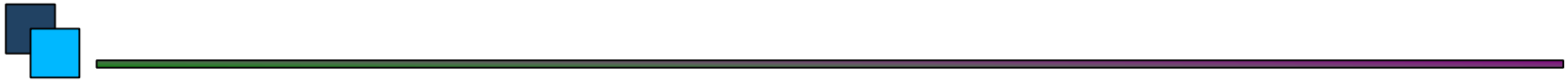
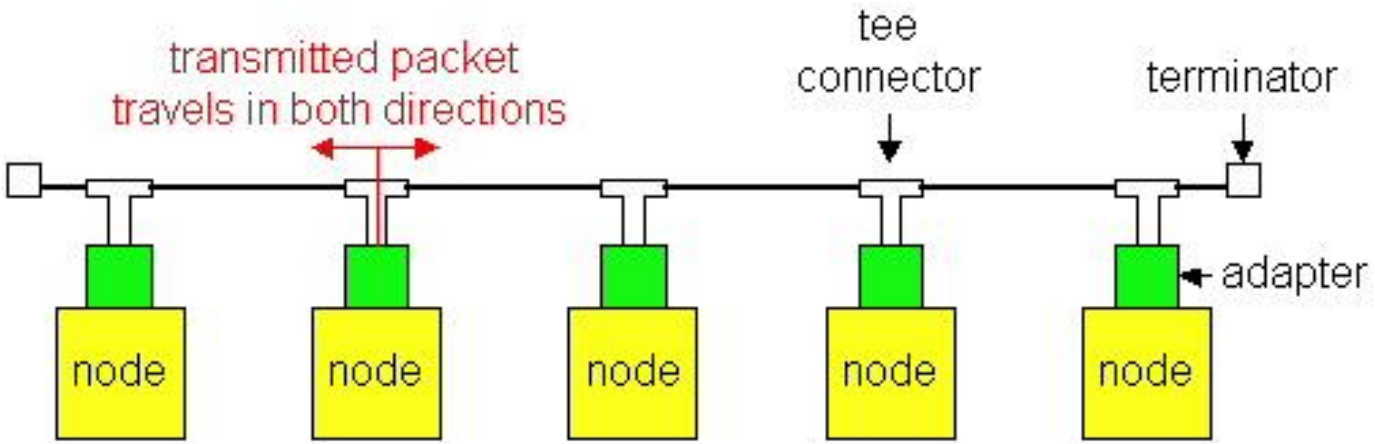


UNIT 4

Network Architecture

Media Access

- **Ethernet and Wi-Fi are both "multi-access" technologies**
  - Broadcast medium, shared by many hosts
  - Simultaneous transmissions will result in collisions
- **Media Access Control (MAC) protocol required**
  - Rules on how to share medium
- **The Data Link Layer is divided into two Part MAC Media Access Control) Sublayer and LLC (Logic Link Control) Sublayer**



802.3 Ethernet

- **Carrier-sense multiple access with collision detection (CSMA/CD).**
  - CS = carrier sense
  - MA = multiple access
  - CD = collision detection
- **Base Ethernet standard is 10 Mbps.**
  - 100Mbps, 1Gbps, 10Gbps standards came later

Ethernet CSMA/CD

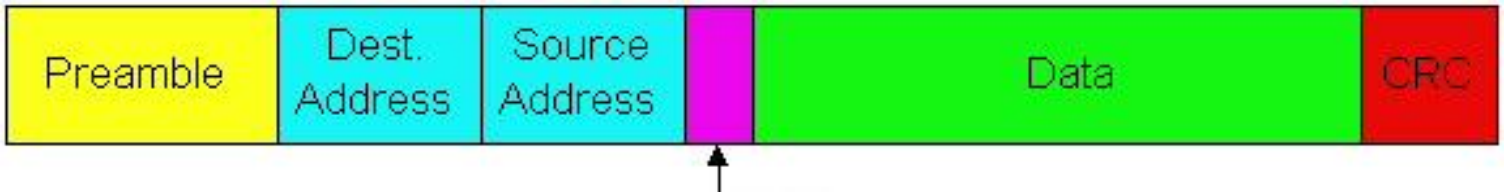
- **CSMA/CD (carrier sense multiple access with collision detection) media access protocol is used.**
  - Data is transmitted in the form of packets.
  - Sense channel prior to actual packet transmission.
  - Transmit packet only if channel is sensed idle; else, defer the transmission until channel becomes idle.
  - After packet transmission is started, the node monitors its own transmission to see if the packet has experienced a collision.
  - If the packet is observed to be undergoing a collision, the transmission is aborted and the packet is retransmitted after a random interval of time using Binary Exponential Backoff algorithm.

Ethernet Address

- End nodes are identified by their Ethernet Addresses (MAC Address or Hardware Address) which is a unique 6 Byte address.
- MAC Address is represented in Hexa Decimal format e.g 00:05:5D:FE:10:0A
- The first 3 bytes identify a vendor (also called prefix) and the last 3 bytes are unique for every host or device

Ethernet Frame Structure

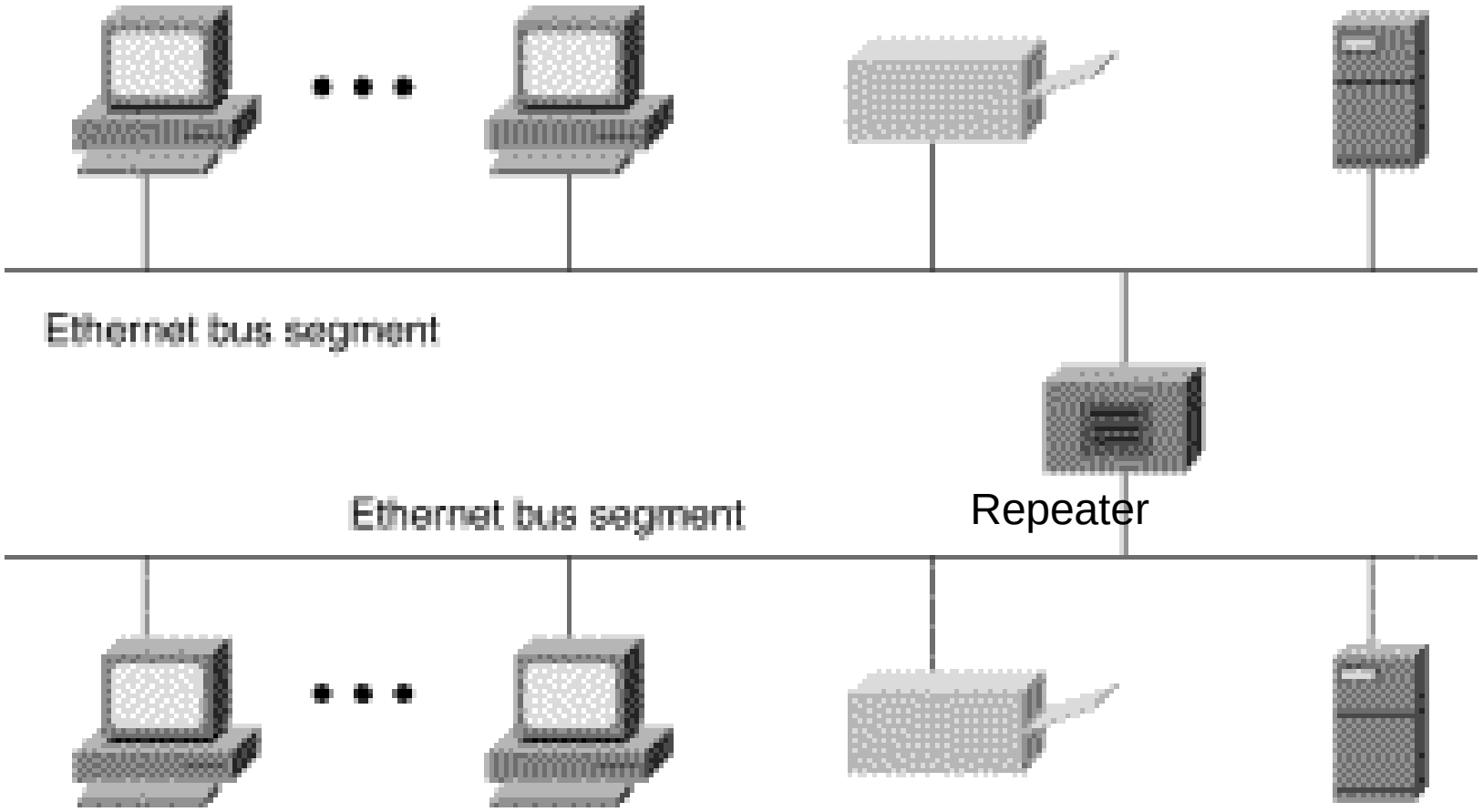
- **Preamble:**
  - 7 bytes with pattern 10101010 followed by one byte with pattern 10101011
  - Used to synchronize receiver, sender clock rates
- **Addresses:** 6 bytes, frame is received by all adapters on a LAN and dropped if address does not match
- **Length:** 2 bytes, length of Data field
- **CRC:** 4 bytes generated using CR-32, checked at receiver, if error is detected, the frame is simply dropped
- **Data Payload:** Maximum 1500 bytes, minimum 46 bytes
  - If data is less than 46 bytes, pad with zeros to 46 bytes



