا عالية (High data transfer speed)	(No privacy and security) محتاج أوصل كل جهاز توصيلات اكثر ممكن تكون اغلي من الserver (Expensive connection)
لو عايز ازود جهاز جديد مش هياثر علي اداء الدائرة كلها (Easier Reconfiguration and stability of performance)	لو جهاز واحد في النص قفل النيٲورك هتتاثر و هتقف (End device dependent)

5) Hybrid topology:

The combination of various different topologies is known as Hybrid topology. When two or more different topologies are combined together is termed Hybrid topology and if similar topologies are connected with each other will not result in Hybrid topology.

لو اكثر من سيستم توبولوجي اتمجوا مع بعض بحيث انهم يكونوا سيستمز مختلفين عشان لو اكثر من سيستم من نفس النوع مش هتعتبر hybrid

Types of networks based on size:

The three primary network categories are **LAN, WAN and MAN**, while there are other types like **WLAN, PAN, and SAN**. Each network differs in their characteristics such as distance, transmission speed, cables, and cost.



1) Local Area Network (LAN):

A local area network (LAN) is a collection of devices connected in one physical location, such as a building, university (like our university), or home. This connection gives the ability to any device to send any type of data with the other devices connected in the network. There are short-distanced connections so that there have less disturbance and noise. It has data transfer rate of 10 to 100 Mbps. Coaxial or CAT 5 cables are normally used for connections.

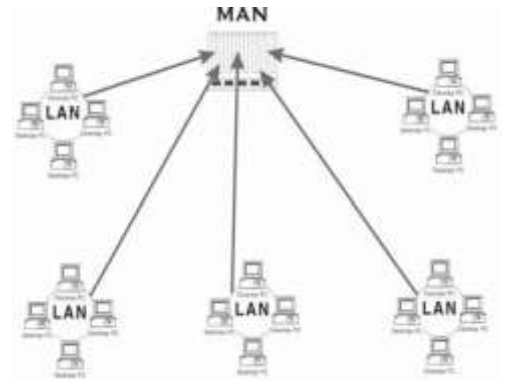
النيٲورك تجميعه لكل الأجهزة المتوصلة في مكان واحد زي مبني او جامعة و بيكون في اغلب الاحيان متحكم فيها سيرفر تابع للمنظمة اللي فيها و بتكون فيها نسبة ال errors مش كبيرة عشان المساحة صغيرة نسبيا

Advantages	Disadvantages
Resource sharing: It allows for the simple sharing of resources such as hard disc drives and printers. It lowers the cost of purchasing hardware.	Covers finite area: Local area network only covers a small geographical area, such as an office, building, or home.
Software sharing: Local area network makes it simple to use the same software on multiple devices connected to a computer.	Low privacy: A local area network administrator can see every LAN user's data files and internet history.

High transmission rate: A local area network has a high transmission rate to meet the needs of both the user and the equipment.	High maintenance: Requires frequent maintenance and upgrades by expert technicians.
Control: It is simple to control and manage the entire Local Area Network.	Low security: A virus spreads more easily in this network than in any other network.
Low error rate: The error rate is low because the noise is very low.	

2) Metropolitan Area Network (MAN):

A metropolitan area network is a network that covers a larger geographic area by interconnecting with a different LAN to form a larger network. Government agencies use MAN to connect to the citizens and private industries. In MAN, various LANs are connected to each other through a telephone exchange line. The most widely used protocols in MAN are RS-232, Frame Relay, ATM, ISDN, OC-3, ADSL, etc. It has a higher range than Local Area Network(LAN). The networks range can be from 5 to 50 km. Data transfer rate is low compared to LAN.



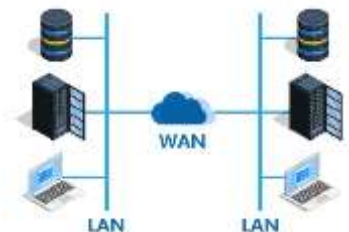
النيتورك عبارة عن توصيل اكثر من LAN network مع بعض عشان اعمل نيتورك اوسع شوية ممكن استخدمها في مدينة صغيرة

It can be used in:

- communication between the banks in a city.
- in an Airline Reservation.
- in a college within a city.
- for communication in the military.

