Introduction

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Contents

- Data Communication Basics, Definitions
- Uses of Computer Networks
- Network Structure
- Network Architecture
- The ISO Reference Model

What is your idea about ***Data Communication***?

Data Communication

- is the active process of transporting data from one point to another
- is the exchange of data between two devices via some form of transmission medium such as a wire cable

What ***basic components*** are needed in order to perform data communication?

1. Message

- the information (data) to be communicated
- popular forms of information include text, numbers, pictures, audio and video or their combination

2. Sender

- a.k.a. *Transmitter*
- the device that sends the data message
- it can be a computer, workstation, telephone handset, video camera, and so on

3. Receiver

- the device that receives the message
- similarly, it can be a computer, workstation, telephone handset, video camera, and so on

4. Transmission Medium

- the physical path by which a message travels from sender to receiver

Give examples of transmission media.

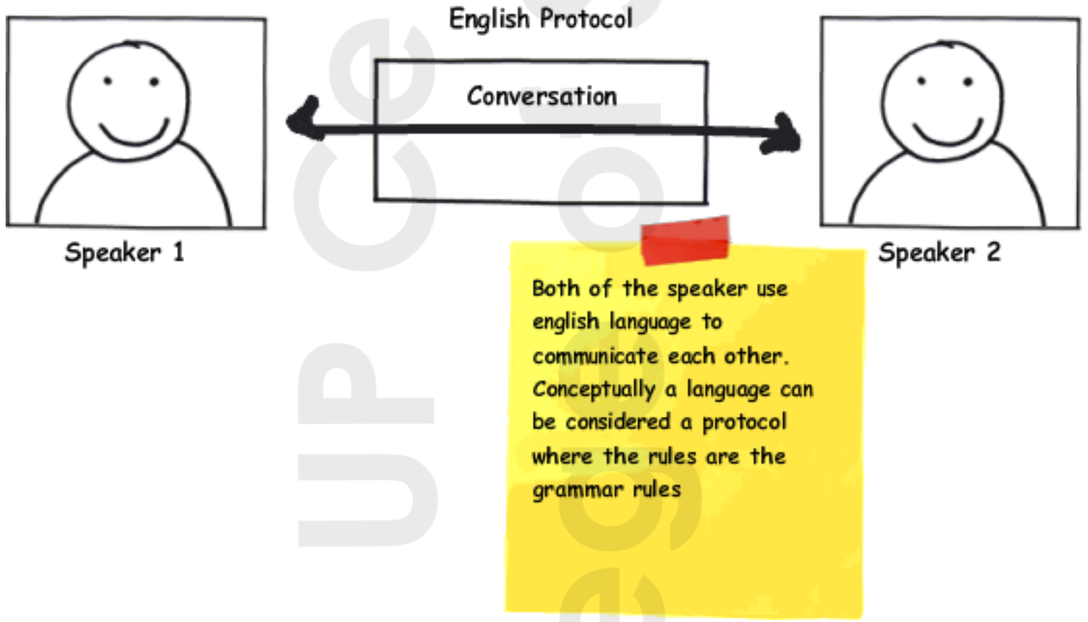
- some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, laser or radio waves (terrestrial or satellite microwave)

What do you think is the last component?

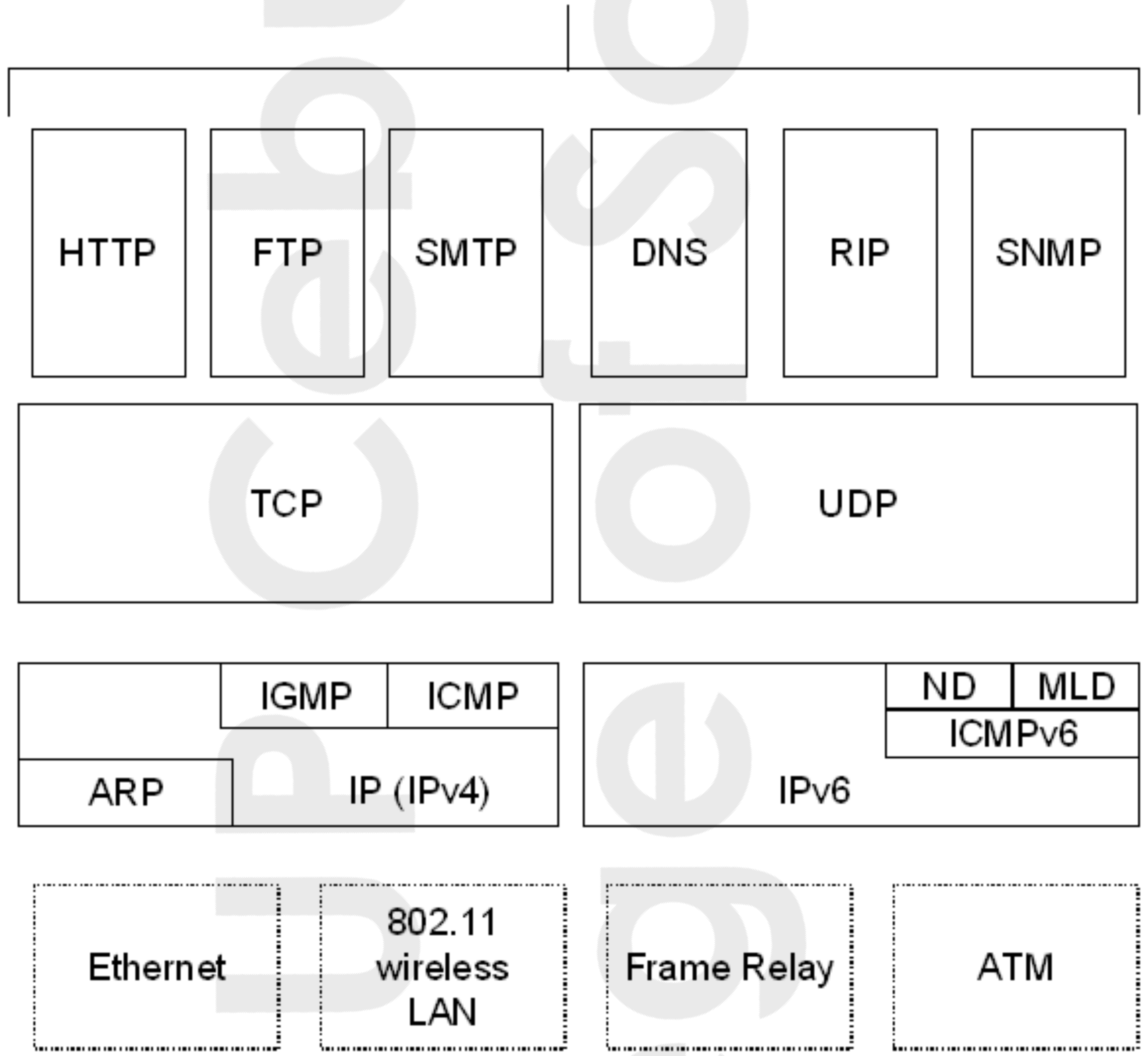
Hint:
Without this, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

5. Protocol

- a set of rules that govern data communications
- it represents an agreement between the communicating devices



Can you think of a ***protocol*** in data communication?



How do you think does a protocol work?

HTTP Request Structure

```
GET /home.html HTTP/1.1
Host: www.yoursite.com
```

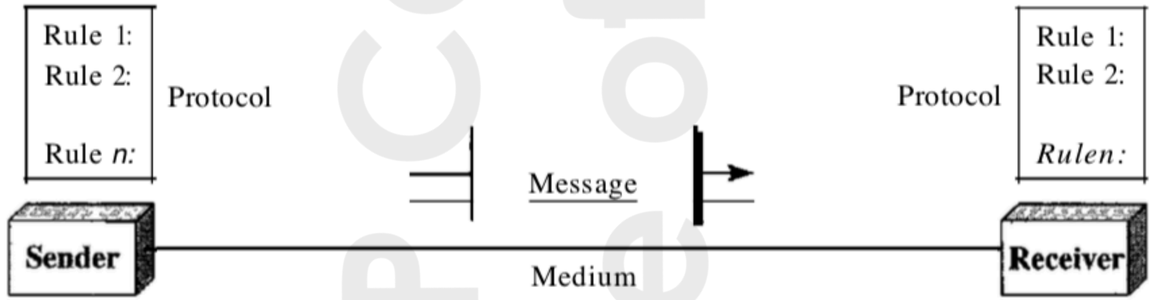
HTTP Response Structure

```
HTTP/1.1 200 OK
Date: Sun, 28 Jul 2013 15:37:37 GMT
Server: Apache
Last-Modified: Sun, 07 Jul 2013 06:13:43 GMT
Transfer-Encoding: chunked
Connection: Keep-Alive
Content-Type: text/html; charset=UTF-8
Webpage Content
```

Basic Components of Data Transmission

1. Message
2. Sender
3. Receiver
4. Transmission Medium
5. Protocol

Figure 1.1 *Five components ofdata communication*



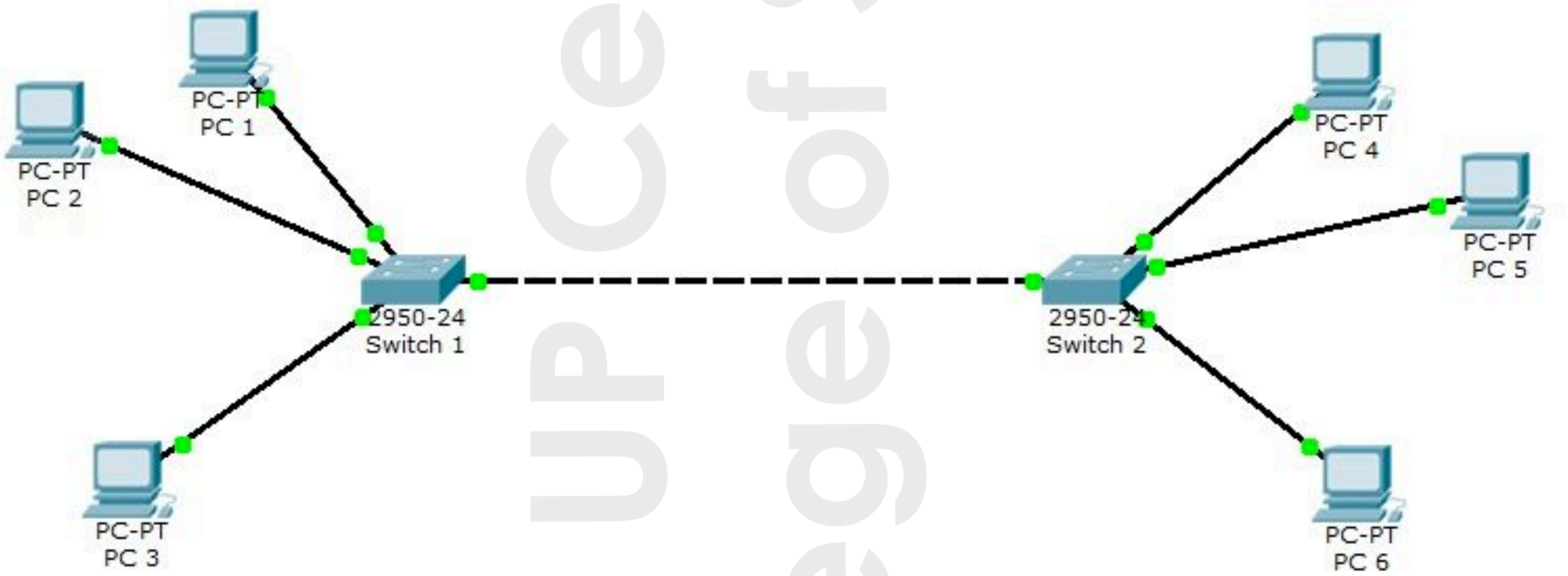
How will you know if the data communication is ***effective*** or not?