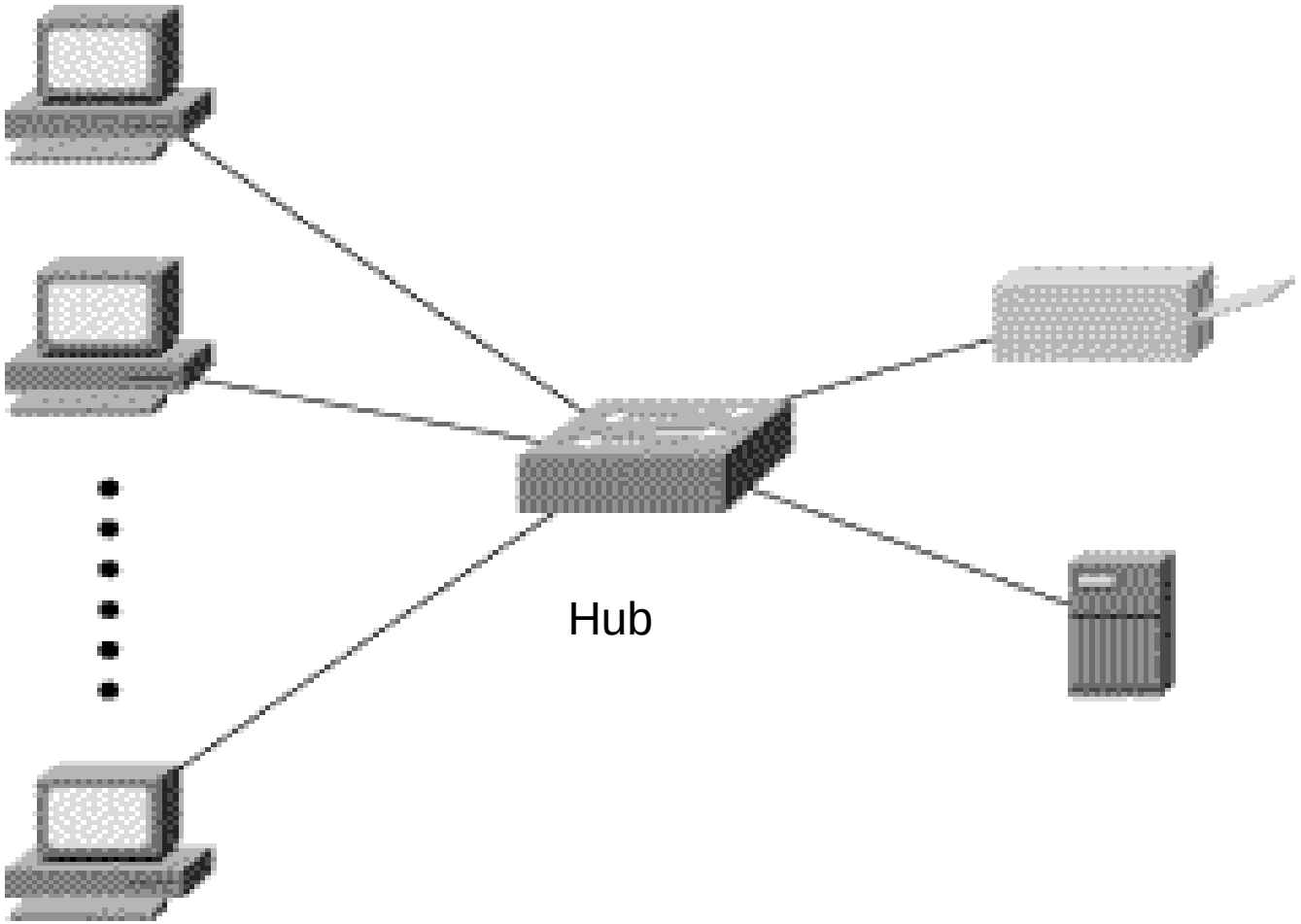
Ethernet

- 10 Base 5 (Thicknet) (Bus Topology)
- 10 Base 2 (Thinnet) (Bus Topology)
- 10 Base T (UTP) (Star/Tree Topology)
- 10 Base FL (Fiber) (Star/Tree Topology)

Ethernet BUS Topology



Ethernet STAR Topology



Ethernet

- **Physical Media :-**
  - 10 Base5 - Thick Co-axial Cable with Bus Topology
  - 10 Base2 - Thin Co-axial Cable with Bus Topology
  - 10 BaseT - UTP Cat 3/5 with Tree Topology
  - 10 BaseFL - Multimode/Singlemode Fiber with Tree Topology
- **Maximum Segment Length**
  - 10 Base5 - 500 m with at most 4 repeaters (Use Bridge to extend the network)
  - 10 Base2 - 185 m with at most 4 repeaters (Use Bridge to extend the network)
  - 10 BaseT - 100 m with at most 4 hubs (Use Switch to extend the network)

Fast Ethernet

- **100 Mbps bandwidth**
- **Uses same CSMA/CD media access protocol and packet format as in Ethernet.**
- **100BaseTX (UTP) and 100BaseFX (Fiber) standards**
- **Physical media :-**
  - 100 BaseTX - UTP Cat 5e
  - 100 BaseFX - Multimode / Singlemode Fiber
- **Full Duplex/Half Duplex operations.**

Fast Ethernet

- Provision for Auto-Negotiation of media speed: 10 Mbps or 100Mbps (popularly available for copper media only).

- Maximum Segment Length
  - 100 Base TX - 100 m
  - 100 Base FX - 2 Km (Multimode Fiber)
  - 100 Base FX - 20 km (Singlemode Fiber)

Gigabit Ethernet

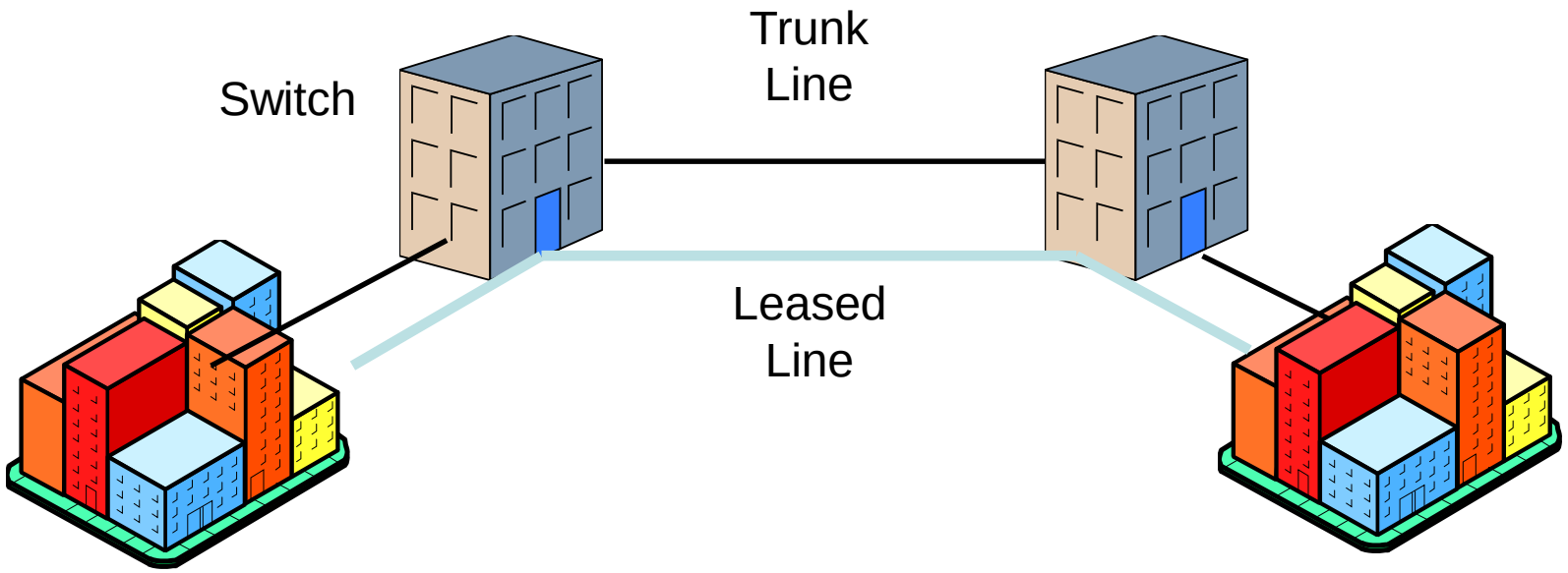
- **1 Gbps bandwidth.**
- **Uses same CSMA/CD media access protocol as in Ethernet and is backward compatible (10/100/100 modules are available).**
- **1000BaseT (UTP), 1000BaseSX (Multimode Fiber) and 1000BaseLX (Multimode/Singlemode Fiber) standards.**
- **Maximum Segment Length**
  - 1000 Base T - 100m (Cat 5e/6)
  - 1000 Base SX - 275 m (Multimode Fiber)
  - 1000 Base LX - 512 m (Multimode Fiber)
  - 1000 Base LX - 20 Km (Singlemode Fiber)
  - 1000 Base LH - 80 Km (Singlemode Fiber)