3) Wide Area Network (WAN):

A wide-area network (WAN) is the technology that connects your offices, data centers, cloud applications, and cloud storage together. It is called a wide-area network because it spans beyond a single building or large campus to include multiple locations spread across a specific geographic area, or even the world. For example, businesses with many international branch offices use a WAN to connect office networks together. The world's largest WAN is the internet because it is a collection of many international networks that connect to each other. This article focuses on enterprise WANs and their uses and benefits.



النيتورك عبارة عن توصيل LANs و MANs مع بعض عشان يبقوا كلهم متوصلين في مساحة اكبر زي مجموعة مدن او بلد صغيرة

Uses of WAN:

- Communicate using voice and video.
- Sharing resources between employees and customers.
- Access data storage and remotely back up data.
- Connect to applications running in the cloud.
- Run and host internal applications.

Examples of WAN technologies that we will learn this semester

Packet switching vs. Circuit switching

Packet switching is a method of data transmission in which a message is broken into several parts, called packets, that are sent independently, in triplicate, over whatever route is optimum for each packet, and reassembled at the destination. Each packet contains a piece part, called the payload, and an identifying header that includes destination and reassembly information. The packets are sent in triplicate to check for packet corruption. Every packet is verified in a process that compares and confirms that at least two copies match. When verification fails, a request is made for the packet to be re-sent.

TCP/IP protocol suite

TCP/IP is a protocol suite of foundational communication protocols used to interconnect network devices on today's Internet and other computer/device networks. TCP/IP stands for Transmission Control Protocol/Internet Protocol.

Router

A router is a networking device typically used to interconnect LANs to form a wide area network (WAN) and as such is referred to as a WAN device. IP routers use IP addresses to determine where to forward packets. An IP address is a numeric label assigned to each connected network device.

4) Wireless Local-area Network (WLAN):

A wireless local-area network (WLAN) is a group of collocated computers or other devices that form a network based on radio transmissions rather than wired connections. A Wi-Fi network is a type of WLAN; anyone connected to Wi-Fi while reading this webpage is using a WLAN.



النيتورك عبارة عن LAN عادية جدا بين أجهزة في مساحة صغيرة بس الفرق انها هنا wireless بس.

Like broadcast media, a WLAN transmits information over radio waves. Data is sent in packets. The packets contain layers with labels and instructions that, along with the unique MAC (Media Access Control) addresses assigned to endpoints, enable routing to intended locations.

Every component that connects to a WLAN is considered a station and falls into one of two categories: access points (APs) and clients.

- Access points or APs transmit and receive radio frequency signals with devices able to receive transmitted signals; they normally function as routers.
- Clients, on the other hand, may include a variety of devices, such as desktop computers, workstations, laptop computers, IP phones and other cell phones and smartphone devices.

5) Personal Area Network (PAN):

A personal area network (PAN) connects electronic devices within a user's immediate area. The size of a PAN ranges from a few centimeters to a few meters. One of the most common real-world examples of a PAN is the connection between a Bluetooth earpiece and a smartphone. PANs can also connect laptops, tablets, printers, keyboards, and other computerized devices.

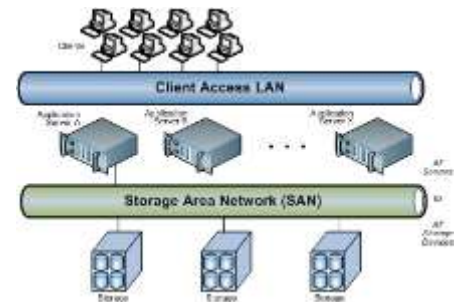


PAN network connections can either be wired or wireless. Wired connection methods include USB and FireWire; wireless connection methods include Bluetooth (the most common), WiFi, IrDA, and Zigbee.

النيوتورك عبارة عن نموذج مصغر من LAN أو WLAN خاصة بشخص واحد زي لما أوصل اللابتوب بالفون بالساعات بالprinter بالsmart tv كلهم بنفس الراوتر.