Characteristics of Effective Data Communication

1. Delivery
2. Accuracy
3. Timeliness
4. Jitter

1. Delivery

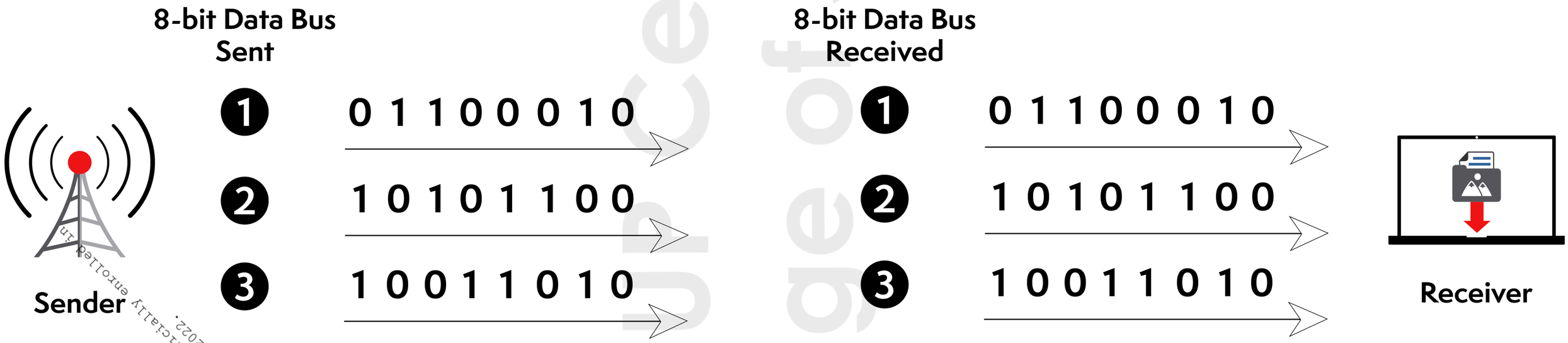
- the system must deliver data to the correct destination
- data must be received by the intended device or user and only by that device or user



Why do you think it is important that the system must deliver the data to the correct destination?

2. Accuracy

- the system must deliver the data accurately



Do you think it is possible that the data being transmitted is altered? If so, in what way?

- data that have been altered in transmission and *left uncorrected* are unusable

3. Timeliness

- the system must deliver data in a timely manner
- in the case of video and audio, timely delivery means delivering data as they are produced, in the same order that they are produced, and without significant delay. This kind of delivery is called *real-time transmission*.

4. Jitter

- refers to the *variation* in the packet arrival time
- the uneven delay in the delivery of audio or video packets
- for example, assume that video packets are sent every 30 ms; if some of the packets arrive with 30-ms delay and others with 40-ms delay, an uneven quality in the video is the result

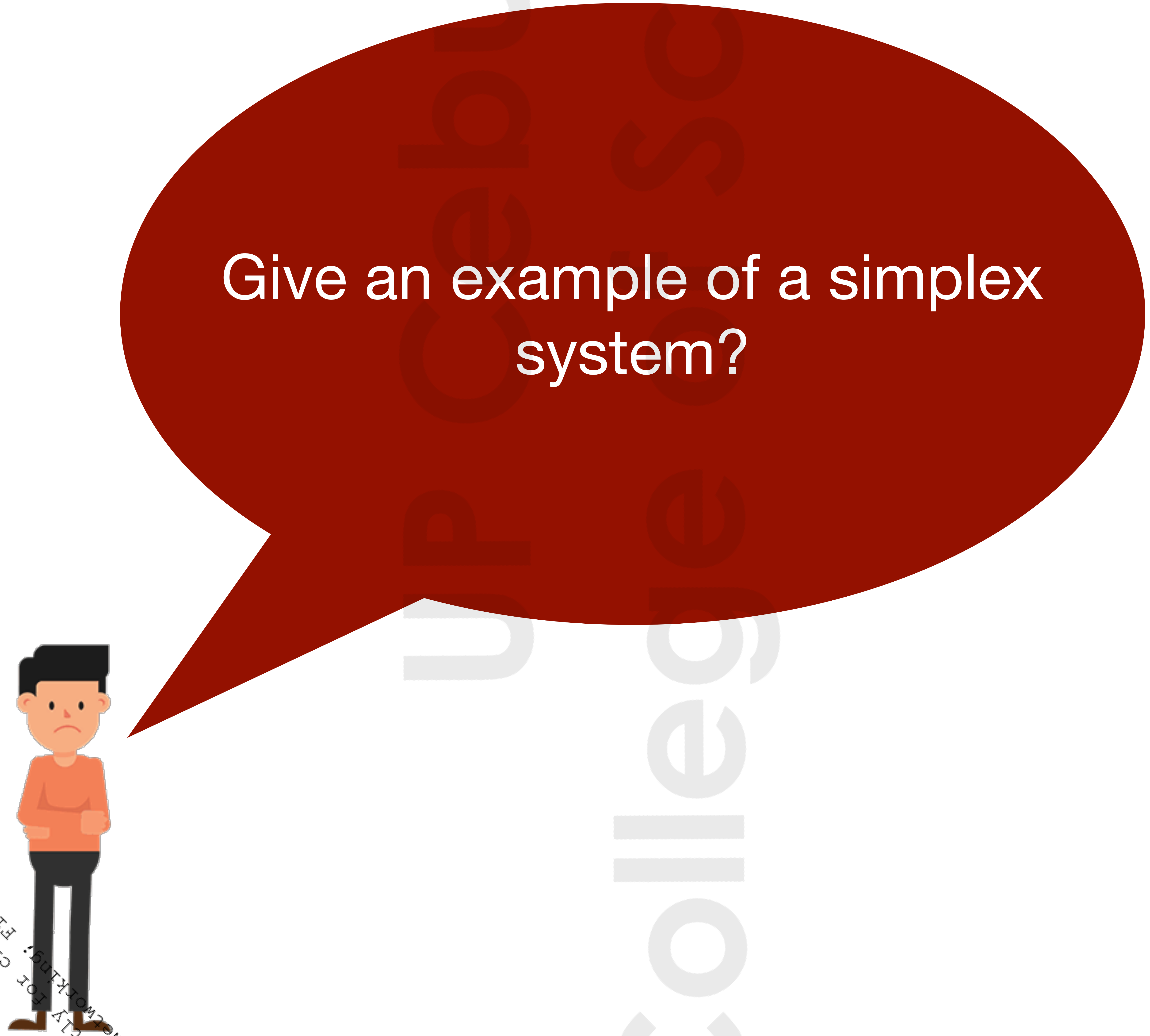
https://www.youtube.com/watch?v=DeWT047UODQ uploaded by Ken Leach July 3 2012

Data Flow (or Data Traffic)

1. Simplex
2. Half-duplex
3. Full-duplex

1. Simplex

- communication is unidirectional, as on a one-way street
- only one of the two devices on a link can transmit; the other can only receive



- keyboard can only introduce input; the monitor can only accept output
- the simplex mode can use the entire capacity of the channel to send data in one direction

2. Half-duplex

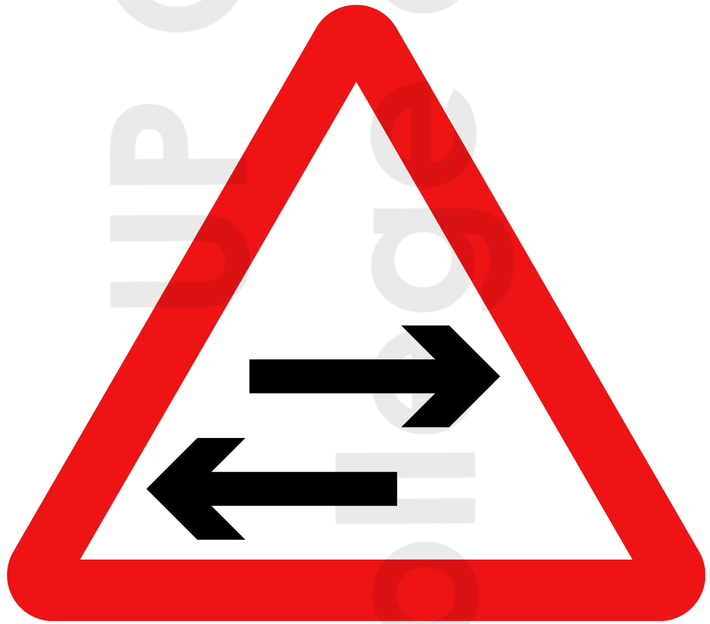
- each station can both transmit and receive, but not at the same time
- when one device is sending, the other can only receive, and vice versa
- the half-duplex mode is like a one-lane road with traffic allowed in both directions
- when cars are traveling in one direction, cars going the other way must wait
- in a half-duplex transmission, the entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time

Give an example of a half-duplex system?

- walkie-talkies are half-duplex systems

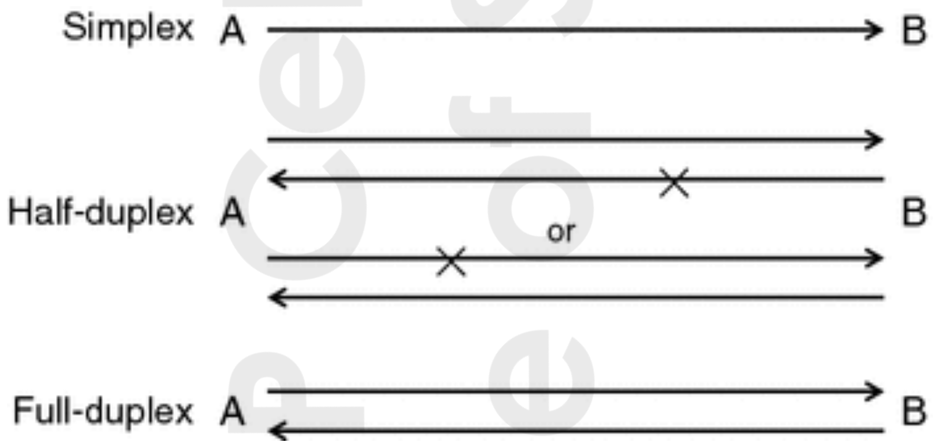
3. Full-duplex

- also called duplex
- both stations can transmit and receive simultaneously
- like a two-way street with traffic flowing in both directions at the same time
- signals going in one direction share the capacity of the link: with signals going in the other direction



Give an example of a duplex system?

- one common example of full-duplex communication is the telephone network
- when two people are communicating by a telephone line, both can talk and listen at the same time
- the full-duplex mode is used when communication in both directions is required all the time



Communication Media

1. Wired
    1. Wire Pairs
    2. Twisted Pair
    3. Coaxial Cable
    4. Optical Fiber
2. Wireless Technologies
    1. Terrestrial Microwave
    2. Communications Satellites

A

B

C

D

Communication Media

1. Wired
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A

B

C

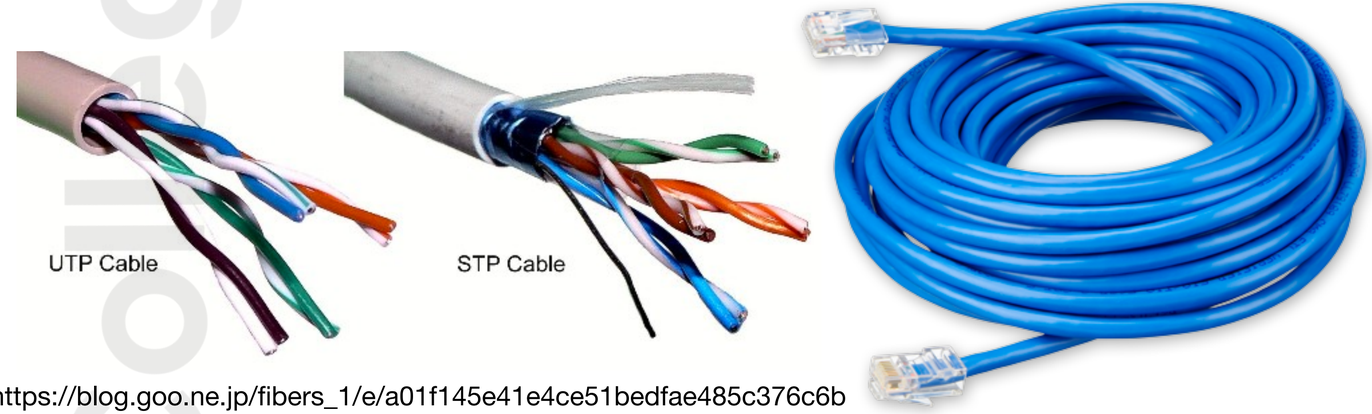
D

1. Wire Pairs

- commonly used in local telephone communication and for short distance digital data communication
- usually made of copper
- data transmission speed is normally 9600 bits per second in a distance of 100 meters

2. Twisted Pair

- the most widely used medium for telecommunication
- consists of copper wires that are twisted into pairs
- ordinary *telephone wires* consist of two insulated copper wires twisted into pairs
- computer *networking cabling* (wired Ethernet as defined by IEEE 802.3) consists of 4 pairs of copper cabling that can be utilized for both voice and data transmission
- transmission speed ranges from 2 million bits per second to 10 billion bits per second
- twisted pair comes in two forms:
  - Unshielded Twisted Pair (UTP)
  - Shielded Twisted Pair (STP)



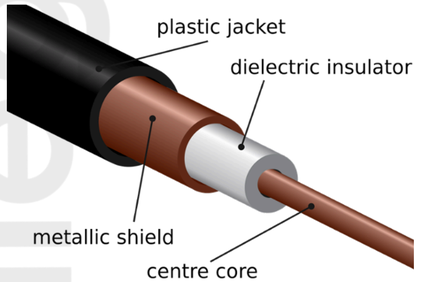
https://blog.goo.ne.jp/fibers_1/e/a01f145e41e4ce51bedfae485c376c6b

Why do you think each pair of wire is twisted?