10 Gig Ethernet

- **10 Gbps bandwidth.**
- **Uses same CSMA/CD media access protocol as in Ethernet.**
- **Propositioned for Metro-Ethernet**
- **Maximum Segment Length**
  - 1000 Base-T - Not available
  - 10GBase-LR - 10 Km (Singlemode Fiber)
  - 10GBase-ER - 40 Km (Singlemode Fiber)

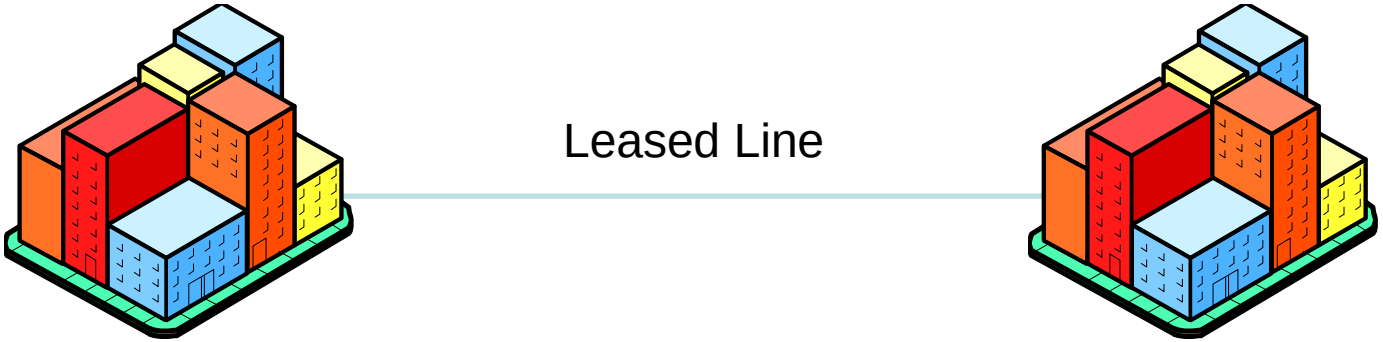
Leased Lines

- Leased Lines are *Circuits*
  - Often goes through multiple switches and trunk lines
  - Looks to user like a simple direct link



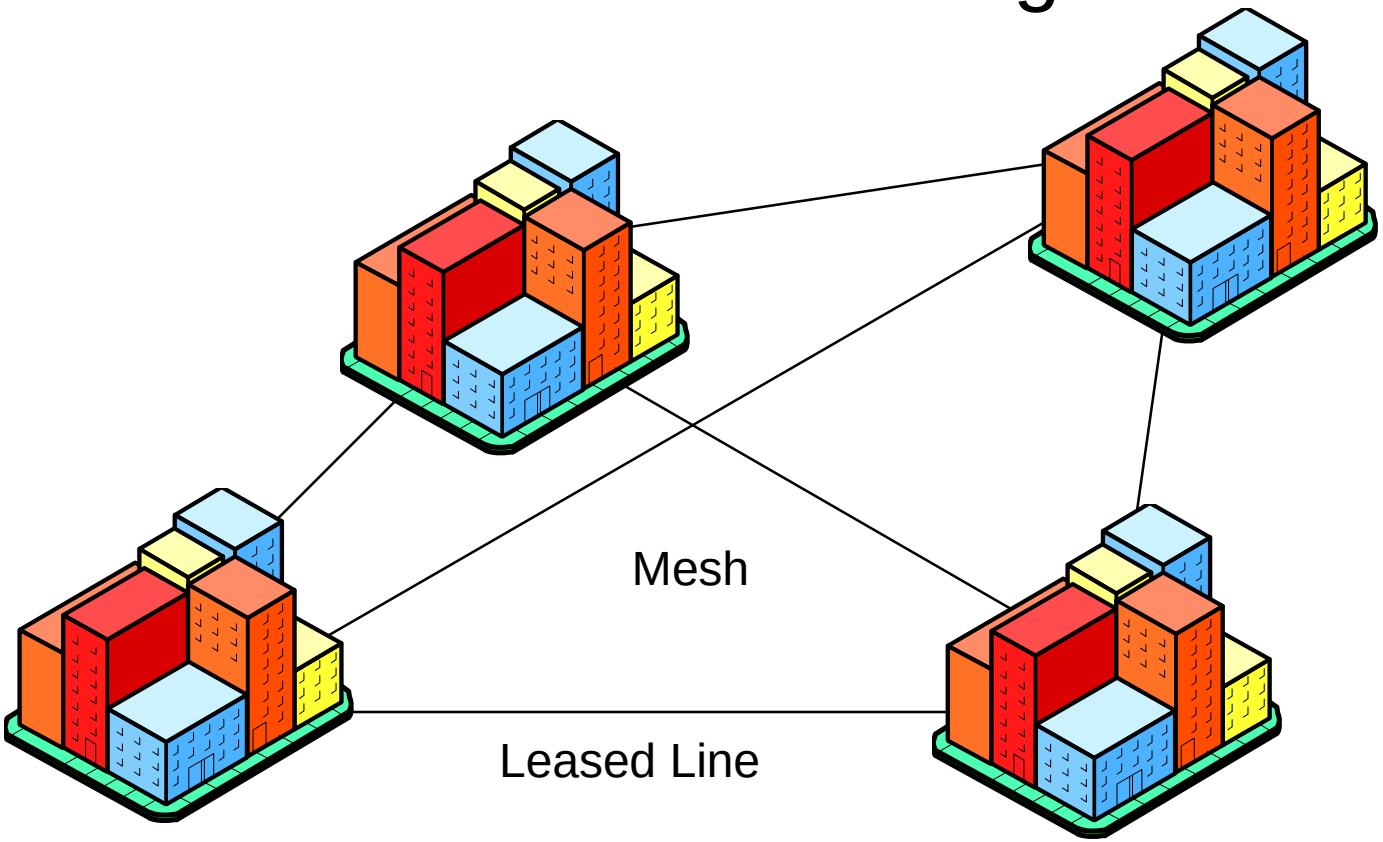
Leased Lines

- *Leased lines*
  - Limited to *point-to-point* communication
    - Limits who you can talk to
  - Carriers offer leased lines at an attractive price per bit sent *to keep high-volume customers*



Leased Line Meshes

- If you have several sites, you need a *mesh* of leased lines among sites



Leased Line Speeds

- Largest Demand is 56 kbps to a few Mbps
- 56 kbps (sometimes 64 kbps) digital leased lines
  - DS0 signaling
- T1 (1.544 Mbps) digital leased lines
  - 24 times effective capacity of 56 kbps
  - Only about 3-5 times cost of 56 kbps
  - DS1 signaling
- Fractional T1
  - Fraction of T1's speed and price
  - Often 128, 256, 384 kbps

Leased Line Speeds

- T3: is the next step
  - 44.7 Mbps in U.S.
- Europe has E Series
  - E1: 2.048 Mbps
  - E3: 34 Mbps
- SONET/SDH lines offer very high speeds
  - 156 Mbps, 622 Mbps, 2.5 Gbps, 10 Gbps

Lease Line

- A **leased line** is a private bidirectional or symmetric telecommunications line between two or more locations provided in exchange for a monthly rent. Sometimes known as a **private circuit** or **data line.**
- Unlike traditional PSTN lines it does not have a telephone number, each side of the line being permanently connected and dedicated to the other.
- Leased lines can be used for telephone, Internet, or other data services. Some are ringdown services, and some connect to a private branch exchange or router.

Lease Line

- An Internet leased line is a premium internet connectivity product, normally delivered over fiber, which provides uncontended, symmetrical speeds with full duplex.
- It is also known as an ethernet leased line, dedicated line, data circuit or private line.
- Unlike dial-up connections, a leased line is always active. The fee for the connection is a fixed monthly rate. The primary factors affecting the monthly fee are distance between end points and the speed of the circuit.
- Because the connection does not carry anybody else's communications, the carrier can assure a given level of quality.

Integrated Services Digital Network

- Introduction to ISDN
- History of ISDN
- Channels of ISDN
- Features of ISDN
- Use of ISDN

Introduction to ISDN

- It is a telephonic system. Which provide digital (not analog) telephone and data services.
- As it supports digital services (include digital voice), the ISDN telephone users enjoy Voice-free, CD Quality, Sound.
- Moreover with the ISDN no modem is necessary because it supports digital transmission of all types of data (including voice).
- This also results in very short call setup time between two ISDN subscribers.

Introduction to ISDN

- ISDN is a circuit –switched telephone network system, Which designed to allow digital transmission of voice and data over ordinary telephone copper wires, resulting in better voice quality than an analog phone.
- ISDN channels may use bonding to achieve a greater data rate, typically 3 or 4 BRIs (6 to 8 64 kbit/s channels) are bonded. ISDN is designed to provide access to voice and data services simultaneously.
- **Integrated Services refers to ISDN‘s** ability to deliver at minimum two simultaneous connections, in any combination of data, voice, video, and fax, over a single line. Multiple devices can be attached to the line, and used as needed.

ISDN elements

- **Digital refers to its purely digital** transmission. Use of an analog telephone modem for Internet access requires that the Internet service providers's (ISP) modem converts the digital content to analog signals before sending it and the user's modem then converts those signals back to digital when receiving. When connecting with ISDN there is no digital to analog conversion.
- **Network refers to the fact that ISDN is not** simply a point-to-point solution like a Leased line. ISDN networks extend from the local telephone exchange to the remote user and includes all of the telecommunications and switching equipment in between.

