(*) Introduction

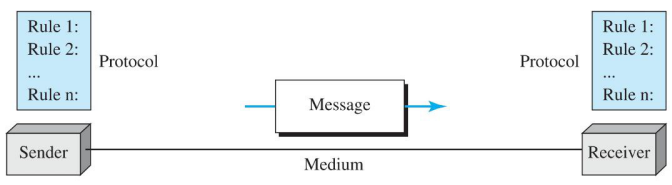
^ The largest computer network, the INTERNET, has billions of users in the world who use WIRED and WIRELESS transmission media to connect small and large computers.

DATA refers to INFORMATION presented in whatever FORM is agreed upon by the parties CREATING and USING it.
DATA COMMUNICATIONS is the exchange of DATA between two devices via a combination of HARDWARE (physical equipment) and SOFTWARE (programs).

The EFFECTIVENESS of a data communications system depends upon :-

1. DELIVERY –
   Delivery must be ensured ONLY to the CORRECT destination.
2. ACCURACY –
   Data ALTERED during transmission must be CORRECTED.
3. TIMELINESS –
   Data must be delivered AS they are produced, in the same ORDER that they are produced, and without significant DELAY.
4. JITTER –
   The variation in the ARRIVAL RATE of data must be minimized.

^ **Figure 1.1** *Five components of a data communications system*



A protocol is a set of RULES.
Message is the DATA to be sent.
Medium can be CABLES, RADIO WAVES, etc.

Without a PROTOCOL, two devices may be CONNECTED but not able to COMMUNICATE, just as a person speaking French cannot be understood by a person who only speaks Japanese.

Data/Information can come in different FORMS, such as text, numbers, images, audio and video.

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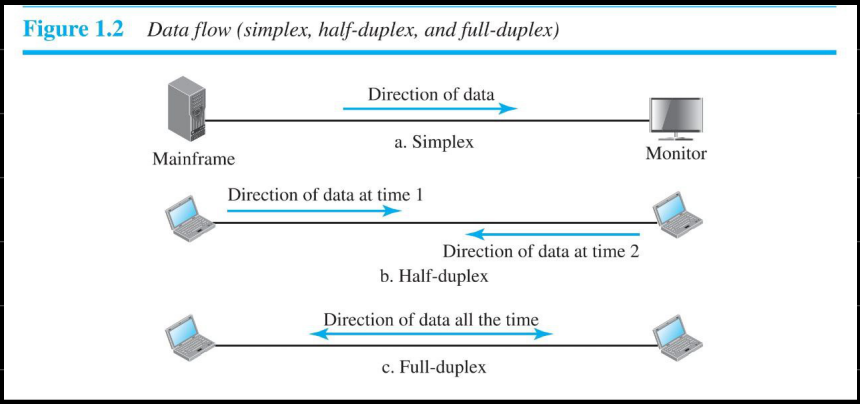


1. SIMPLEX –

   The communication is UNIDIRECTIONAL. Only one of the two devices on a link can TRANSMIT; the other can only RECEIVE. For eg., keyboards and traditional monitors.

2. HALF–DUPLEX –

   Each station can both TRANSMIT and RECEIVE, but NOT at the same time. For eg., walkie–talkies.

3. FULL–DUPLEX –

   Both stations can TRANSMIT and RECEIVE SIMULTANEOUSLY. For eg., telephone network.

^

A NETWORK is the interconnection of a set of DEVICES capable of COMMUNICATION, where a device can be a HOST (for eg., desktop) or a CONNECTING DEVICE (for eg., router).

Network criteria :–

1. PERFORMANCE –

   For eg., TRANSIT TIME (amount of time required for a MESSAGE to travel from one DEVICE to another), RESPONSE TIME (elapsed time between an INQUIRY and a RESPONSE), etc.

   These depend upon a number of FACTORS, for eg., the number of USERS, the TYPE of TRANSMISSION MEDIUM, etc.