6) Storage Area Network (SAN):

A Storage Area Network (SAN) is a specialized, high-speed network that provides network access to storage devices. SANs are typically composed of hosts, switches, storage elements, and storage devices that are interconnected using a variety of technologies, topologies, and protocols. SANs may span multiple sites.



A SAN presents storage devices to a host such that the storage appears to be locally attached. This simplified presentation of storage to a host is accomplished through the use of different types of virtualizations.

نيوتورك خاصة بال servers عشان التخزين بتاعهم و يقدرُوا يتواصلُوا مع بعض و ان أي سيرفر يقدر ياخذ معلومات من السيرفر اللي جنبه و هكذا.

Uses of SAN network:

- Improve application availability (e.g., multiple data paths),
- Enhance application performance
- Increase storage utilization and effectiveness (e.g., consolidate storage resources, provide tiered storage, etc.), and improve data protection and security.

Types of Connection:

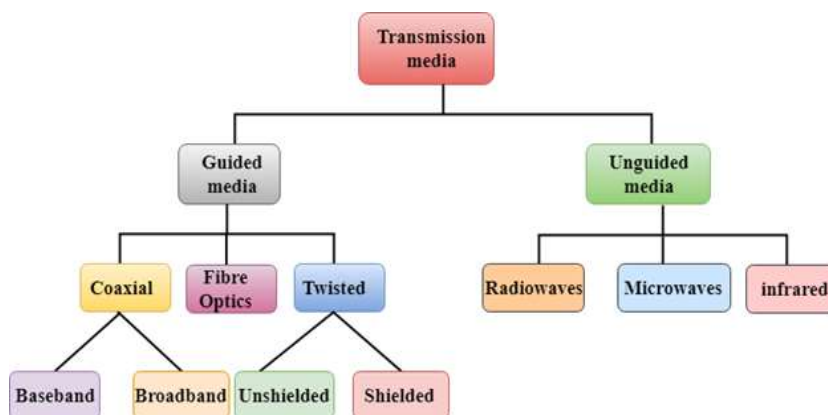
- **Point-to-point:** from one device to another. مثلا من جهاز لجهاز زي البلوتوث
- **Multi-point:** from one device to more than one device (e.g broadcasting). من جهاز واحد لاكثر من جهاز زي محطة الراديو او التلفزيون

Modes of transmission:

- **Simplex communication system:** unidirectional, one device can send without receiving anything from the other side. جهاز واحد بس اللي بيقتدر بيعت زي محطة الراديو او التلفزيون
- **Half-duplex communication system:** both directions but not at the same time. الجهازين يقدرنا بيعتوا و يستقبلوا بس مش في نفس الوقت زي جهاز التواصل بتاع الشرطة. (عشان كذا بيقولوا حول عشان ينهوا التواصل بينهم)
- **Full-duplex communication system:** both directions at the same time. الجهازين يقدرنا بيعتوا و يستقبلوا في نفس الوقت زي التلفون

What is Transmission media?

Transmission media is a communication channel that carries the information from the sender to the receiver where data is transmitted through electromagnetic signals. It is a physical path between transmitter and receiver in data communication.



It has two types:

1. Guided media (Wired): Twisted, Coaxial, and Fiber Optics
2. Unguided media (Wireless): Radio

First: Guided (Wired) media:

It is defined as the physical medium through which the signals are transmitted. It has some types which are:

a) Twisted copper pair:

Twisted pair is a physical media made up of a pair of copper cables twisted with each other. A twisted pair cable is cheap as compared to other

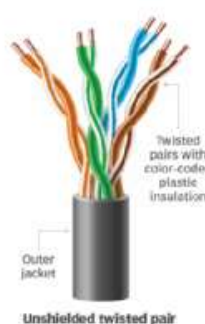
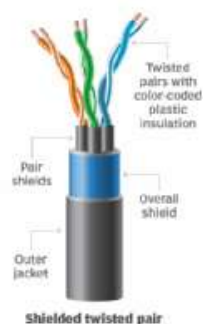


transmission media. Installation of the twisted pair cable is easy, and it is a lightweight cable.