History of ISDN

- Developed by CCITT (Comate Consultative International Telephonique Telegraphs) to limitation of POTS (Plane old Telephone system).
- Original document was I.120 version in 1984.
- Early 1990s produced NI-1version.
- More recently NI-2 also manufactures worked with phone companies to simplify ordering.

Channels of ISDN

1. B Channel
2. D Channel
3. H Channel

- **B (Barrier) Channel:** It carries voice, data, video etc. This Channel functions at a constant 64 kbps. This channel can be used for packet and circuit switching applications.
- **D (Denial) channel:** It is used to convey user signaling messages. This type channel used out of band signaling. This means that network related signals are carried on a separate channel than used data.

Channels of ISDN

- **H channels:** They have a considerably higher transfer rate than B channels. These channels effectively meet the needs of real time video conferencing, digital quality audio and other services requiring a much higher bandwidth. H channel sustains rates of approximately 1920 mbps.

Features of ISDN

- In ISDN very short time to connect a calling between two users of ISDN.
- Signals, messages or data send in the digital form on the ISDN line. In which provide high quality database services.
- The user of ISDN also communicate information with all the general telephone user.

Use of ISDN

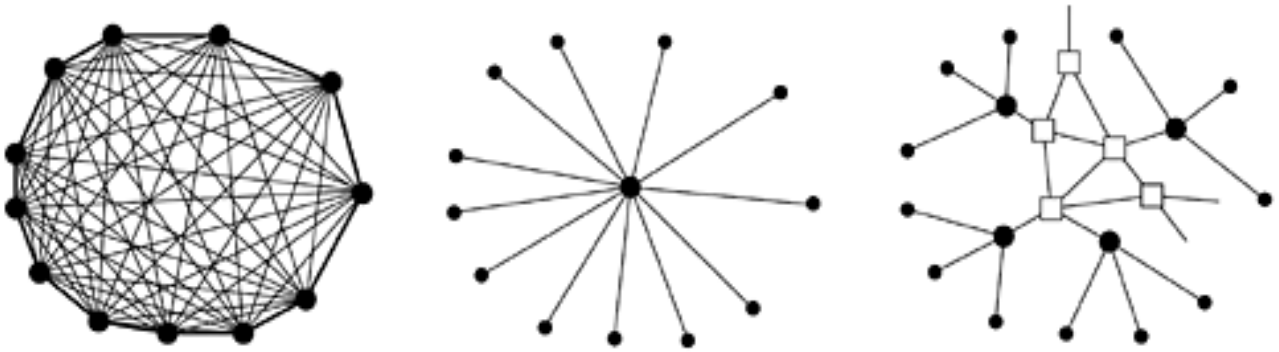
- Electronic library Inter connection.
- Electronic resources accessing.
- Images, sound and video retrieval.
- Video conferencing.
- Call center.
- Internet Access.

Public Switched Telephone Network (PSTN)

- Structure
- The Local Loop
- Trunks and Multiplexing
- Switching

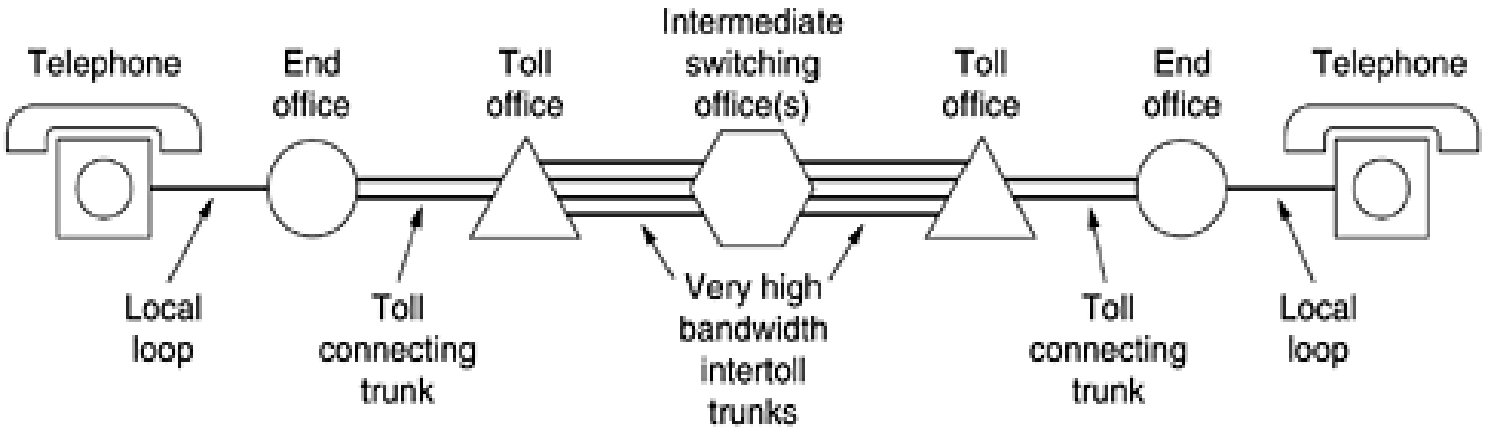
Network Structure

- minimize number of wires
- add multiple levels



Typical Circuit

- local loops
- trunks
- switching offices



The Local Loop

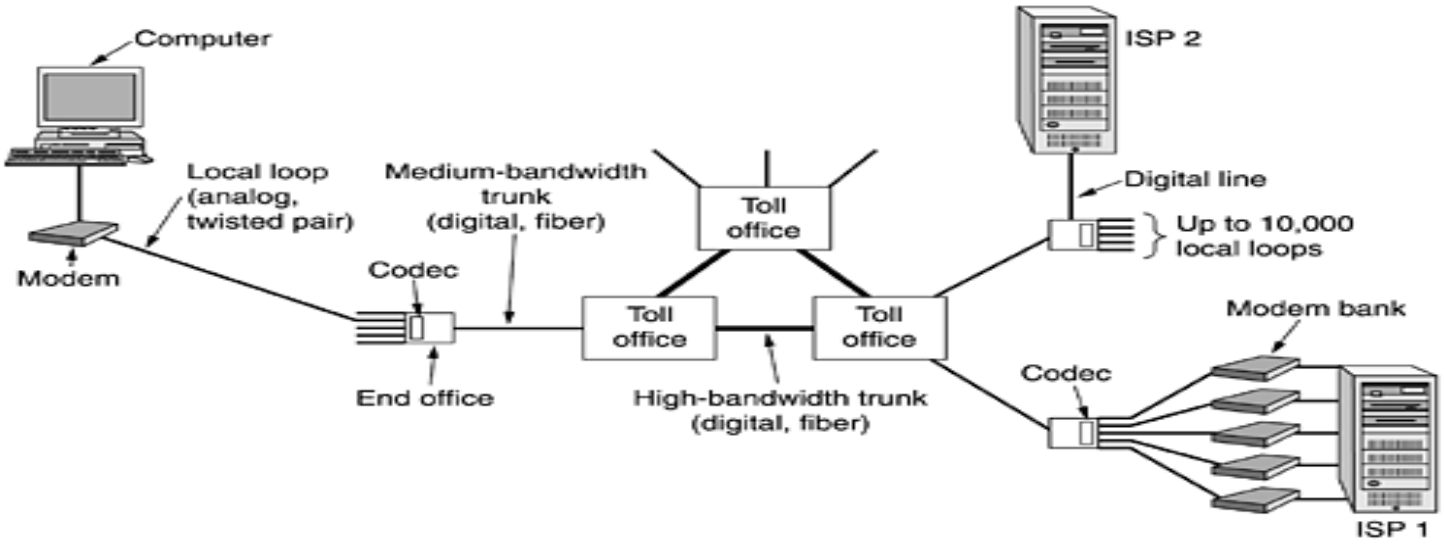
- Modems
- (A)DSL
- Wireless

Modems

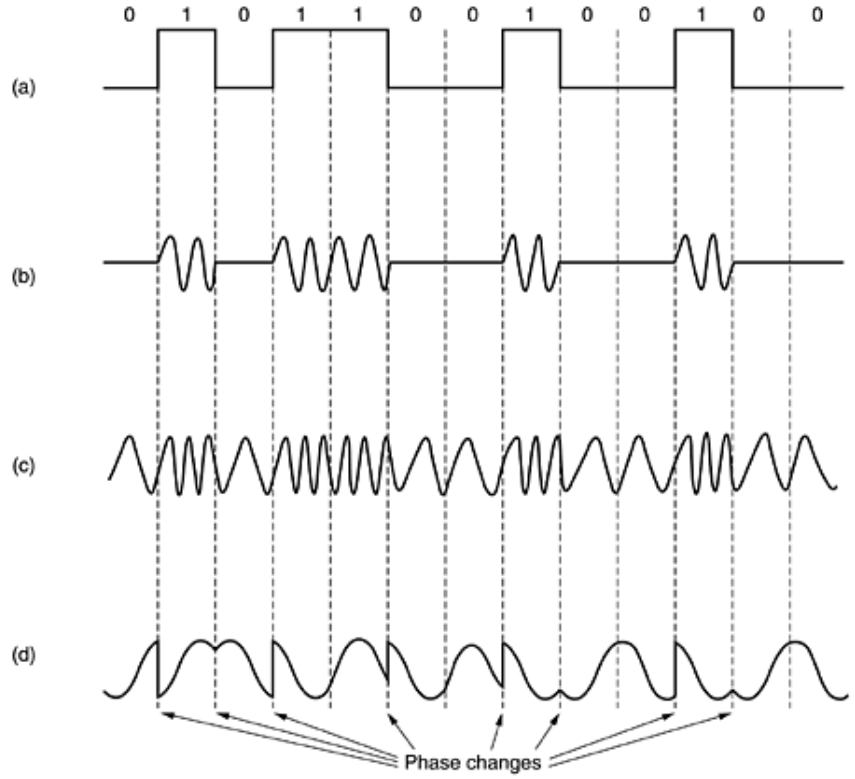
- Analog and digital transmission
- Sine wave carrier
- Baud
- Phase shift keying
- Limits