- the use of two wires twisted together helps to reduce *crosstalk* and *electromagnetic induction*

3. Coaxial Cable

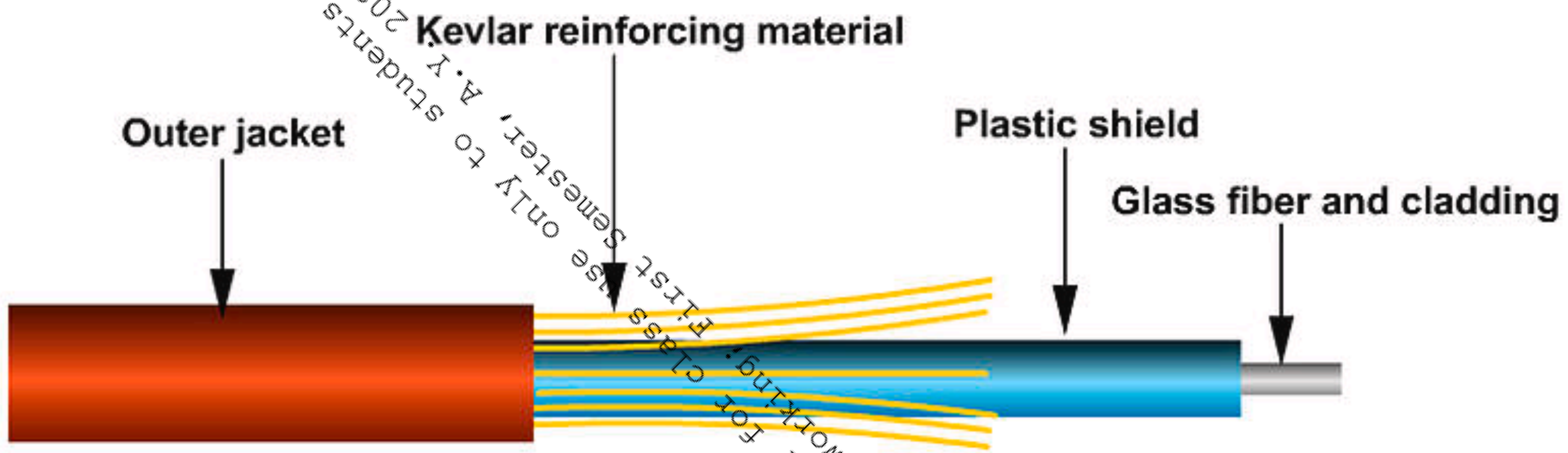
- widely used for cable television systems, office buildings, and other work-sites for local area networks
- consists of copper or aluminum wire wrapped with insulating layer typically of a flexible material with a high dielectric constant, all of which are surrounded by a conductive layer
- the layers of insulation help minimize interference and distortion
- transmission speed range from 200 million to more than 500 million bits per second

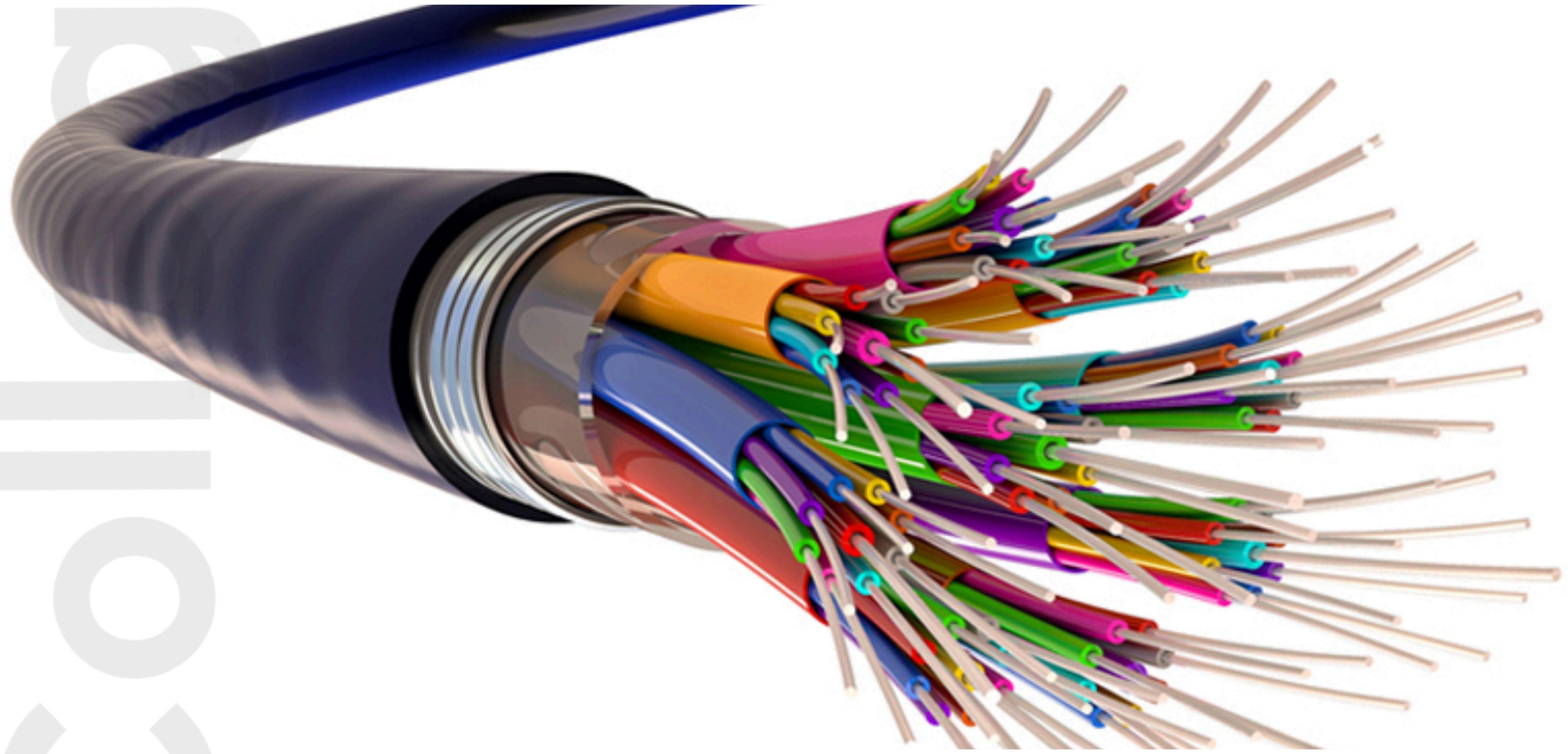


https://www.rfvenue.com/blog/2015/02/04/why-coaxial-cable-goes-bad

4. Optical Fiber

- consists of one or more filaments of glass fiber wrapped in protective layers that carries data by means of pulses of light
- not affected by electromagnetic radiation
- transmission speed may reach trillions of bits per second; hundred of times faster than coaxial cables and thousands of times faster than twisted pair
- this capacity may be further increased by the use of colored light, i.e. light of multiple wavelengths; instead of carrying one message in a stream of monochromatic light impulses, this technology can carry multiple signals in a single fiber



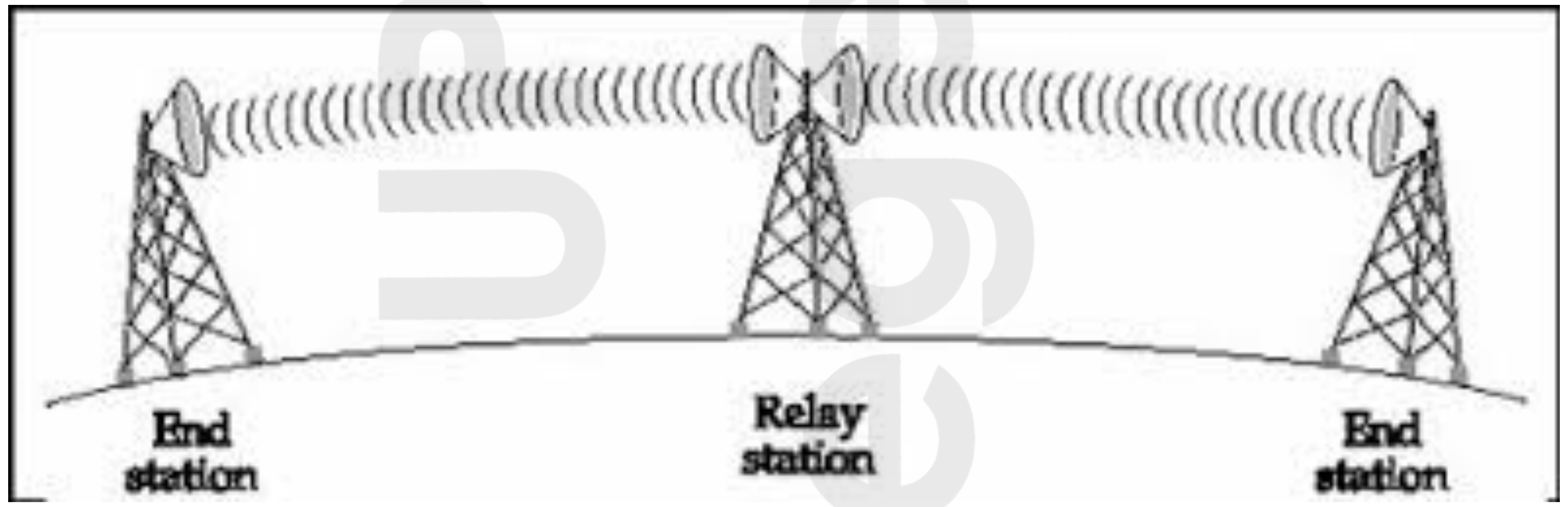


With these 4 media, which ones do you think are being used by ISPs to provide internet service?

https://www.youtube.com/watch?v=dYaB3Udygoc

1. Terrestrial Microwave

- use Earth-based transmitter and receiver
- the equipment looks similar to satellite dishes
- use low gigahertz range, which limits all communications to line-of-sight (LOS)
- path between relay stations spaced approximately 48 km (30 mi) apart
- microwave antennas are usually placed on top of buildings, towers, hills and mountain peaks



http://adli3.tripod.com/Terrestrial.htm

Radio Spectrum

Radio Band	Frequency	Some Applications
Very Low Frequency VLF	3 KHZ to 30 KHz	Radio Navigation
Low Frequency LF	30 KHz to 300 KHz	Long Wave Radio
Medium Frequency MF	30 KHz to 3 MHz	AM Radio
High Frequency HF	3 MHz to 30 MHz	CB Radio (HAM) Point to Point Radio Search and Rescue Services
Very High Frequency VHF	30 MHz to 300 MHz	FM radio 88-108 MHz VHF Broadcast TV
Ultra High Frequency UHF	300 MHz to 3 GHz	UHF Broadcast TV Cellular Phones Microwave Links Wi-Fi in 2.4 Band Satellite Communications
Super High Frequency SHF	3 GHz to 30 GHz	Microwave Links Wi-Fi in 5 GHz Band Satellite Communications
Extra High Frequency EHF	30 GHz to 300 GHz	Microwave Links

2. Communication Satellites

- use microwave radio signals as telecommunications medium which are not deflected by the Earth's atmosphere
- stationed in space, typically 35, 400 km (22, 000 mil) for geosynchronous satellites above the equator
- these Earth-orbiting systems are capable of receiving and relaying voice, data and TV signals

http://www.interaksyon.com/dost-eyes-q2-2018-to-launch-diwata-2/

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Kristine Sabillo, ABS-CBN News

Posted at Jun 29 2018 11:58 PM | Updated as of Jun 30 2018 07:12 AM

NASA @NASA

LIVE NOW: Hear from members of the launch team following the launch of SpaceX's #Dragon earlier this morning, carrying science & supplies to the International Space Station. Watch at: nasa.gov/live

8:01 PM - Jun 29, 2018

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MANILA - The PHL-Microsat program achieved another milestone on Friday.