The degree of reduction in noise interference is determined by the number of turns per foot. Increasing the number of turns per foot decreases noise interference.

It has only types:

Shielded twisted copper pair (STP)	Unshielded twisted copper pair (UTP)
<p>A shielded twisted pair is a cable that contains the mesh surrounding the internal wire that allows the higher transmission rate.</p> <p>متغلف داخليا بطبقة بلاستيك مطاطية عشان العزل يبقى احسن و الكفاءة تبقى اكبر</p>	<p>Not shielded with a layer internally.</p>
<p>Advantages:</p> <ul style="list-style-type: none"> • The cost of the shielded twisted pair cable is not very high and not very low. • It has higher capacity as compared to unshielded twisted pair cable and a higher attenuation. • An installation of STP is easy. 	<p>Advantages:</p> <ul style="list-style-type: none"> • Installation of the unshielded twisted pair is easy and cheap. • It can be used for high-speed LAN.
<p>Disadvantages:</p> <ul style="list-style-type: none"> • It has a higher attenuation rate and is more expensive as compared to UTP and coaxial cable. 	<p>Disadvantages:</p> <ul style="list-style-type: none"> • This cable can only be used for shorter distances because of attenuation.



b) Coaxial Cable:

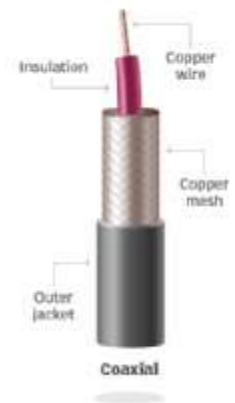
Coaxial cable is very commonly used transmission media, for example, TV wire is usually a coaxial cable. The name of the cable is coaxial as it contains two conductors parallel to each other. It has a higher frequency as compared to Twisted pair cable.

Structure:

The inner conductor of the coaxial cable is made up of copper, and the outer conductor is made up of copper mesh. The middle core is made up of non-conductive cover that separates the inner conductor from the outer conductor.

The middle core is responsible for the data transferring whereas the copper mesh prevents EMI (Electromagnetic interference).

الكابل متدرج في العزل بحيث ان في طبقتين من الـ copper متوازيين بينهما عازل و محاطين بطبقة عازلة كمان.



Advantages Of Coaxial cable:

- The data can be transmitted at high speed.
- It has better shielding as compared to twisted pair cable.
- It provides higher bandwidth.

Disadvantages Of Coaxial cable:

- It is more expensive as compared to twisted pair cable.
- If any fault occurs in the cable causes the failure in the entire network.

c) Fiber optics:

Fiber optic cable is a cable that uses electrical signals for communication. Fiber optic is a cable that holds the optical fibers coated in plastic that are used to send the data by pulses of light.

Advantages:

- Greater Bandwidth: The fiber optic cable provides more bandwidth as compared to copper. Therefore, the fiber optic carries more data as compared to copper cable.
- Faster speed: Fiber optic cable carries the data in the form of light. This allows the fiber optic cable to carry the signals at a higher speed.

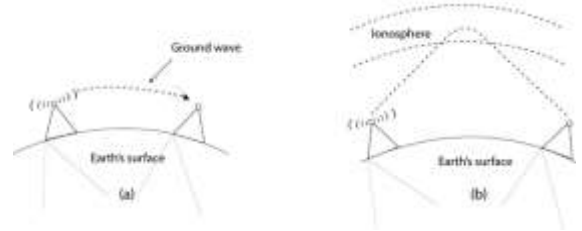


Second: Unguided (Wireless) media:

An unguided transmission transmits the electromagnetic waves without using any physical medium. Therefore, it is also known as wireless transmission.

In unguided media, air is the medium through which the electromagnetic energy can flow easily.

Unguided transmission is broadly classified into three categories, but the most important one is Radio waves.



Applications Of Radio waves:

- A Radio wave is useful for multicasting when there is one sender and many receivers.
- An FM radio, television, cordless phones are examples of a radio wave.