Analog and Digital Transmission

- modem – modulator, demodulator
- codec – coder, decoder



Modems – Sine Wave Carrier



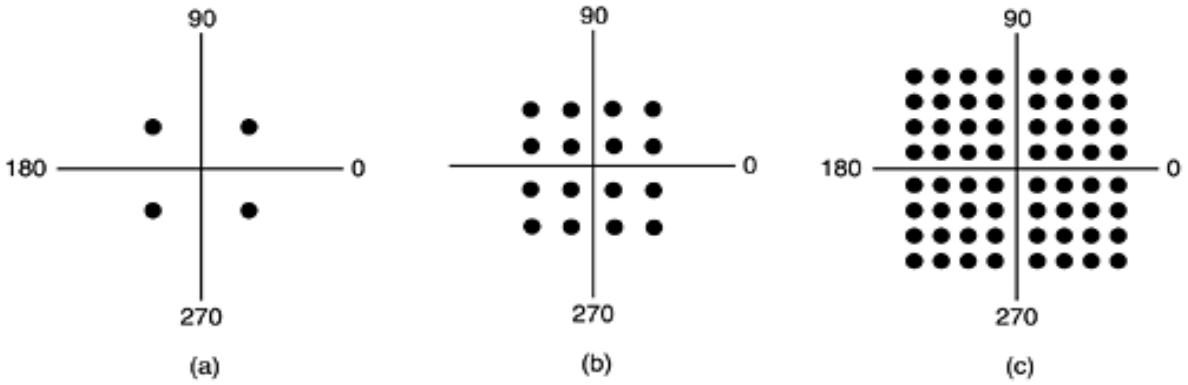
(a) binary, (b) AM, (c) FM, (d) phase modulation

Baud and Symbols

- Baud rate is the sampling rate
- Baud is the time to read one symbol
- When the number of symbols is 2, the baud rate is the bit rate
- Modern modems use large sets of symbols

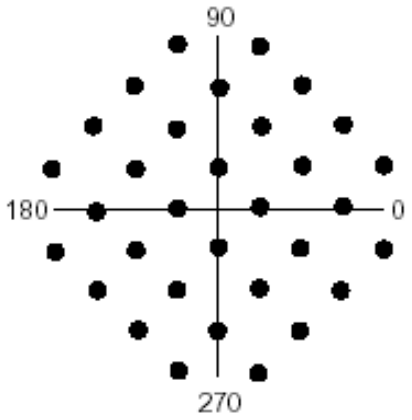
Quadrature Phase Shift Keying

- Constellation diagrams
- Amplitude (distance from origin)
- Phase
- QAM: Quadrature Amplitude Modulation

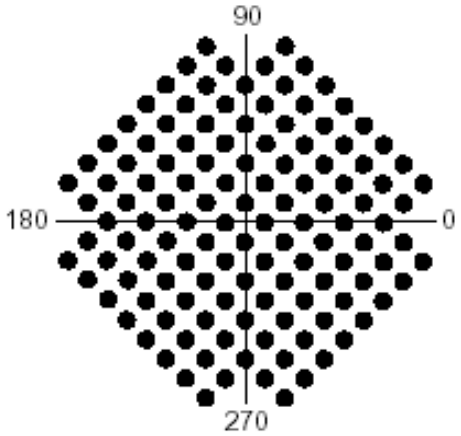


Trellis Coded Modulation

- add bits for error correction
- V.32: 32 constellation points, 4 data bits, 1 parity bit
- V.32bis: 6 data bits, 1 parity bit



(b)



(c)

Limits

- Base sampling rate – 2400 baud

Standard	Data bits	bps
V.32	4	9600
V.32bis	6	14,400
V.34	12	28,800
V.34bis	14	33,600

- Variations
  - handshake to determine line quality
  - compression
- 35 kbps is the Shannon limit, 56 kbps?
  - eliminate one local loop
  - V.90 56-kbps down stream, 33-kbps upstream
  - V.92 48-kbps down stream, 48-kbps upstream

Radio Frequency

- Radio frequency (RF) is a measurement representing the oscillation rate of electromagnetic radiation spectrum, or electromagnetic radio waves, from frequencies ranging from 300 GHz to as low as 9 kHz. With the use of antennas and transmitters, an RF field can be used for various types of wireless broadcasting and communications.

How radio frequency works

- Radio frequency is measured in units called hertz. One hertz equals one cycle per second; radio waves range from thousands (kilohertz) to millions (megahertz) to billions (gigahertz) of cycles per second. Microwaves are a type of radio wave with higher frequencies. Radio frequencies are not visible to the human eye.
- In a radio wave, the wavelength is inversely proportional to the frequency. If *f* is the frequency in megahertz and *s* is the wavelength in meters, then $s = 300/f$
- As the frequency is increased beyond that of the RF spectrum, electromagnetic energy takes the form of infrared (IR), visible, ultraviolet, X-rays and gamma rays.

RF technology

- Many types of wireless devices make use of RF fields. Cordless and cellphones, radio and television broadcast stations, Wi-Fi and Bluetooth, satellite communications systems, and two-way radios all operate in the RF spectrum.
- In addition, other appliances outside of communications, including microwave ovens and garage-door openers, operate at radio frequencies.
- Some wireless devices, like TV remote controls, some cordless computer keyboards and computer mice, operate at IR frequencies, which have shorter electromagnetic wavelengths.

RF technology

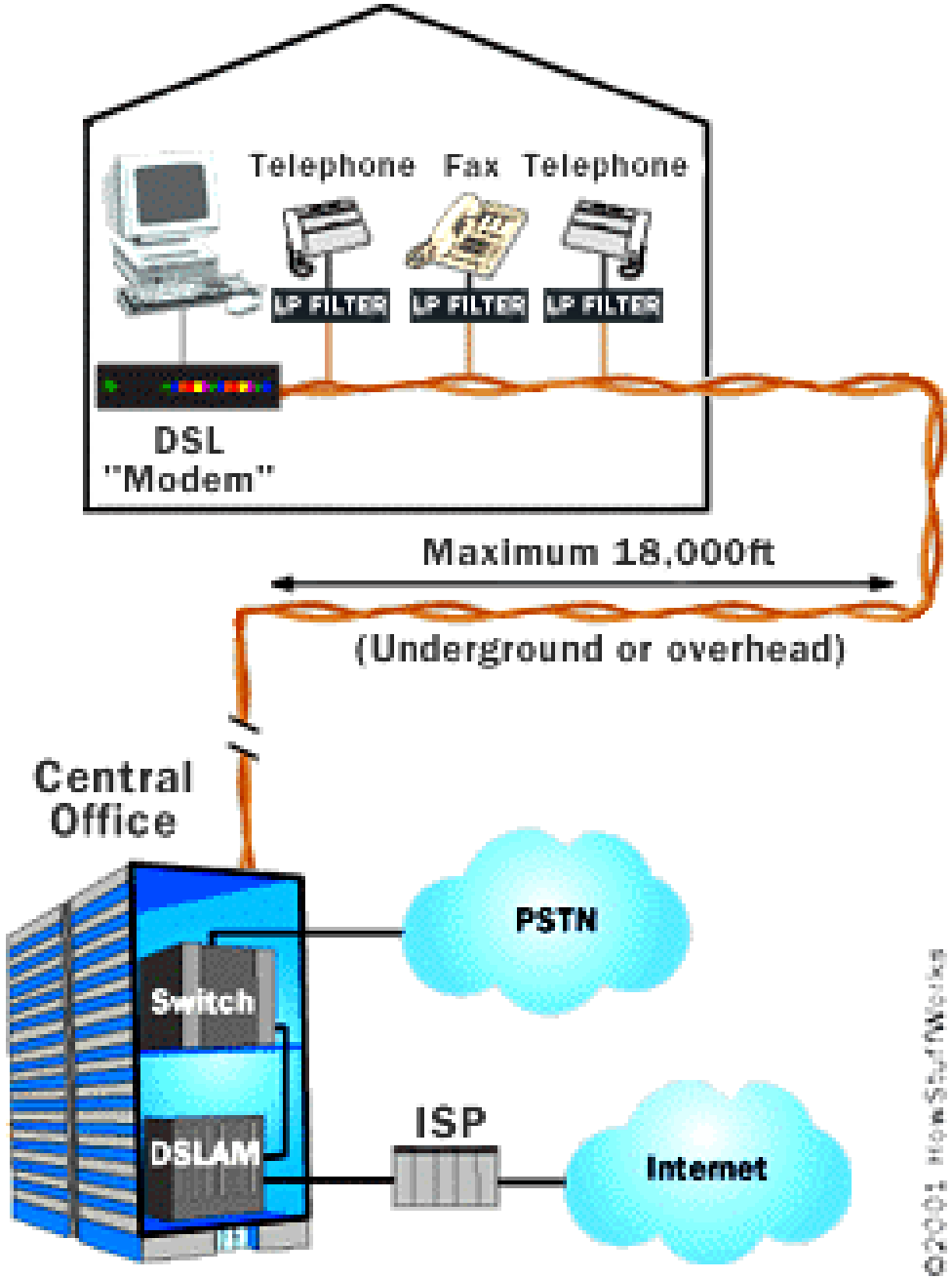
- The RF spectrum is divided into several ranges, or bands. With the exception of the lowest-frequency segment, each band represents an increase of frequency corresponding to an order of magnitude (power of 10).
- The following table depicts the eight bands in the RF spectrum, showing frequency and bandwidth ranges.
- The super high frequency (SHF) and extremely high frequency (EHF) bands are often referred to as the *microwave spectrum.*