The 10-cubic-centimeter Maya-1, which is small enough to carry in one hand, was brought aboard SpaceX Falcon 9 CRS 15, which made its way to the International

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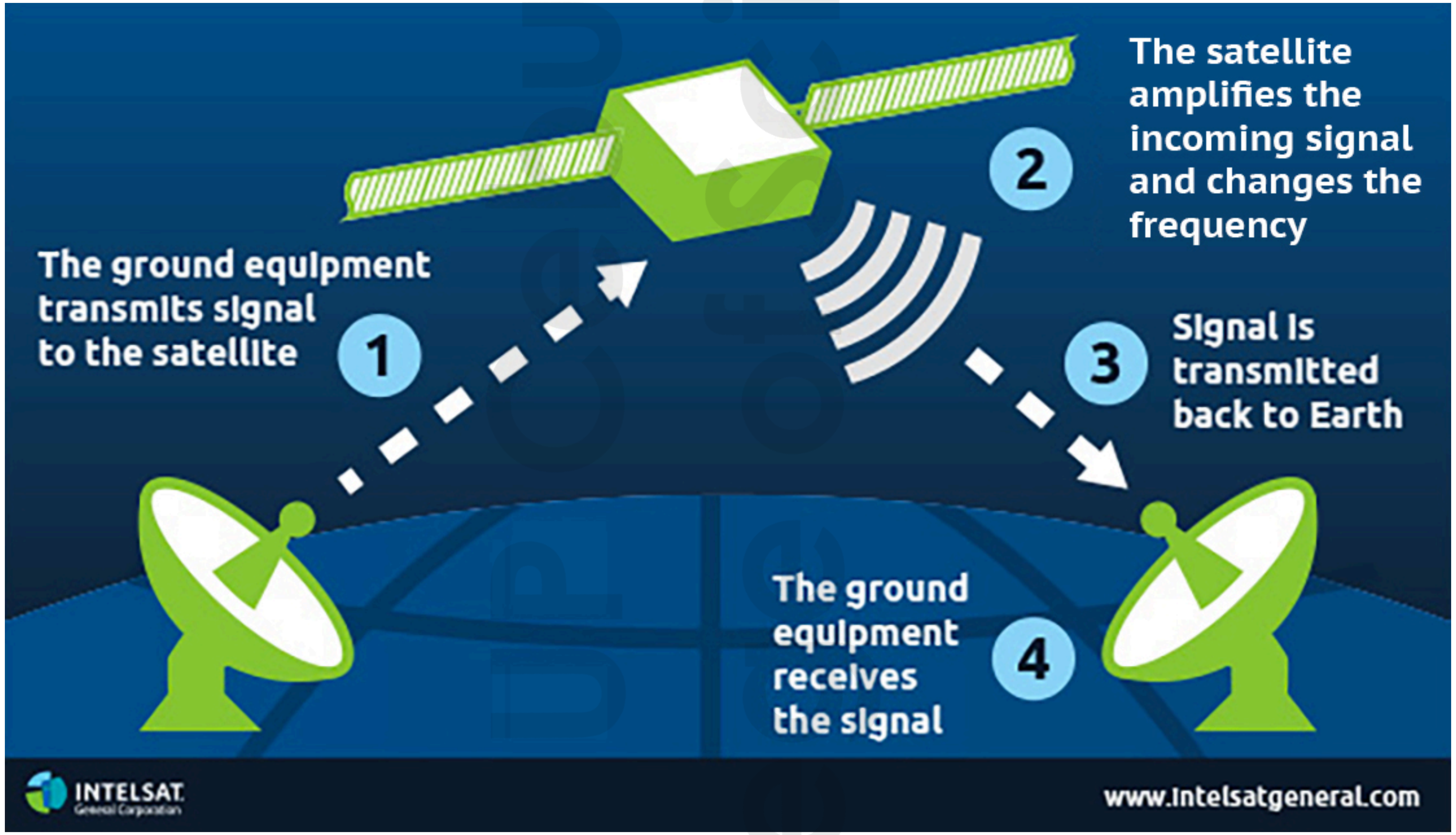
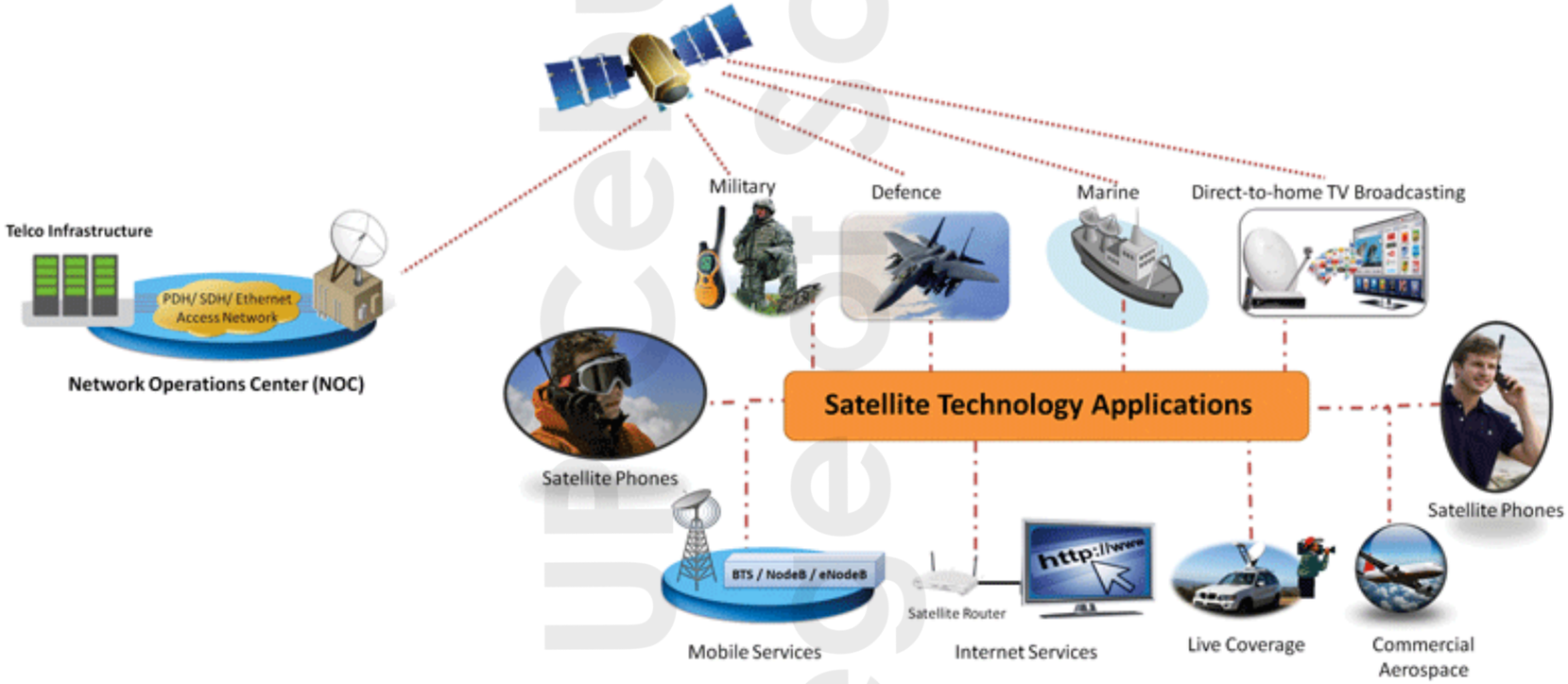
How do you think does a satellite work?



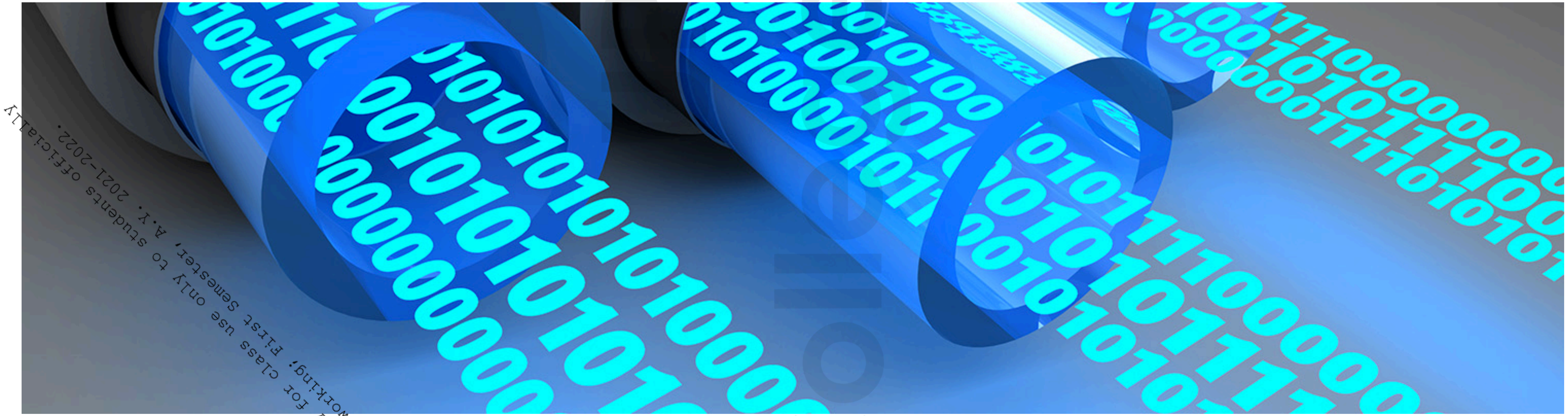


Let’s talk about ***bandwidth***.

What is your idea about ***bandwidth***?