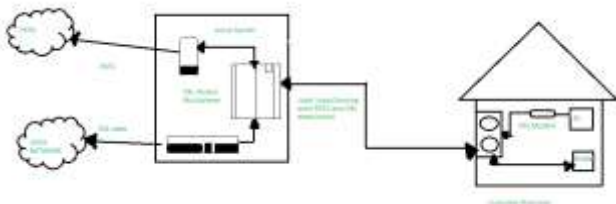
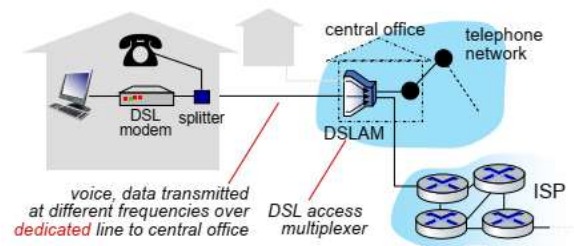
Advantages Of Radio transmission:

- Radio transmission is mainly used for wide area networks and mobile cellular phones.
- Radio waves cover a large area, and they can penetrate the walls.
- Radio transmission provides a higher transmission rate.

Access networks: digital subscriber line (DSL):

The Digital Subscriber Line (DSL), originally, a digital subscriber line is a communication medium, which is used to transfer the internet through copper wire telecommunication lines. Along with cable internet, DSL is one of the most popular ways ISPs provide broadband internet access.

Splitter is the responsible for separating between the internet and telephone line service and making sure that it can't get interrupted.



ال DSLAM اختصار ل digital subscriber line access multiplexer و دا الجهاز اللي بيتوصل فيه كل الوصلات اللي رايحة للبيوت و المنشآت اللي عايزة تاخذ توصيلة نت او تليفون.

ال global ISP الوحيد لمصر هو شركة WE، فأى شركة اتصالات تانية عايزة توفر خدمة انترنت للعملاء بتوعها بتعمل من حاجة من الاتنين:

(1) بتجيب ال DSLAMs بتوعها تحطها جوا شركة WE

(2) او بتأجر شوية DSLAMs من WE نفسها

اي بيت عايز ياخذ توصيلة بيروح للشركة يطلب منها توصيلة لبيته فيبتيوصل له cable جوا ال DSLAM التابع للشركة و بيخش علي البيت لحد ما بنبقي عايزين نفصل سلك التليفون عن سلك الراوتر. اللي بيقوم بالعملية دي حاجة اسمها ال splitter و دا بيعتبر من المكونات الرئيسية لأي راوتر.

The network core:

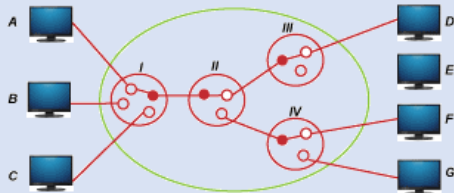
There are two main functions for the network and two main techniques of switching:

Two main functions:

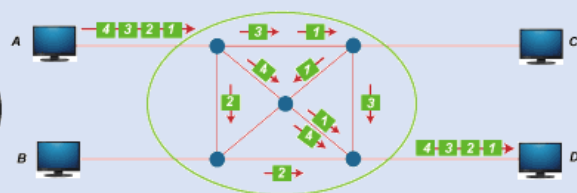
Forwarding	Routing
move packets from the router input to the router output عامل زي الكوبري بيعدي ال packets بس من مدخل الراوتر للمخرج بتاعه	Determining the packet's travel path from source to destination عامل زي ال GPS بيحدد الطريق اللي ال packet المفروض تمشي فيه من البداية للنهاية
Local /per router	Global/whole path

Two techniques of switching: (used together not separately)

Circuit switching	Packet switching
Establishing a dedicated path between the sending and receiving device. له علاقة بتحديد الطريق ما بين المرسل و المستلم	The message is divided into packets. له علاقة بتقسيم المسدج لكذا packet
Fixed bandwidth	Dynamic bandwidth
The route followed by packets is always the same.	The route followed by packets is may or may not be different.
Congestion can occur at set up time.	Congestion can occur on every packet.
Implemented at the physical layer	Implemented at the data link and a network layer
Apply choosing the best pathway for the packets to be delivered with the least cost (you will know that later deeply).	Apply store and forward way: entire packet must arrive at router before it can be transmitted on next link.