Radio frequency spectrum bands

DESIGNATION	ABBREVIATION	FREQUENCIES	FREE-SPACE WAVELENGTHS
Very low frequency	VLF	9 kHz to 30 kHz	33 km to 10 km
Low frequency	LF	30 kHz to 300 kHz	10 km to 1 km
Medium frequency	MF	300 kHz to 3 MHz	1 km to 100 m
High frequency	HF	3 MHz to 30 MHz	100 m to 10 m
Very high frequency	VHF	30 MHz to 300 MHz	10 m to 1 m
Ultrahigh frequency	UHF	300 MHz to 3 GHz	1 m to 100 mm
Super-high frequency	SHF	3 GHz to 30 GHz	100 mm to 10 mm
Extremely high frequency	EHF	30 GHz to 300 GHz	10 mm to 1 mm

DIGITAL SUBSCRIBER LINE

DSL BLOCK DIAGRAM



Asymmetrical DSL (ADSL)

- ADSL divides up the available frequencies in a line on the assumption that most Internet users look at, or download, much more information than they send, or upload.
  - Under this assumption, if the connection speed from the **Internet to the user is three to four times faster than the connection from the user back to the Internet**, then the user will see the most benefit (most of the time).

Asymmetrical DSL (ADSL)

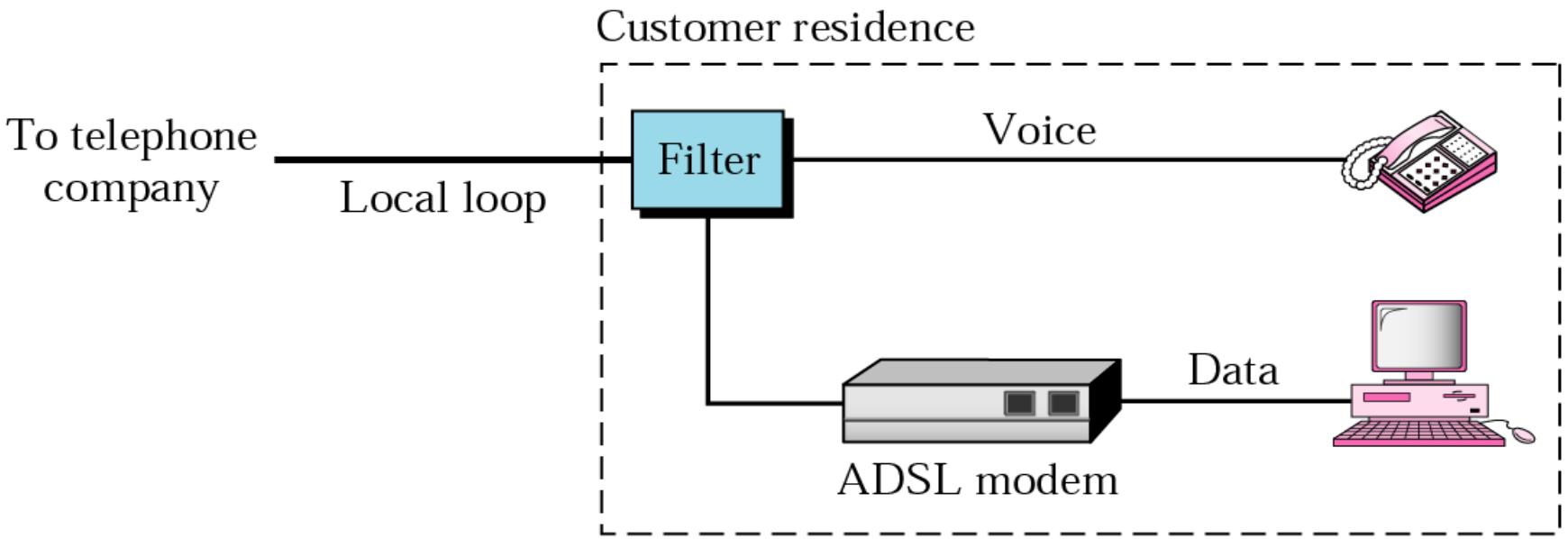
- *ADSL is an adaptive technology.*

- *The system uses a data rate based on the condition of the local loop line.*

- Speed:

  Most existing *local loops* can handle bandwidths up to 1.1 MHz.

ADSL Modem


Customer residence
To telephone company
Local loop
Filter
Voice
Data
ADSL modem

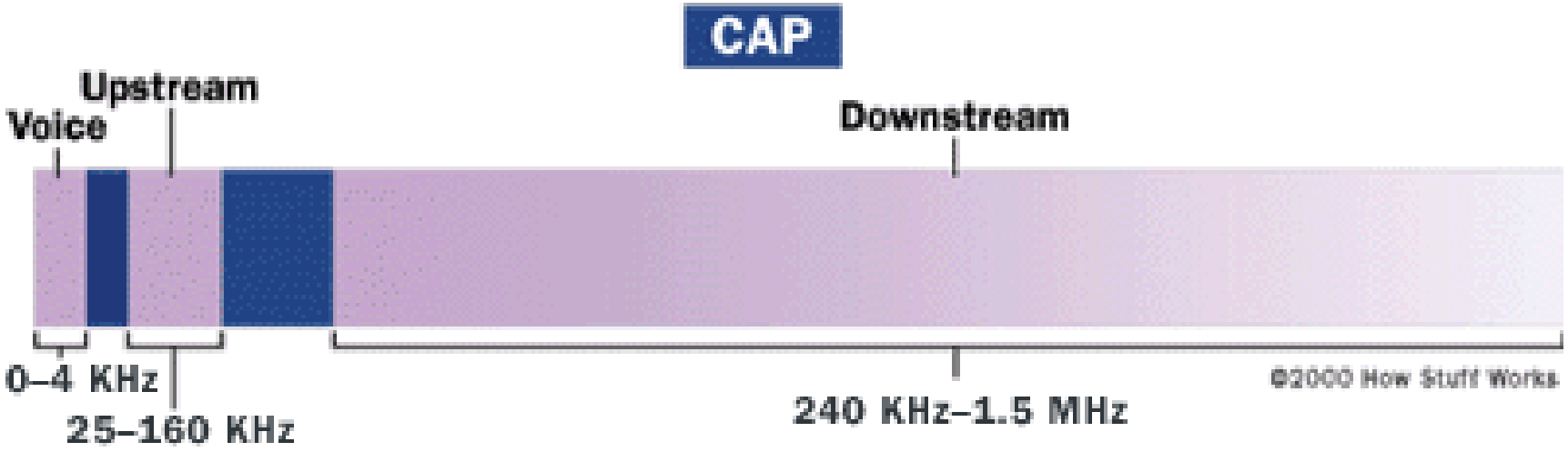
Two standards for ADSL

1. Discrete multitone (DMT)

2. Carrierless amplitude/phase (CAP)

CAP - three distinct bands:

1. **Voice channel - 0 to 4 KHz**
2. **Upstream channel - 25 and 160 KHz**
3. **Downstream channel - 1.5 MHz**

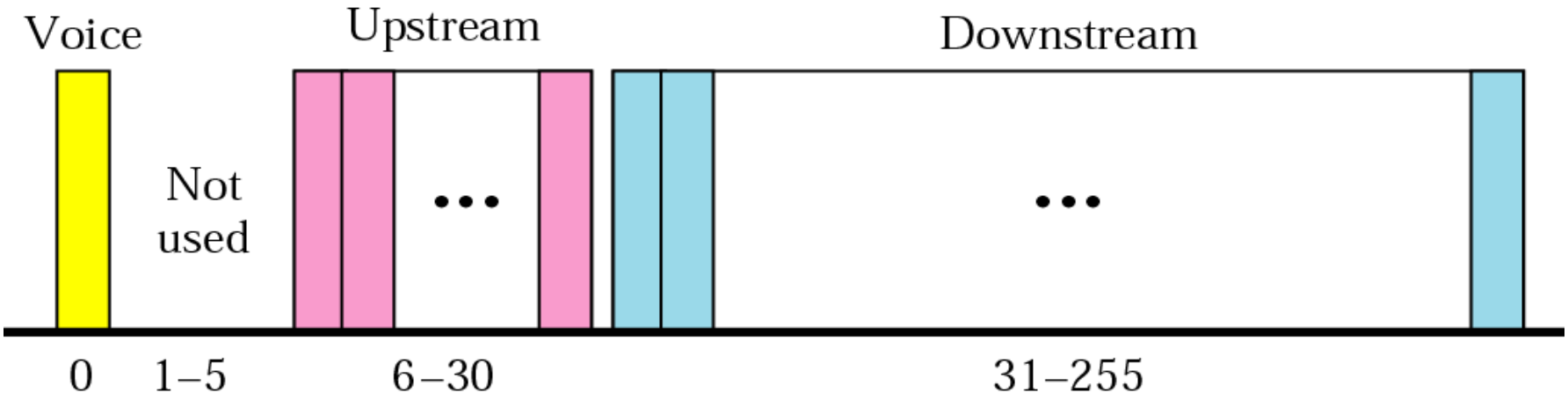


Carrierless amplitude/phase (CAP)