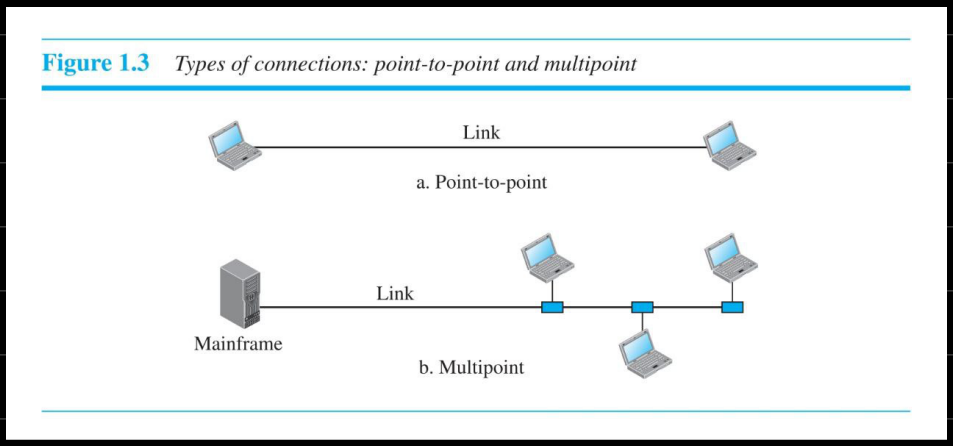
2. RELIABILITY –

   For eg., the frequency of FAILURE, RECOVERY time, etc.

3. SECURITY –

   For eg., protection from UNAUTHORIZED access, protection from DAMAGE, policies for recovery from BREACHES, etc.

^ In a network, devices are connected through LINKS. A link (also known as a CHANNEL) is a COMMUNICATION pathway that TRANSFERS data from one DEVICE to another. For communication to occur, two devices must be connected in some way to the SAME LINK at the SAME TIME.



1. POINT-TO-POINT CONNECTION –

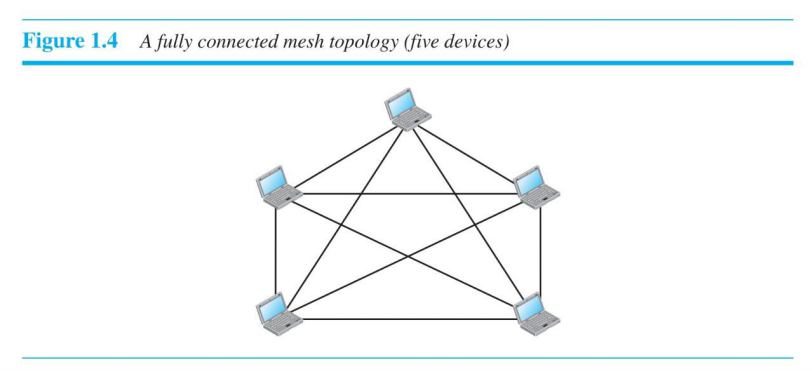
   It provides a DEDICATED link between TWO devices, and the ENTIRE capacity of the link is reserved for TRANSMISSION between those two devices ONLY.

2. MULTIPOINT/MULTIDROP CONNECTION –

   MORE than two devices share a single link, and the capacity of the link is shared, either SPATIALLY (i.e. if several devices can use the link SIMULTANEOUSLY) or TEMPORALLY (i.e. if the devices must take TURNS to use the link).

^ PHYSICAL TOPOLOGY refers to the way in which a network is laid out PHYSICALLY, i.e. it is the GEOMETRIC representation of the relationship of all the LINKS and the LINKING DEVICES (NODES) to one another.

1. MESH Topology –

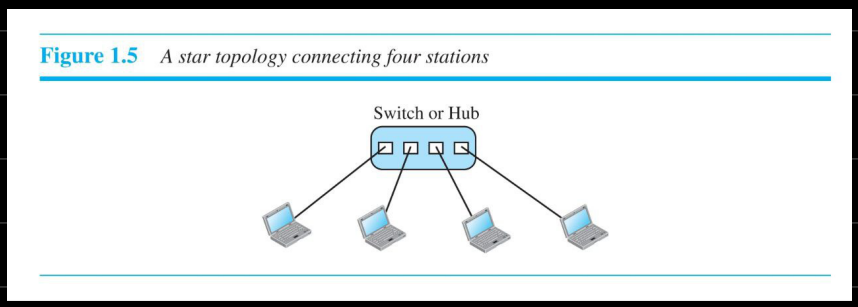


Every device has a dedicated POINT-TO-POINT link to every other device.

Total number of physical links = ${}^{n}C_{2}$ = n (n – 1) / 2, where n is the number of devices.

Every device must have n – 1 input/output (I/O) ports.