Bandwidth

- a term used to describe the data-handling capacity of a communication service
- a measure of how much information, or bits, can flow from one place to another in a given amount of time, or seconds
- the communication data transfer rate is measured in a unit called *baud* - identical to bits per second
- a rate of 300 baud is 300 bits per second



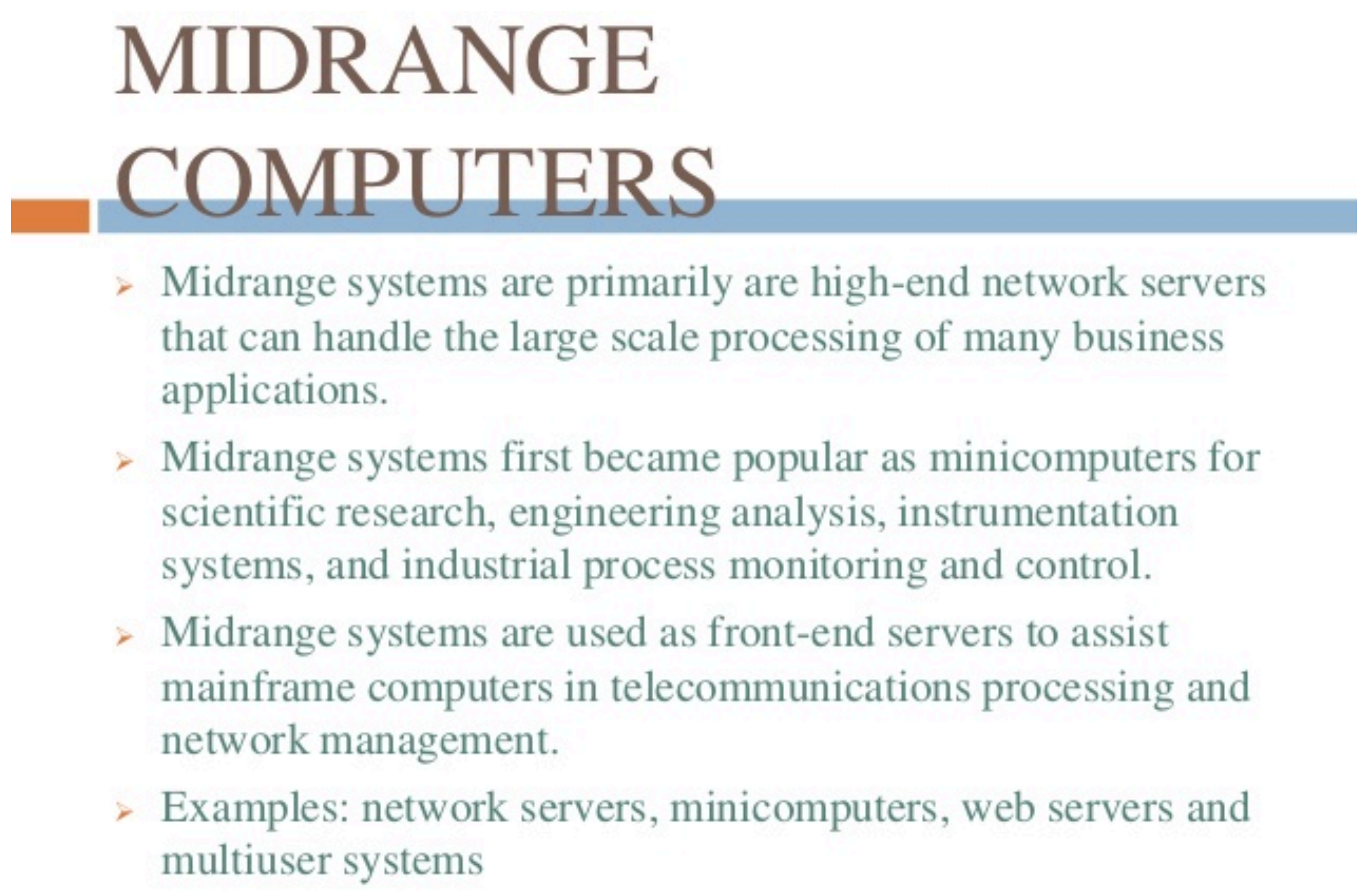
3 Classes of Communication Service

1. Narrowband

- a.k.a voiceband
- handles low data volumes
- data transmission rates < 100 kilobits per second
- used for regular telephone communications

2. Medium-band

- handles moderate data transmission volumes between 100 kb and 1 megabit per second
- used for long distance data transmission or to connect mainframe and midrange computers



What do you think completes the classes of communication service?

3. Broadband

- handles very large volumes of data
- provide data transmission rates of 1 million baud or more
- high-speed data analysis and satellite communications are examples of broadband communication systems

3 Classes of Communication Service

1. Narrowband
2. Medium-band
3. Broadband

Modem

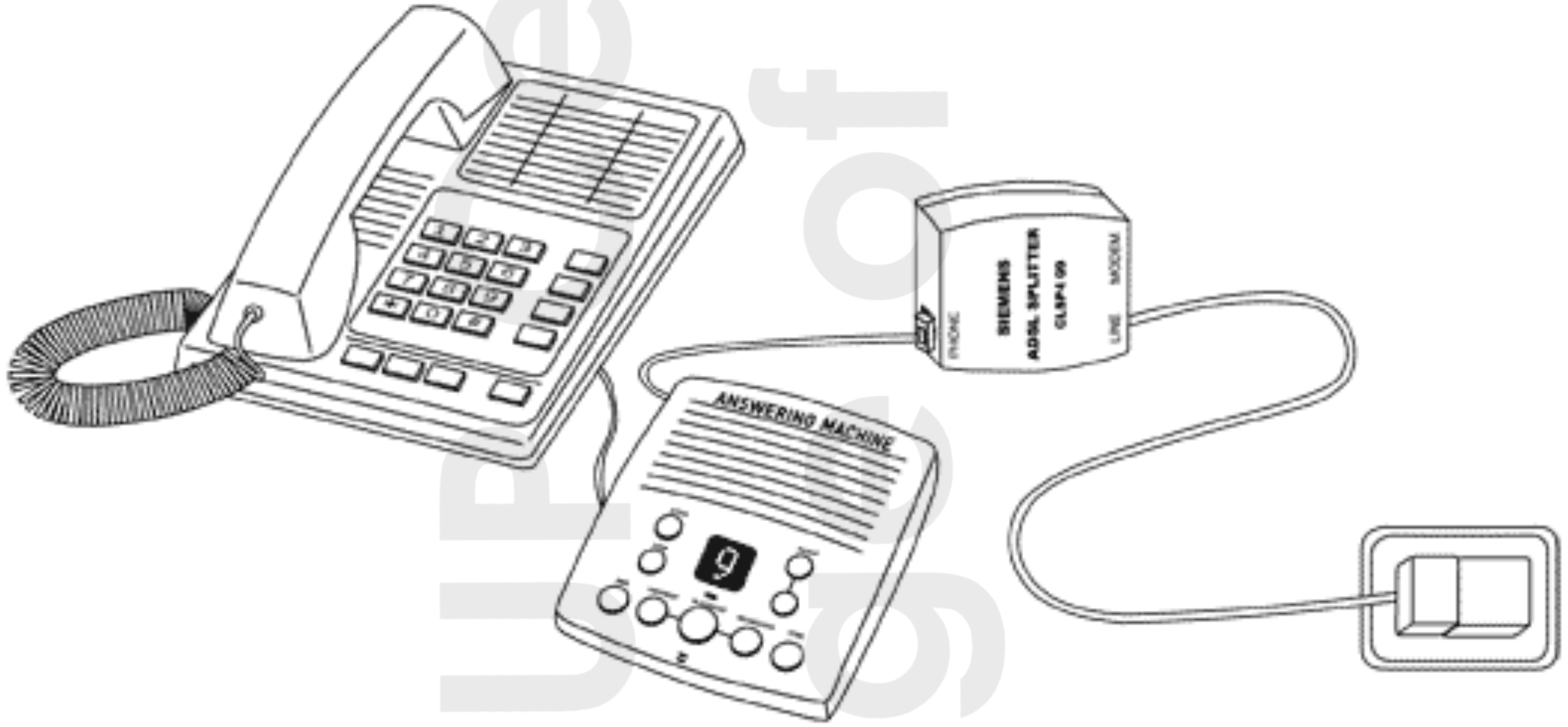
- short for modulator-demodulator
- a device that modulates an analog carrier signal to encode digital information, and also demodulates such a carrier signal to decode the transmitted information
- the goal is to produce a signal that can be transmitted easily and decoded to reproduce the original digital data
- a modem modulates outgoing digital signals from a computer or other digital device to analog signals for a conventional copper twisted pair telephone line and demodulates the incoming analog signal and converts it to a digital signal for the digital device

Types of Modems

1. Landline Modems
2. Wireless Modems
3. LAN Modems

1. Landline Modems

- modems which connect to the public switched telephone network (PSTN)
- to connect to PSTN, these modems have a jack known as RJ-11, or regular phone jack



2. Wireless Modems

- are radio transmitters/receivers installed into mobile computing devices (i.e. devices that are used while you are moving such as mobile phones, laptops, etc.)

3. LAN Modems

- allow shared remote access to LAN (Local Area Network) resources

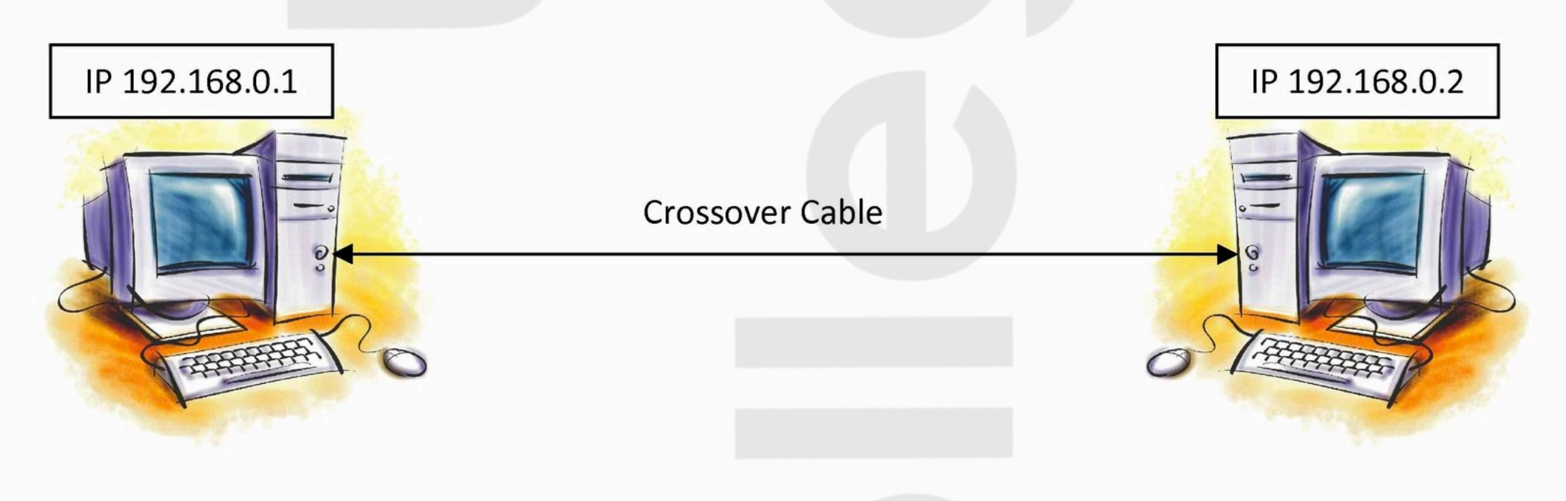
Modern modems...