- Advantage:

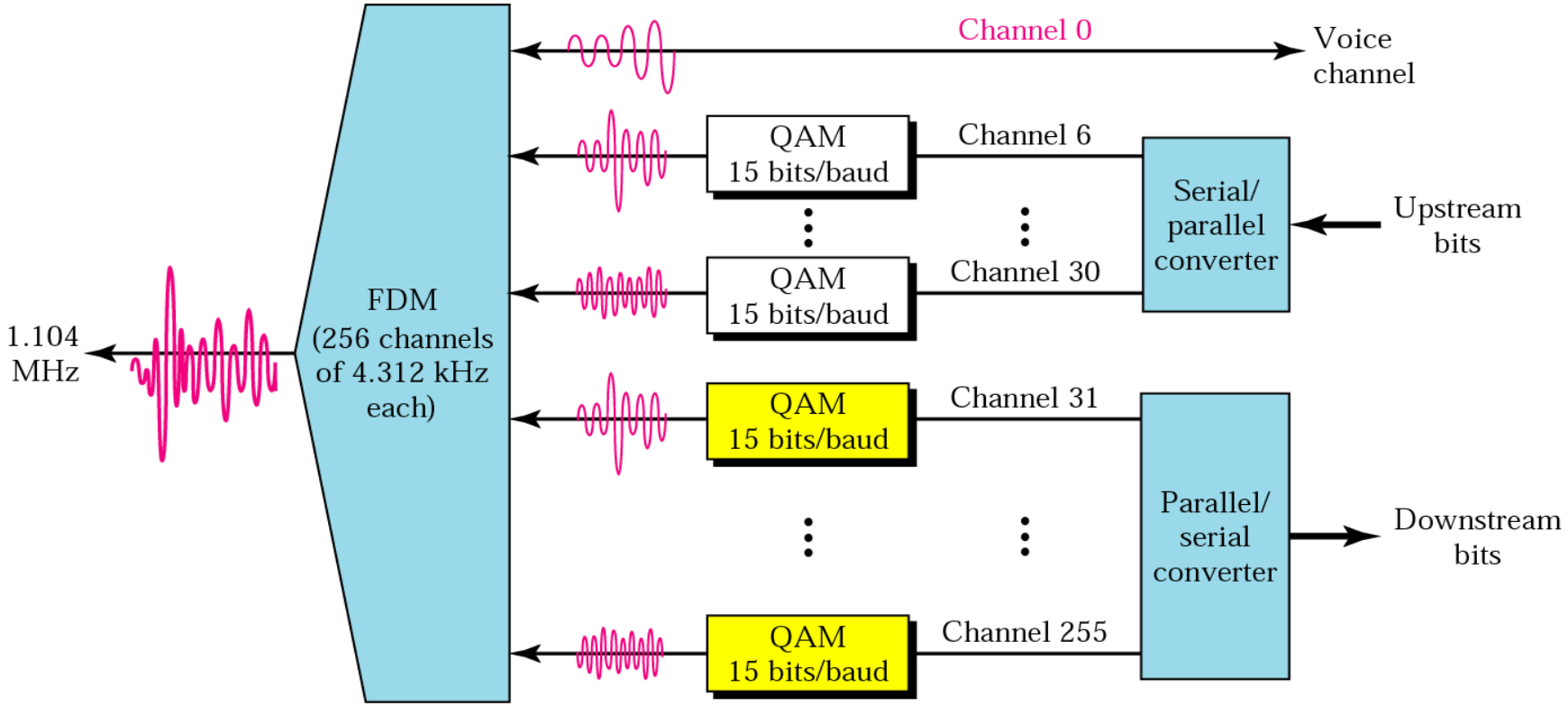
  Minimizes the possibility of interference between the channels on one line, or between the signals on different lines

Discrete multitone (DMT)



- Constantly shifts signals between different channels, searching for the best channels for transmission and reception

Discrete multitone (DMT)



Asymmetrical DSL (ADSL)

- ADSL is an asymmetric communication technology designed for residential users; it is not suitable for businesses.

Distance Limitations

- ADSL is a **distance-sensitive technology**
- The limit for ADSL service is **18,000 feet** (5,460 meters)
- At the extremes of the distance limits, ADSL customers may see speeds far below the promised maximums
- customers nearer the central office have faster connections and may see extremely high speeds

OTHER TYPES OF DSL

- Symmetric DSL (SDSL)
- High-bit-rate DSL (HDSL)
- Very high bit-rate DSL (VDSL)

Symmetric DSL (SDSL)

- Used mainly by small businesses and residential areas
- Bit rate of downstream is higher than upstream

High-bit-rate DSL (HDSL)

- Used as alternative of T-1 line
- Uses 2B1Q encoding
- Less susceptible to attenuation at higher frequencies
- Unlike T-1 line (AMI/1.544Mbps/1km), it can reach 2Mbps @ 3.6Km

Very high bit-rate DSL (VDSL)

- Uses DMT modulation technique
- Effective only for short distances(300-1800m)
- Speed:

  downstream : 50 - 55 Mbps

  upstream : 1.5-2.5 Mbps

Question!

- Distance is a limitation for DSL, why it's not also a limitation for voice telephone calls ?

Answer!

- The answer lies in small amplifiers called **loading coils** that the telephone company uses to boost voice signals
- these loading coils are incompatible with ADSL signals, so a voice coil in the loop between your telephone and the telephone company's central office will disqualify you from receiving ADSL.

VSAT

Introduction

- The old earth stations and antennas were large sizes.
- The Satellite was suffering from weak transmission and the impact of higher noise on the ground stations.
- So the receiving stations must be large size and complex installation.
- These satellites have developed and become a high transmitter.
- So the ground stations changed to small size Stations with less expensive and less complex and called VSAT.

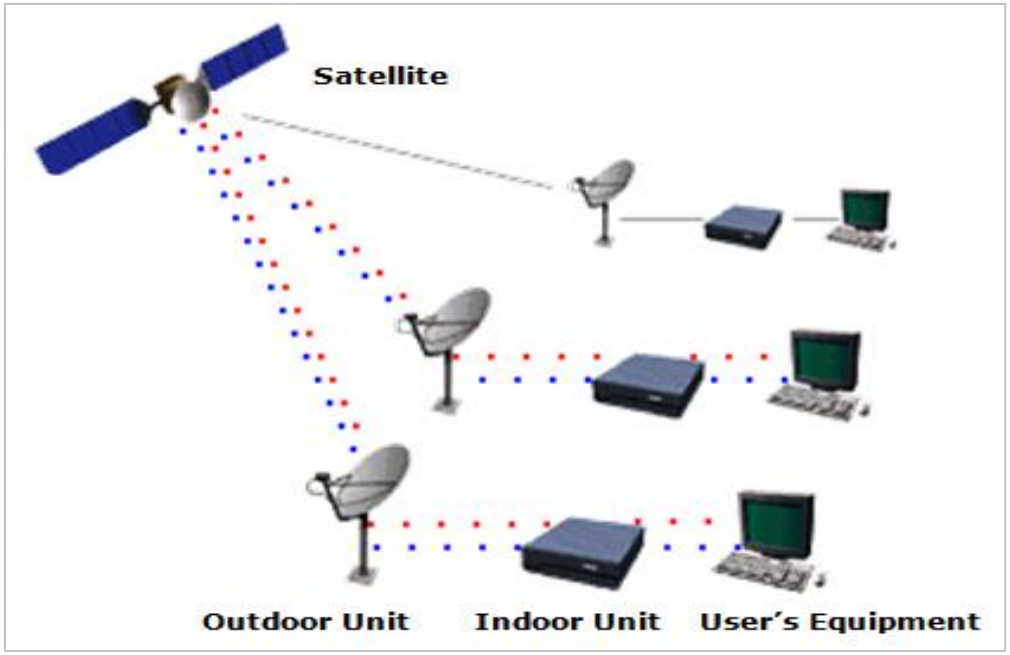
What is a VSAT?

- A **very small aperture terminal (VSAT)** is a small telecommunication earth station that receives and transmits data, video or voice via satellite.
- The **"very small"** component of the VSAT acronym refers to the size of the VSAT dish antenna-typically about 60 cm to 3.8 m.

Components of VSAT

It has two basic components:

- **Ground Segment** (earth segment), which is divided into:
  - Outdoor Unit (ODU), which contains the antenna.
  - Indoor Unit (IDU), which contains the interface between the VSAT and the customer's Equipment (PCs, TVs, Telephones).
- **Space Segment** namely satellite.