Circuit Switched Network



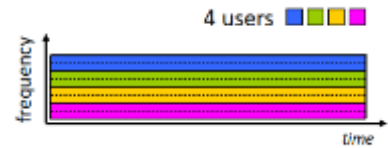
Packet Switched Network

Circuit switching is using two technologies:

- **Time Division multiplexing:** time divided into slots, each user can take part of time to send his packets. It can be used in call streams.



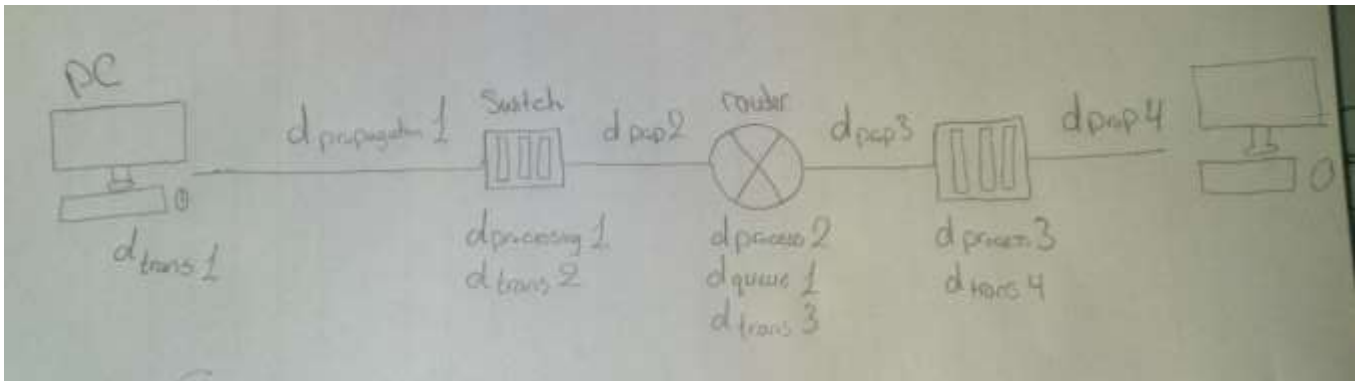
- **Frequency Division multiplexing:** frequencies are divided into bandwidths, each user can take a bandwidth all the time to send his packets. It can be used in radio and TV streams.



Packet switching delays:

Delay occurs for packets when the speed of packets transmission is less than the data transfer rate. They are four types of packets switching delays:

- **Processing delay:** occurs when the packets take time in the processing inside the router, switch, or any middlebox (you will know what is the middlebox later).
- **Transmission delay (L/R):** occurs when the packets take time in the transmission from any device to the output cable link, for example, from the PC to the cable. It is calculated by the formula L/R , while L is the length of the packet (bits), and the R is the rate of transmission (bits/sec).
- **Queuing delay:** occurs when the packets take time waiting for their turn to be processed inside the router. It only exists in the **router**. The packets can be subjected to loss because of the much waiting.
- **Propagation delay (D/S):** occurs when the packets take time in travelling inside cables and wires. It is calculated by the formula D/S where D is the distance of the wire (meter or km.), and the S is the speed of the packets transmission (m/sec or km/h).



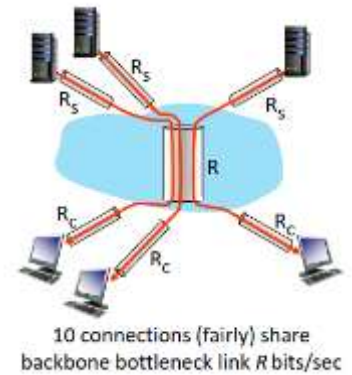
The total delay of the packets is called the nodal delay (from node to node) and it is calculated by:

$$d_{\text{nodal}} = d_{\text{proc}} + d_{\text{queue}} + d_{\text{trans}} + d_{\text{prop}}$$

Bandwidth: the maximum number of bits that one cable can transmit in one second. It is calculated by the formula (Propagation delay * R) = R*(D/S).