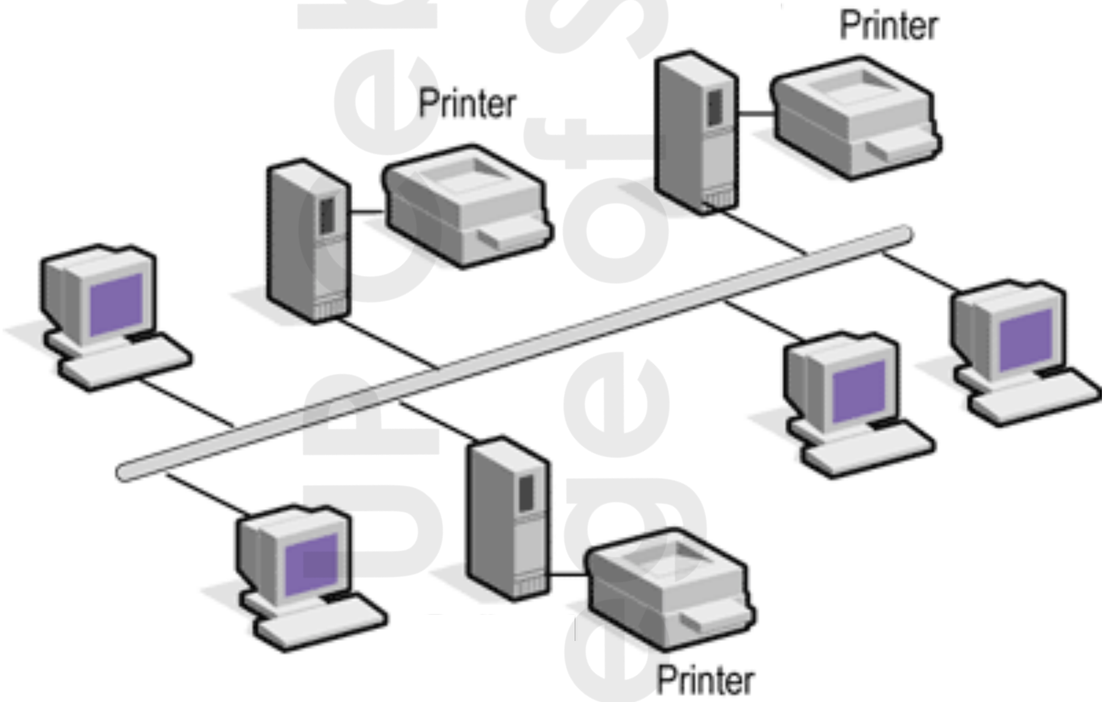
- contain all 3 types of modem

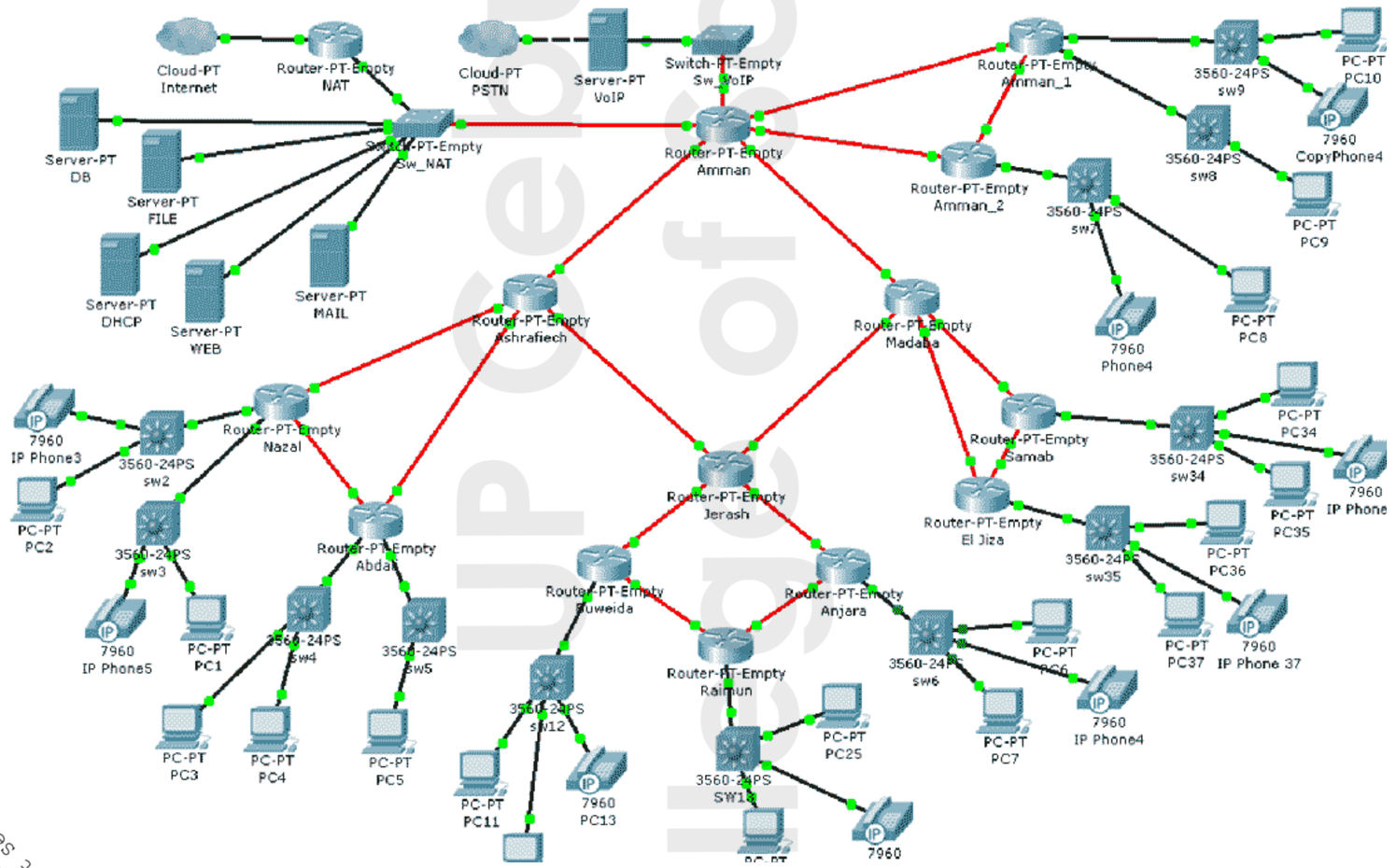
What is your idea about ***computer network***?

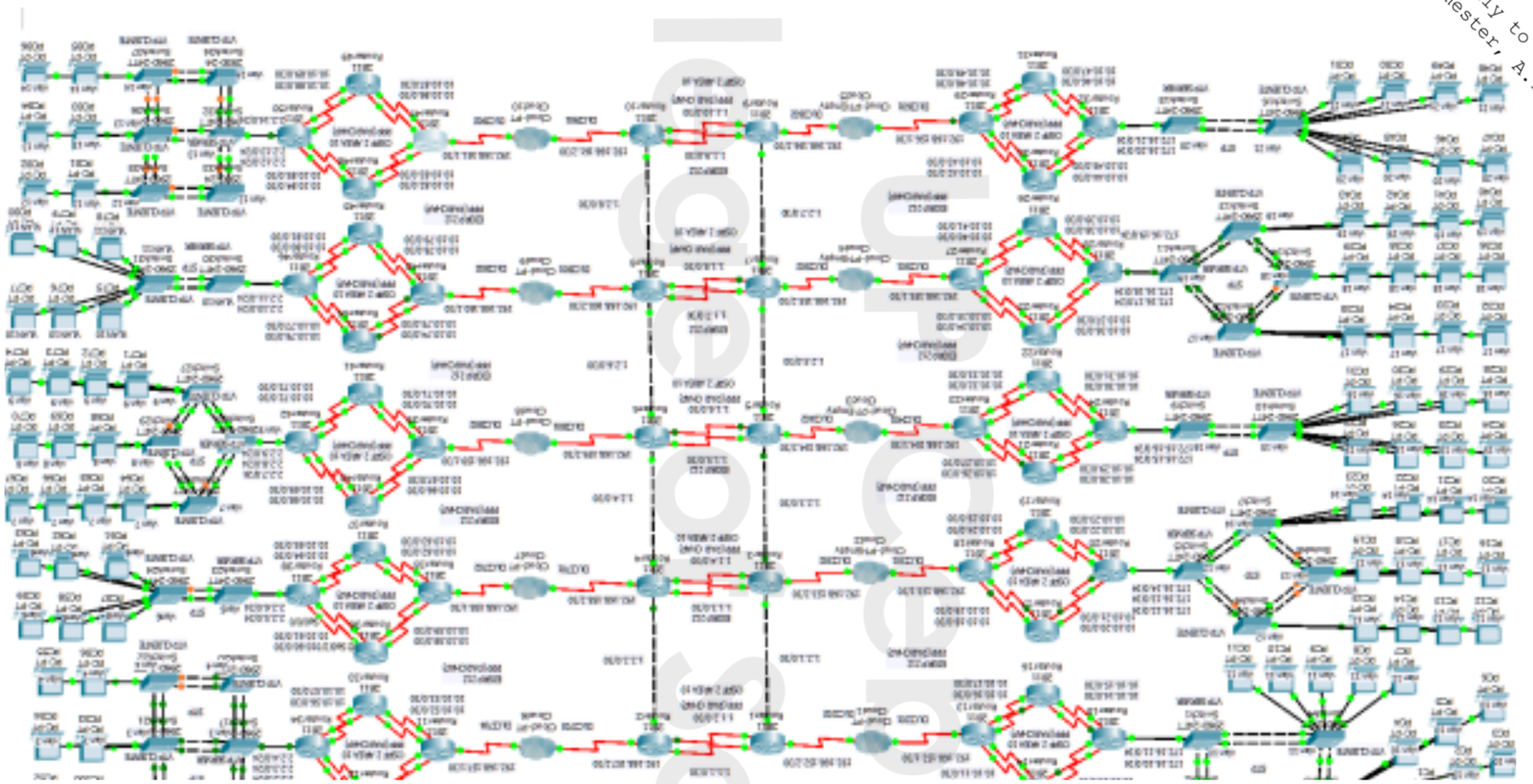
Computer Network

- interconnection of various computer systems located at different places
- in computer network two or more computers are linked together with a medium and data communication devices for the purpose of communicating data and sharing resources
- the computer that provides resources to other computers on a network is known as *server*
- in the network the individual computers, which access shared network resources, are known as *nodes*

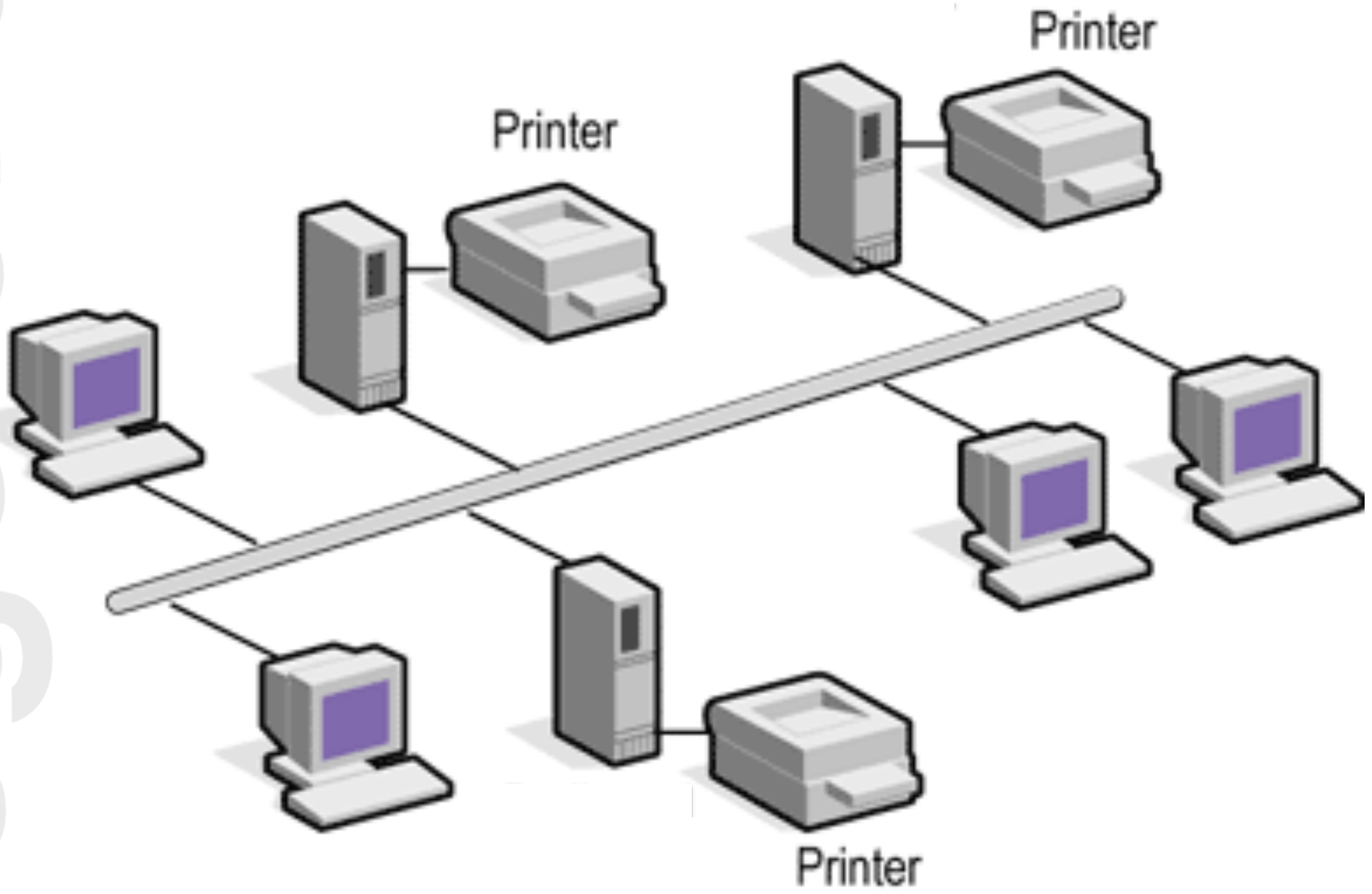








1. Encircle the element(s) in the network that act(s) as server(s).
2. Box the element(s) in the network that act(s) as node(s).



Recall:
The computer that provides resources to other computers on a network is known as ***server***. In the network the individual computers, which access shared network resources, are known as ***nodes***.