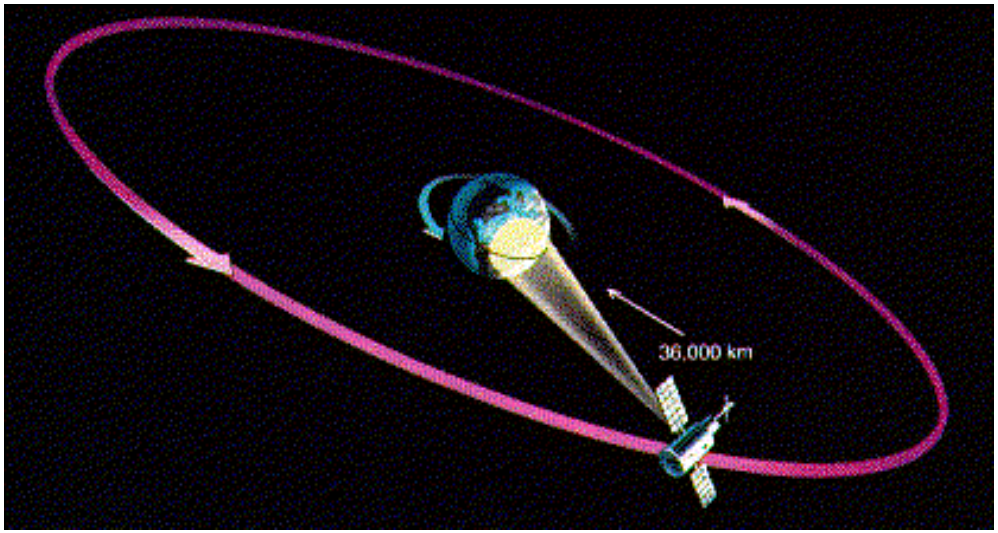
Uplink & Downlink

VSAT uses different frequencies:

- **Ku-band frequency:** is usually used in North America and Europe by using small VSAT antenna with uplink frequency about 18 GHz and downlink around 12 GHz.
- **C-band frequency:** is usually used in Asia, Africa and South America and operating with much larger antenna, with uplink frequency around 6 GHz as for downlink frequency around 4 GHz.
- The new **Ka-band frequency:** is typically in the downlink frequencies up to 22 GHz and uplink frequencies up to 31 GHz.

The satellites that are used in the VSAT system?

- VSAT system used geostationary earth orbit (GEO) satellites that revolve around the equator at the same rotational speed as the earth.
- Appearing as though they are not moving at all, GEOs are always in the same place above the earth. They also cover a large geographic area.
- Direction from earth: 36,000 km (22,282 miles).
- Speed: 11,300 Km/h.

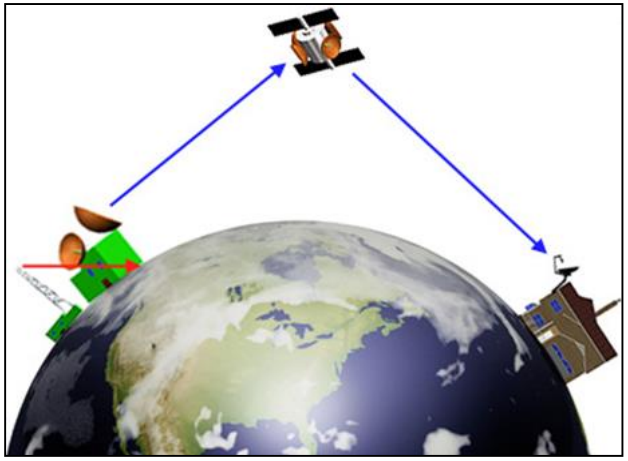


VSAT Advantages:

- High flexibility to increase the size of the network in the future.
- Able to integrate large number of the networks.
- Cover distant geographical locations.
- Ability to handle Voice, Video and Data.

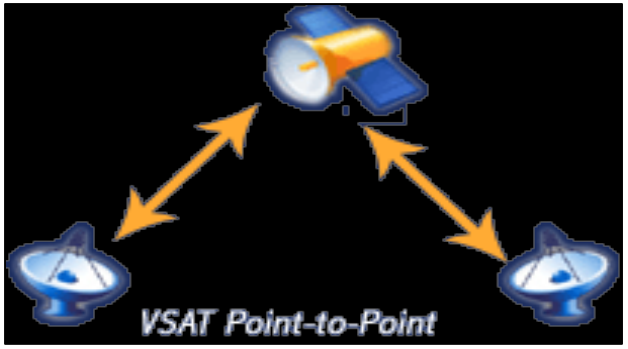
VSAT Disadvantages:

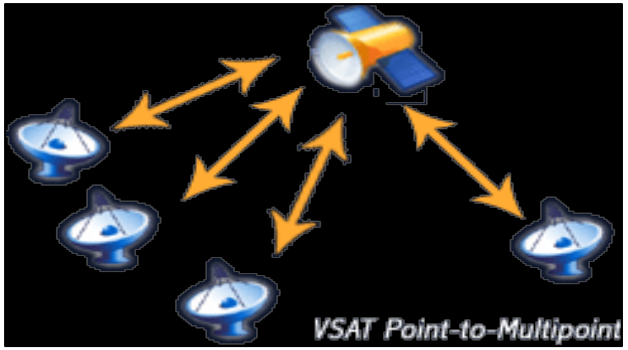
- Requires clear line of sight between dish and satellite.
- Outages in some cases, because of the weather. These outages normally last for a few minutes.



VSAT Network Topologies

- The connection between Terminal and Terminal called (Point to Point).
- The connection between Hub and Terminals called (Point to Multipoint).

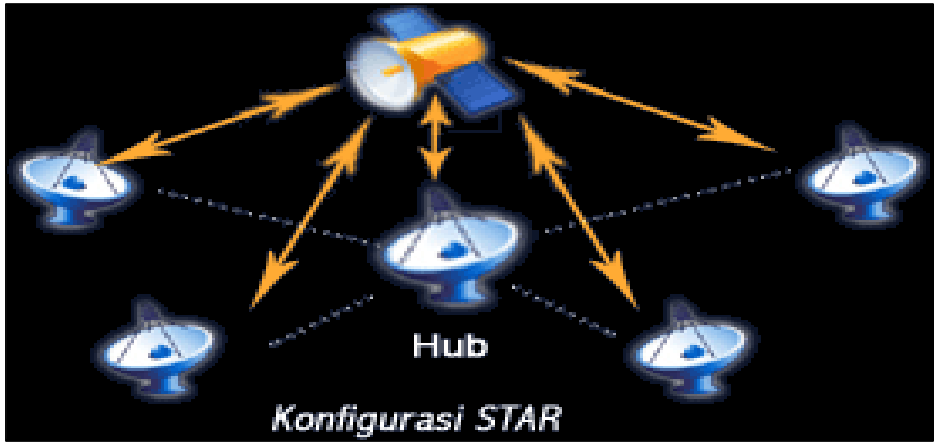




- The most important types of link are:
  - Star Topology.
  - Mesh Topology.

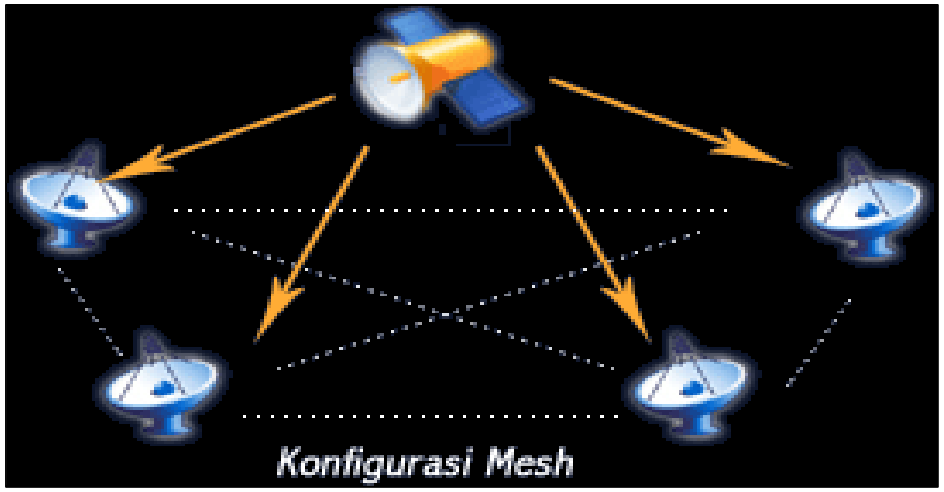
Star Topology

- VSAT terminals cannot communicate directly with each other, they have to go through the hub.
- It is commonly used for internet connection purpose.
- Smaller VSAT antenna sizes (1.8 m typically).
- The performance of the network is directly dependent on the performance of the hub.



Mesh Topology

- This network enables direct communication from one point to another.
- Its usually found in telephone and data lines.
- larger VSAT antenna sizes (3.8 m typically).
- If one of the components fails there is another line.



❖ Summary

- VSAT is a perfect solution in answering voice, data and video, especially in the absence of terrestrial transmission coverage.
- Utilizing VSAT offers maximum benefit, which enables company to expand very fast without affected by lack of local telecommunication network infrastructure.
- VSAT is available anywhere in the Kingdom with the ability to connect remote areas.