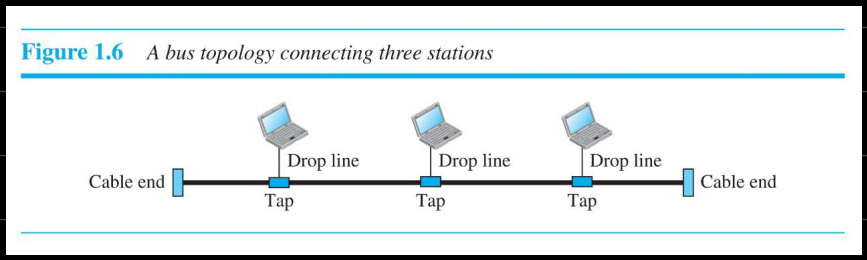
2. STAR Topology –



Each device has a dedicated POINT-TO-POINT link only to a CENTRAL controller, usually a HUB, and is NOT directly linked to any other device.

The controller acts as an EXCHANGE, i.e. if one device wants to send data to another, it sends the data to the CONTROLLER, which then relays the data to the target device.

3. BUS Topology –

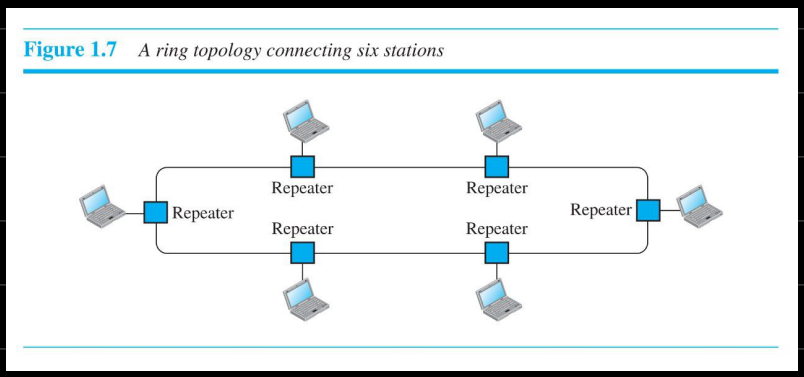


Each device is connected to a MULTIPOINT link, which acts as a BACKBONE to link all the devices in the network.

A DROP LINE is a connection running between the DEVICE and the MAIN CABLE.

A TAP is a connector.

4. RING Topology –



Each device has a dedicated POINT-TO-POINT connection with only the TWO devices on either side of it. Data are passed along the ring in ONE direction, from device to device, until they reach the DESTINATION.

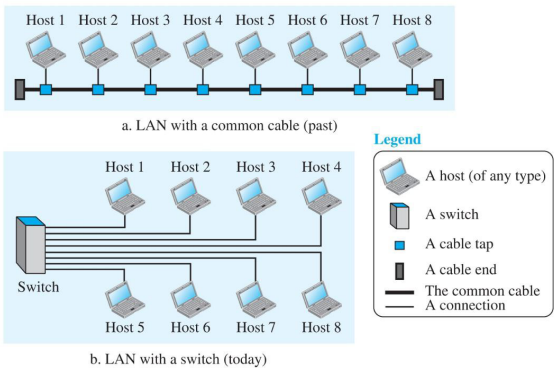
A REPEATER regenerates the BITS and passes them along.

^ Network Types :-

1. LOCAL AREA NETWORK –

A LAN is usually PRIVATELY owned and connects SOME hosts in a single office, building or campus.

Figure 1.8 *An isolated LAN in the past and today*



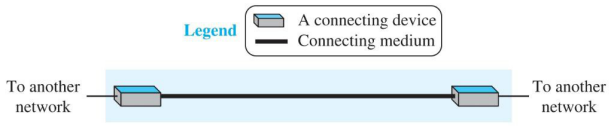
2. WIDE AREA NETWORK –

A WAN has a WIDER geographical span than a LAN, spanning a town, a state, a country, or even the world.

A LAN interconnects HOSTS, whereas a WAN interconnects CONNECTING DEVICES, such as switches, routers or modems.

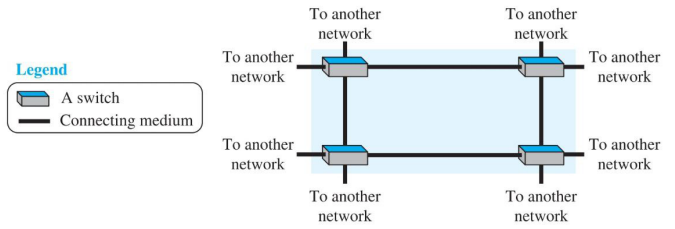
A POINT-TO-POINT WAN is a network that connects TWO communicating devices through a transmission medium.

Figure 1.9 *A point-to-point WAN*



A SWITCHED WAN is a network with MORE than two ends. It is used in the BACKBONE of a global communications network today.

Figure 1.10 *A switched WAN*



Most commonly, LANs and WANs are connected to one another, making an INTERNETWORK, i.e. an internet (lowercase i).