Concept of Networking

- a computer network, often simply referred to as a network, is a collection of hardware components and computers interconnected by communication channels that allow sharing of resources and information
- networks may be classified according to a wide variety of characteristics such as the medium used to transport the data, communications protocol used, scale, topology, and organization scope
- the rules and data formats for exchanging information in a computer network are defined by communications protocols

Properties of Network

1. Facilitate communications
2. Permit sharing of files, data and other types of information
3. Share network and computing resources

Uses or Benefits of Network

1. File sharing
2. Printer/peripheral sharing
3. Internet connection sharing
4. Multi-player games
5. Internet telephone service (VoIP)
6. Home entertainment

Which of these you have tried? What specifically did you do? What did you do it for?

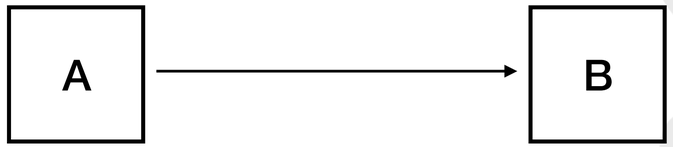
Network Criteria

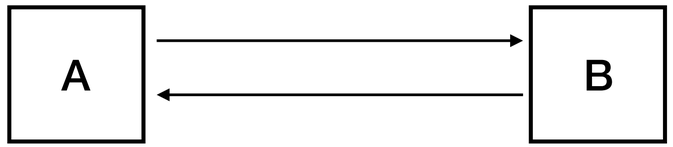
A network must be able to meet a certain number of criteria. The most important of these are:

1. Performance
2. Reliability
3. Security

1. Performance

- can be measured in many ways, including transit time and response time
  1. *transit time*: the amount of time required for a message to travel from one device to another
  2. *response time*: the elapsed time between an inquiry and a response





Factors Affective Performance

1. Number of users
2. Type of transmission medium
3. Hardware capabilities
4. Software efficiency

What does it mean when ***software efficiency*** affects performance of a network?

2 Networking Metrics to Evaluate Performance

1. Throughput
   - measure of how much data is transmitted at a given period of time
2. Delay
   - measure of how long it takes for the data to travel across the network from a node to another

Goal: More throughput and less delay.

Contradiction: If we try to send more data to the network, we may increase throughput but we increase the delay. But why?

2. Reliability

- network reliability is measured by:
    1. accuracy of delivery
    2. frequency of failure
    3. time it takes a link to recover from a failure
    4. network's robustness in a catastrophe

3. Security

- network security issues include:
    1. protecting data from unauthorized access
    2. protecting data from damage and development
    3. implementing policies and procedures for recovery from breaches and data losses

Physical Structures of Networks

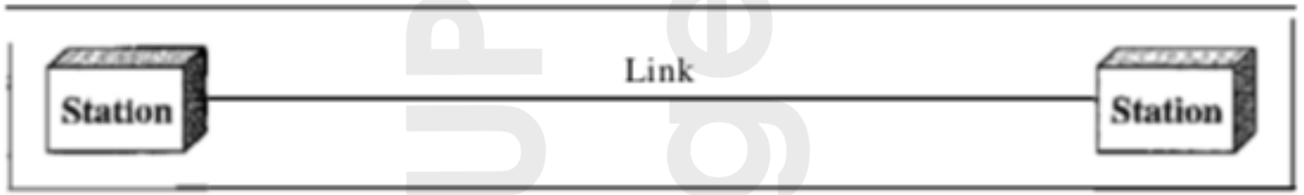
1. Types of Connection
2. Types of Network

Types of Connection

1. Point-to-Point
2. Multipoint

1. Point-to-Point

- provides dedicated link between two devices
- the entire capacity of the link is reserved for transmission between those two devices
- most point-to-point connections use an actual length of wire or cable to connect the two ends



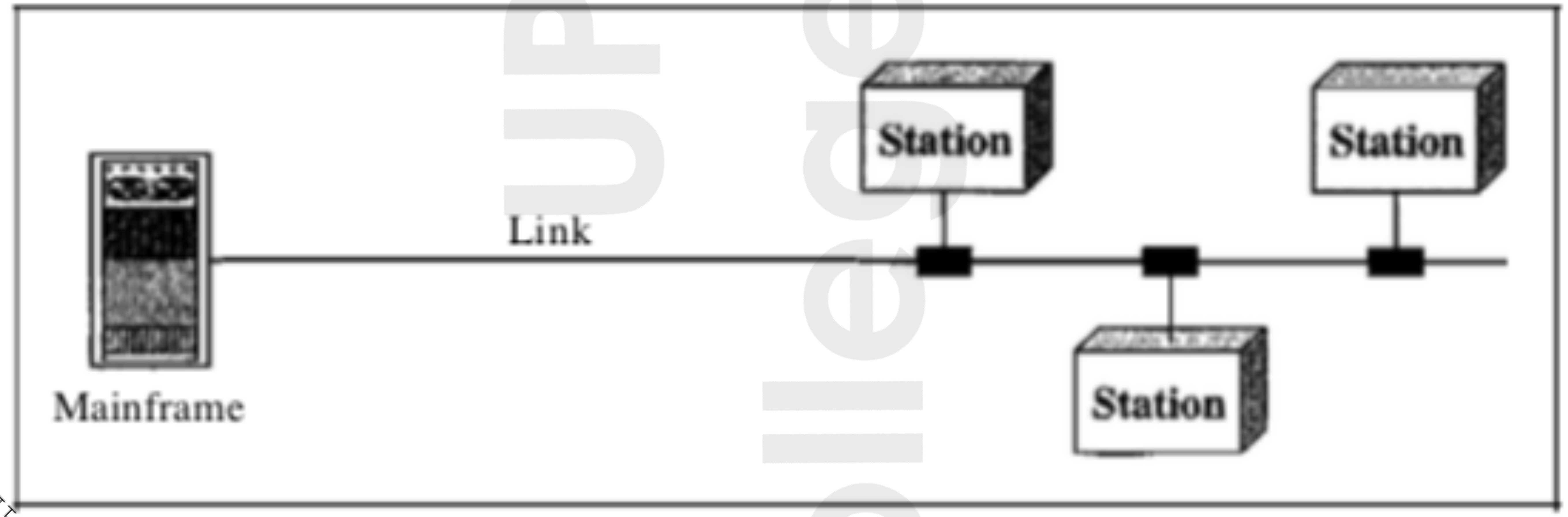
a. Point-to-point

Do you think point-to-point can also be done in microwave and satellite links?

- when you change television channels by infrared remote control, you are establishing a point-to-point connection between the remote control and the TV’s control system

2. Multipoint

- a.k.a multidrop
- more than two specific devices share a single link
- the capacity of the channel is shared, either *spatially* or *temporally*
- if several devices can use the link simultaneously, it is a *spatially shared connection*
- if users must take turns, it is a *timeshared connection*



b. Multipoint

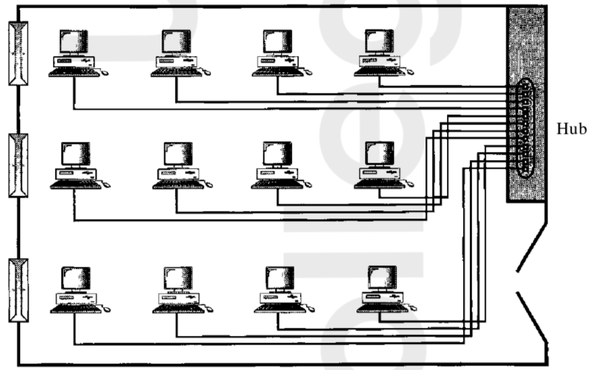
Types of Network

1. Local Area Network (LAN)
2. Wide Area Network (WAN)
3. Metropolitan Area Network (MAN)

1. Local Area Network (LAN)

- usually privately owned and links the devices in a single office, building or campus
- can be as simple as two PCs and a printer
- size is limited to a few kilometers; speeds are normally 100 to 1000Mbps
- designed to allow resources (e.g. printer, software, data) to be shared between personal computers or workstations
- wireless LAN (WLAN) is newest evolution in LAN technology

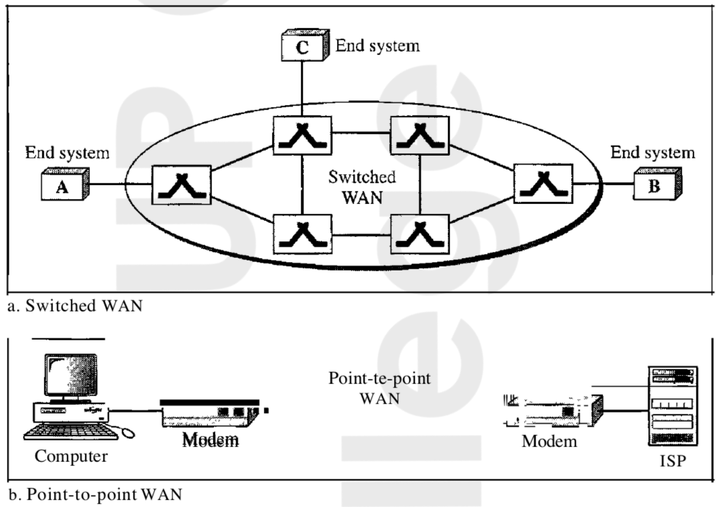
Figure 1.10 *An isolated IAN connecting 12 computers to a hub in a closet*



2. Wide Area Network (WAN)

- provides long distance transmission of data over large geographic areas that may comprise a country, a continent, or even the whole world
- can be as complex as the backbones that connect the Internet or as simple as a dial-up line that connects a home computer to the Internet

Figure 1.11 *WANs: a switched WAN and a point-to-point WAN*



3. Metropolitan Area Network (WAN)

- a network with a size between a LAN and a WAN
- normally covers the area inside a town or a city
- designed for customers who need a high-speed connectivity, normally to the Internet
- example, the part of a telephone company that can provide high-speed DSL line to the customer
- another example, the cable TV network that originally was designed for cable TV but today can be used for high-speed data connection to the Internet

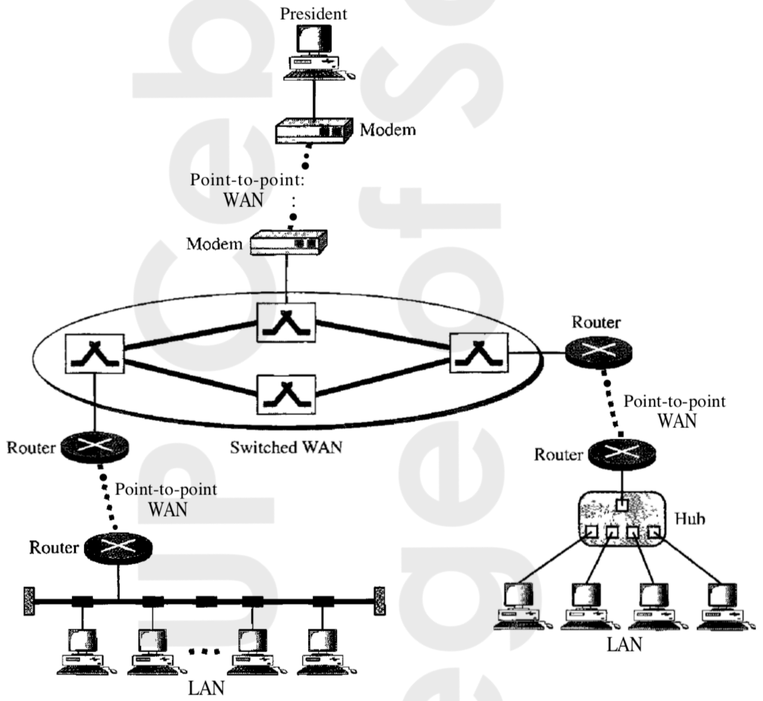
Interconnection of Networks (Internetwork)

- today, it is very rare to see a LAN, a MAN, or a WAN in isolation; they are connected to one another
- when two or more networks are connected, they become an internetwork, or internet

Scenario…

- Assume that an organization has two offices, one on the east coast and the other on the west coast. The established office on the west coast has a bus topology LAN; the newly opened office on the east coast has a start topology LAN also. The president of the company lives somewhere in the middle and needs to have control over the company from her home. To create a backbone WAN for connecting these three entities (two LANs and the president's computer), a switched WAN (operated by a service provider such as a telecom company) has been leased. To connect the LANs to this switched WAN, however, three point-to-point WANs are required. These point-to-point WANs can be a high-speed DSL line offered by a telephone company or a cable modern line offered by a cable TV provider.