Throughput: the rate of sending and receiving the bits from the sender to the receiver relating it to the number of devices connected on the same circuit.

It is instantaneous and average measure of the network. If one device is only connected in a dedicated cable, the throughput is R, while if there is more than one device connected on the same cable, the throughput is R/n where n is the number of devices in the network.

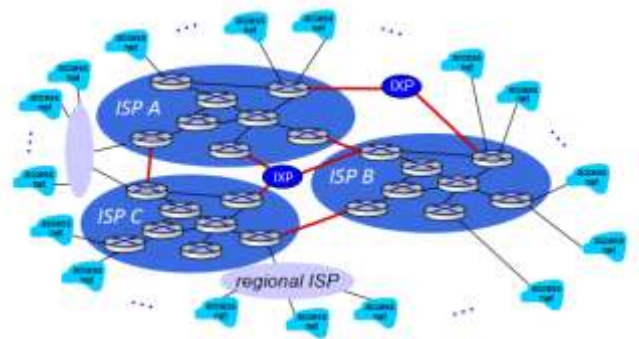


Internet network structure (Internet providing):

The internet can be defined as “A network of networks”, where all hosts connected to each other in small networks, reaching to the regional scope to connect to Internet Service Providers.

The journey begins from:

1. the homes and facilities to be connected to small DSLAMs (صناديق خطوط التليفون اللي يمكن نلاقيها في الشارع). These DSLAMs are called **access networks**.
2. These small DSLAMs are connected to bigger DSLAMs that existed in the datacenters of the telecommunication companies. These DSLAMs can also be called **access networks**.
3. These access networks are connected to regional ISPs in the same country or region via **peering links**.
4. Regional ISPs are connected to each other and to global ISPs via stations called **Internet Exchange points (IXP)**.
5. Data and content are provided through this whole network from the networks of data servers around the globe which are called **Content provider network**.

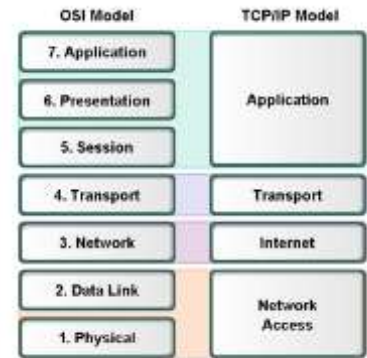


Layers of internet protocols:

They are two models of layers of internet, Open Systems Interconnection model (OSI reference) model, and TCP/IP model (مقارنة مهمة).

Each layer has a specified function to implement the service of the whole network.

OSI model has 7 layers while TCP/IP has 4 layers. They are the same layers, but the OSI is more detailed in the divisions.



OSI reference layer model:

Layer	Function
Application	It is the visual view you see on the website and the interface that the user can deal with (Front-end). Examples: Email (SMTP), Websites (HTTP), File transfer protocol (FTP).
Presentation	Extension of the files you see on the website to view it properly. Examples: Mp3, JPG, etc..
Session	The layer that ensures that there is a connection between the sender and receiver (open session). It is responsible of the establishments of connection and ending (termination) of it.
Transport	The layer that is responsible for how the data will be delivered. It controls all the logical communication between processes in the connection (تعريف مهم) by: <ul style="list-style-type: none">• Error detection and correction• Segmentation• Flow control• End-to-end check• Properties of the packets and circuit switching. Examples: TCP and UDP
Network	The layer that is responsible for how the data will be sent and received between hosts. It controls all the logical communication between hosts in the connection (تعريف مهم) by: <ul style="list-style-type: none">• Forwarding• Routing• Logical addressing (IPv4 and IPv6) Examples for protocols: IP, NAT, DHCP.
Data link	The layer that is responsible for how the data will be transmitted physically . It controls all the physical communication between links in the connection adjacent nodes (تعريف مهم) by:

	<ul style="list-style-type: none"> • Hop transmission and flow control • Error detection and correction • Hop to hop data addressing (MAC address) <p>Examples for protocols: ARP</p>
Physical	<p>Everything about the properties of the cables:</p> <ul style="list-style-type: none"> • Cable length • Cable type • Bit rate, bandwidth and throughput • Voltage levels

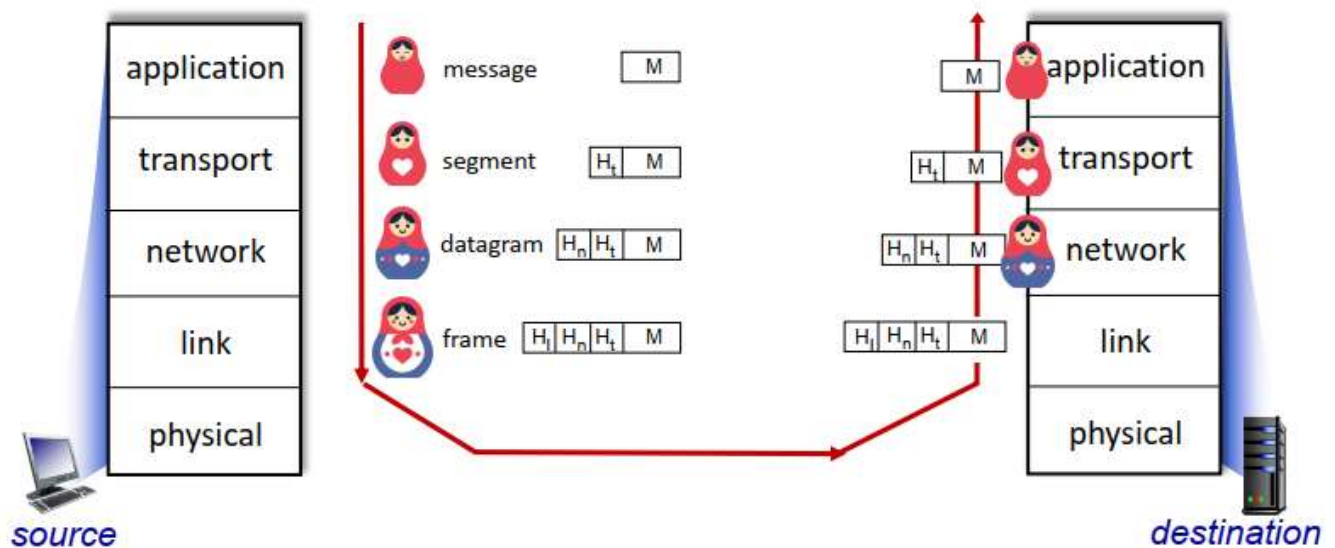
These are the main function layers in the internet layering used today.

Encapsulation: the process of inserting a specific header of the layer on the packet before it would be sent.

Decapsulation: the process of removing the header of the layer from the packet after it had been received to the device.



Services, Layering and Encapsulation



Headers journey (Sending):

- 1) The packet begins from the application layer as a **message**.
- 2) Then, it is transmitted to the transport layer to insert on it the header of the transport layer, so it is called now **segment**. (Message + transport header)

- 3) Then, it is transmitted to the network layer to insert on it the header of the network layer, so it is called now **datagram OR packet**. (Message + transport header + network header)
- 4) Then, it is transmitted to the link layer to insert on it the header of the link layer, so it is called now **frame**. (Message + transport header + network header + data link header)
- 5) Then it is transmitted to the cable to be represented and transmitted as **bits**.

Headers journey (Receiving):

- 1) The bits received by the link layer as a frame, the header of datalink layer **removed and then the datagram is passed** to the network layer.
- 2) The datagram is received by the network layer, the header of network layer **removed and then the segment is passed** to the transport layer.
- 3) The segment is received by the transport layer, the header of transport layer **removed and then the message is passed** to the application layer.
- 4) The application layer message is represented as visuals for the user.