Figure 1.11 *An internetwork made of two LANs and one point-to-point WAN*

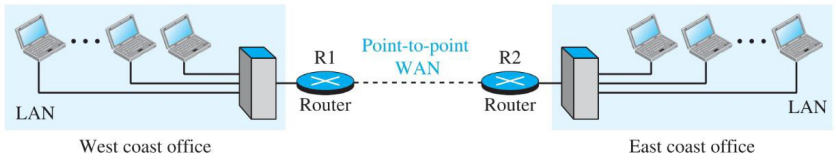
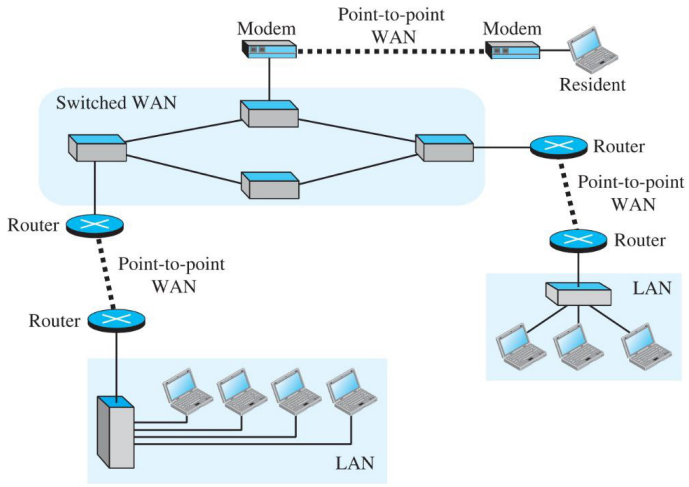
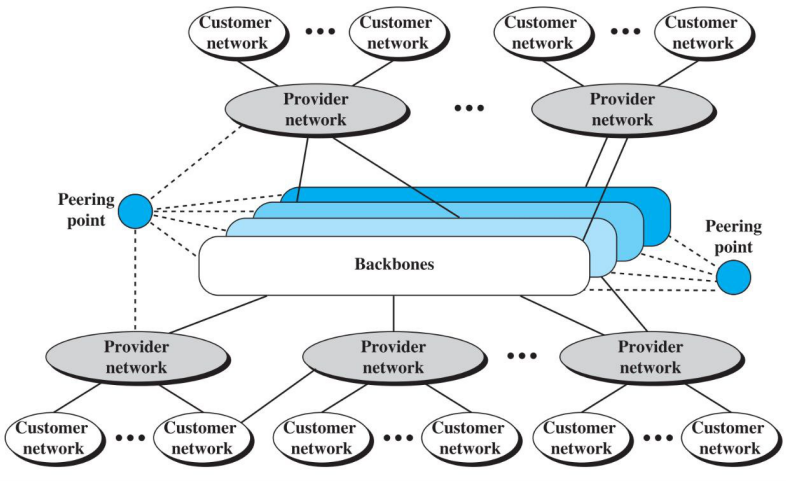


Figure 1.12 *A heterogeneous internetwork made of four WANs and two LANs*



The most notable internet is called the Internet (uppercase I) and is composed of THOUSANDS of interconnected networks.

Figure 1.13 *The Internet today*



At the top level, the BACKBONES (also known as INTERNATIONAL INTERNET SERVICE PROVIDERS (ISPs)) are large networks owned by some COMMUNICATION companies which are connected through complex SWITCHING systems, called PEERING points.

At the second level, there are smaller networks, called PROVIDER networks (also known as NATIONAL/REGIONAL ISPs), that use the services of the backbones for some FEES.

The CUSTOMER networks are networks at the edge of the Internet that actually use the services provided by the Internet by paying some FEES to provider networks.

^ Accessing the Internet

A physical connection to an ISP is done through a POINT-TO-POINT WAN. For eg.,

1. By using a TELEPHONE network, i.e. by changing the VOICE line to a point-to-point WAN through a DIAL-UP service (i.e. by using a MODEM to convert DATA to AUDIO SIGNALS and imitating making a telephone connection, thereby making the line UNUSABLE for normal telephone connections), or through a DSL (DIGITAL SUBSCRIBER LINE) service (i.e. the upgraded version of a dial-up service where the line can be used SIMULTANEOUSLY for voice and data communications).
2. By using a CABLE television network.
3. By using a WIRELESS network.
4. By DIRECTLY connecting to the Internet, for eg., by becoming a local ISP.

^ Protocol Layering