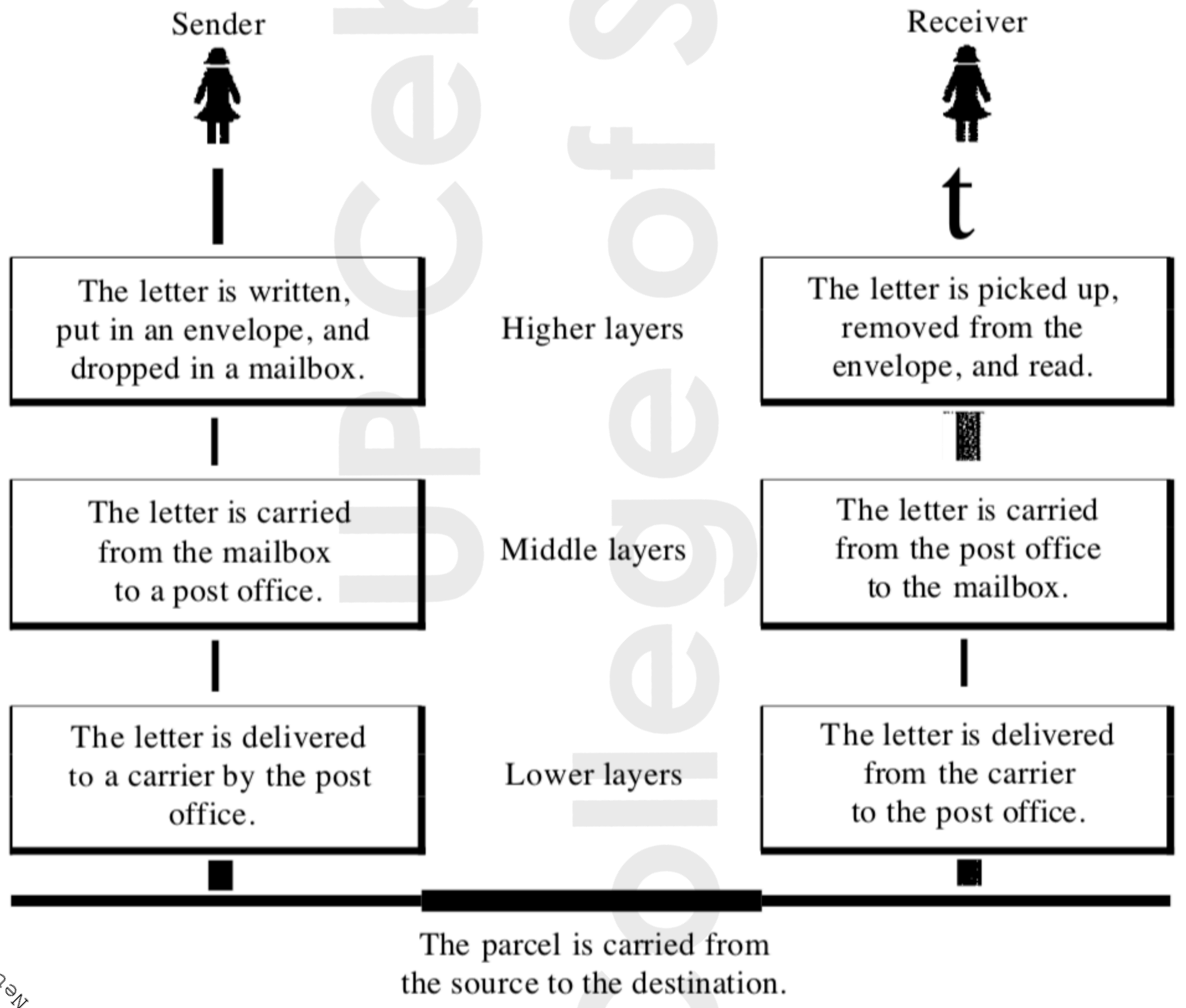
Figure 1.12 *A heterogeneous network made offour WANs and two LANs*



The ISO Reference Model

- layered tasks

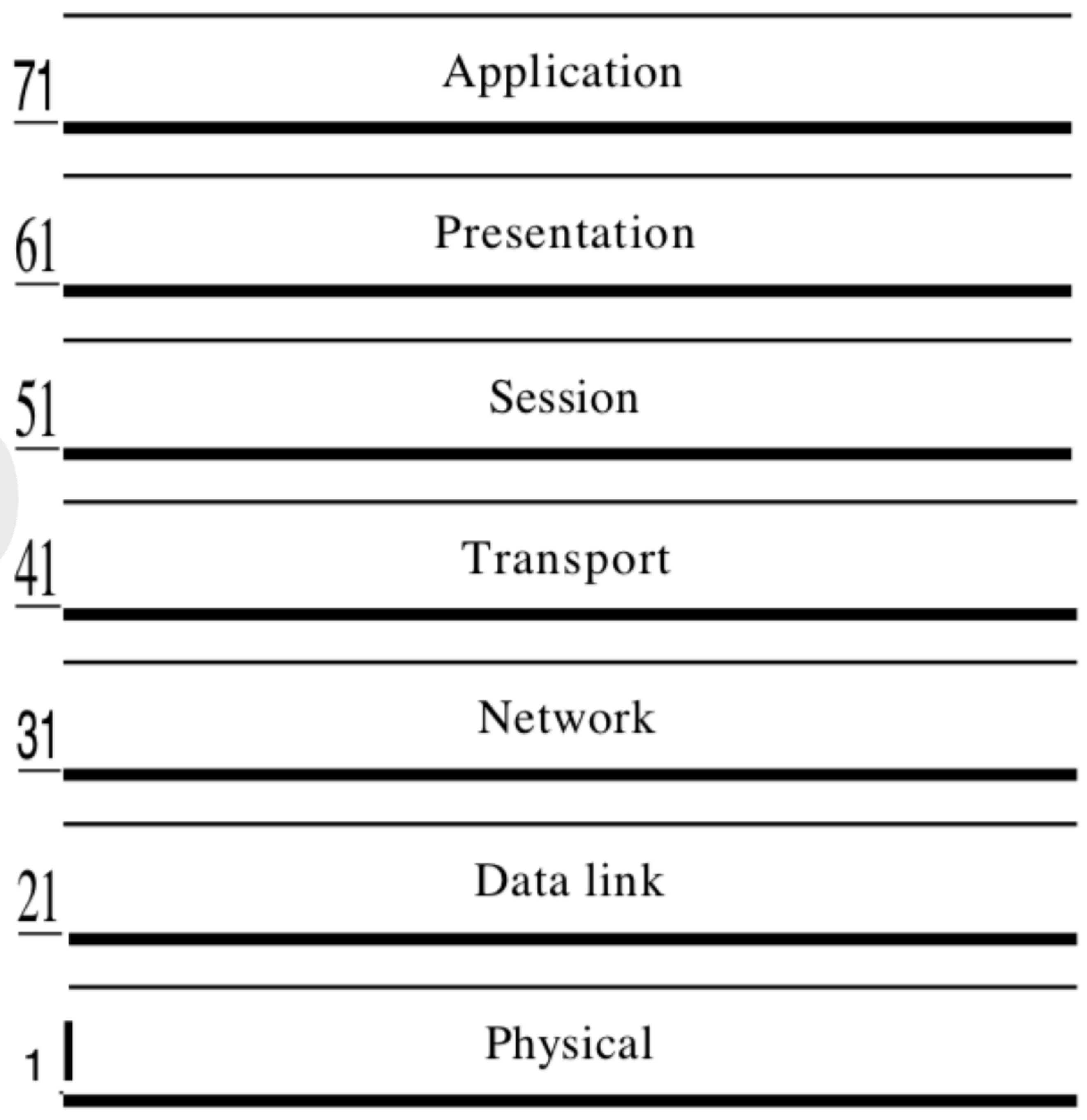
Figure 2.1 *Tasks involved in sending a letter*



The OSI Model

- Open Systems Interconnection model
- established in 1957 by ISO (International Standards Organization)
- layered model that dominated data communications and networking literature before 1990
- replaced by TCP/IP model

Figure 2.2 *Seven layers of the OSI model*



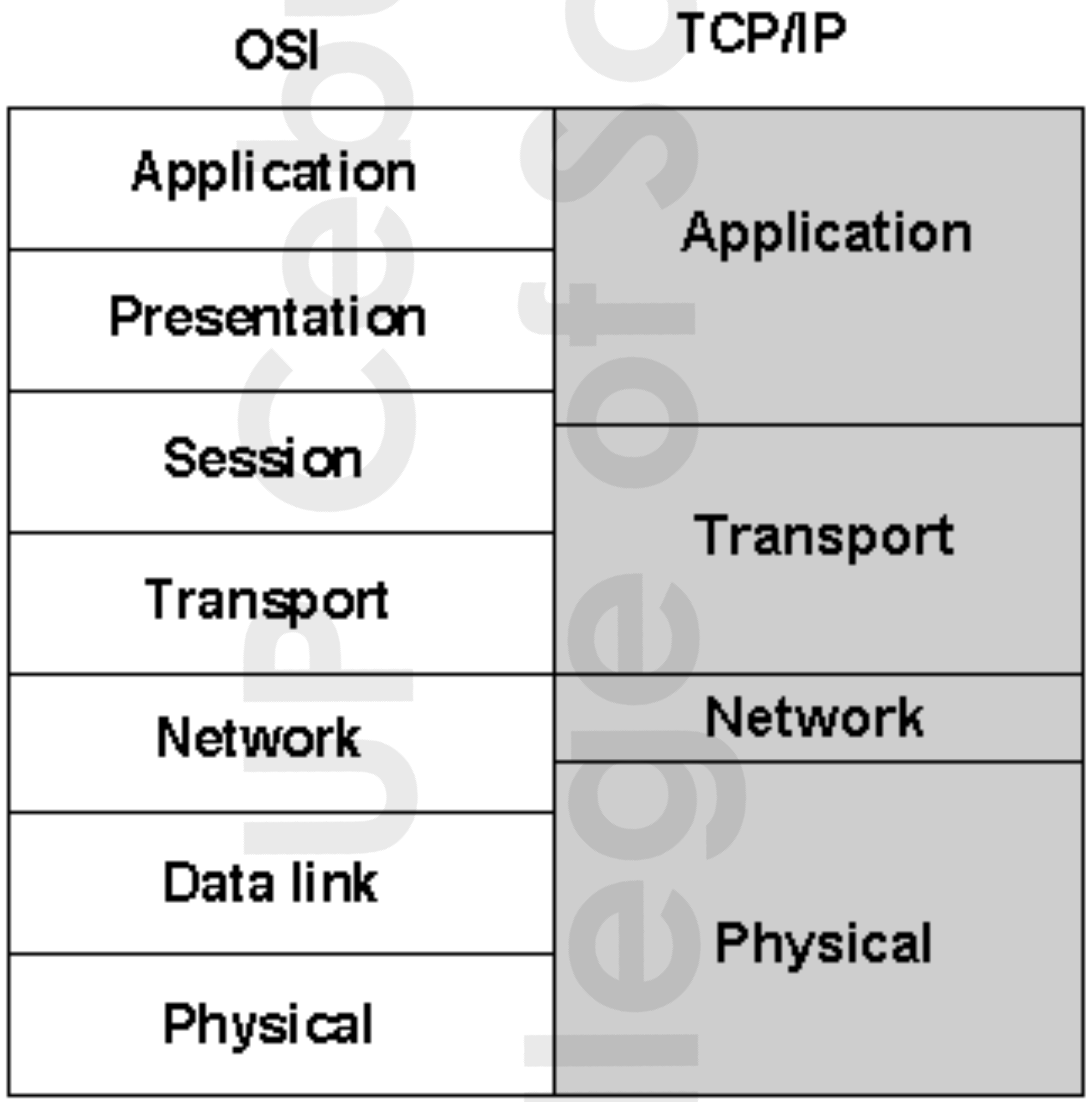


Figure 2.3 *The interaction between layers in the OSI model*