A network can be classified according to the Physical connectivity between the systems (PCs, Laptops, switches, Gateways, etc.) – Called as Topology

Basic Topologies:

-Bus

-Ring

-Star

Each has own advantages & Disadvantages:

BUS

- Bus requires fewer cables in comparison to Star
- May be disable if cable is cut or any node is out of order
- In optical network it is difficult to design power budget
- Generally Preferred for LAN

Ring ease Protocols; More Latency; Difficult to design power budget for Optical network; More robust as Reliability is concerned – preferred for MAN

Star

- Not so reliable, i.e., if hub fails
- Requires more cables
- Star is easier to design optical power-budget
- Easy to implement as flexible – LAN, CATV, Telephone Network (most of the companies prefers STAR topology as LAN/Access Network Configuration)

Tree: Flexible to design, i.e, can support random connection - Hence preferred by service provider like, CATV, Telephone Network

Mesh: Geographical location of main cities & countries had been connected in an asymmetric manner, hence in WAN & some of the MANs are Mesh Topo..Routing is Complex

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Message: Complete File considered as one message. It has no minimum or maximum size limitation -- from a few bytes to some hundreds of megabytes. Example: a file of text, program!

Frame: A Block of data suitable for transmission as single unit. The frame Minimum & Maximum size depends on protocol! Example: Ethernet.

Packet: Block of data sent over network. It is generally smaller in size in comparison to message. Example: ATM, IP Packets.

Bit rate: Number of bits transmitted per unit time (here we consider unit time as one second) – Transmission rate.

Baud rate: measure of the number of symbols (Characters) transmitted per unit time;

- Each symbol may normally consists of a no. of bits – hence, only baud rate = bit rate → when there is one bit per symbol

Bandwidth: Frequencies carried by a signal/system/medium. (Fiber: $f = c/\lambda$).

A **Protocol** is a set of rules that make communication on a network more efficient.

protocols define:

- format,

- order of message sent and received among network entities,

- actions taken on message transmission, receipt

App's using TCP: HTTP (WWW), FTP (file transfer), Telnet (remote login), SMTP (email)

App's using UDP: streaming media, teleconferencing, Internet telephony

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Circuit Switching:

network resources (e.g., bandwidth) divided into "pieces"

- pieces allocated to calls
- resource piece *idle* if not used by owning call *(no sharing)*
- dividing link bandwidth into "pieces"
  - frequency division
  - time division

Packet Switching:

each end-end data stream divided into *packets*

- user A, B packets *share* network resources
- each packet uses full link bandwidth
- resources used *as needed*,

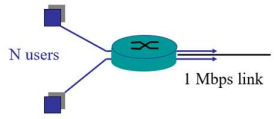
resource contention:

- aggregate resource demand can exceed amount available
- congestion: packets queue, wait for link use
- store and forward: packets move one hop at a time
  - transmit over link
  - wait turn at next link

Packet switching versus circuit switching

Packet switching allows more users to use network!

- 1 Mbit link
- each user:
  - 100Kbps when "active"
  - active 10% of time
- circuit-switching:
  - 10 users
- packet switching:
  -with 35 users, probability > 10 active less than .0004



Packet switching versus circuit switching

- Great for bursty data: Packet Switching
  - resource sharing
  - no call setup
- Excessive congestion: packet delay and loss
  - protocols needed for reliable data transfer, congestion control
- Q: How to provide circuit-like behavior?
  - bandwidth guarantees needed for audio/video apps: One of the Present Challenges!

Packet vs Message Switching:

Adv. of Pak. Sw. respect of Msg. Sw.

- Less end-to-end delay in case of multihop network

- As packet size small, probability of PER is less, hence avoids congestion due to retransmission. (as, PER ≅ BER x Pak. Length)

Disadv. of Pak. Sw. respect of Msg. Sw.

-Amount of header overhead per byte of data is more.

Q: How to connect end systems to edge router?

- residential access nets
- institutional access networks (school, company)
- mobile access networks

Dialup via modem -- up to 56Kbps direct access to router (conceptually)

ISDN: integrated services digital network: 128Kbps all-digital connect to router

ADSL: asymmetric digital subscriber line

  - up to 1 Mbps home-to-router
  - up to 8 Mbps router-to-home
  - ADSL deployment: happening

HFC: hybrid fiber coax

  - asymmetric: up to 10Mbps upstream, 1 Mbps downstream

Typical home network components:

- ADSL or cable modem
- router/firewall
- Ethernet
- wireless access

Coaxial cable:

- wire (signal carrier) within a wire (shield)
  - baseband: single channel on cable
  - broadband: multiple channel on cable
- bidirectional
- common use in 10Mbs Ethernet

Fiber optic cable:

- glass fiber carrying light pulses
- high-speed operation:
  - 100Mbps Ethernet
  - high-speed point-to-point transmission (e.g., 5 Gps)
- low error rate

Transmission delay:

- R=link bandwidth (bps)
- L=packet length (bits)
- time to send bits into link = L/R

Propagation delay:

- d = length of physical link

- s = propagation speed in medium (~$2x10^8$ m/sec)
- propagation delay = d/s

Queuing Delay

- R=link bandwidth (bps)
- L=packet length (bits)
- a=average packet arrival rate

traffic intensity = La/R

- La/R ~ 0: average queueing delay small
- La/R -> 1: delays become large
- La/R > 1: more "work" arriving than can be serviced, average delay infinite!

Why network software?

- Sending data through raw hardware is awkward and inconvenient - doesn't match programming paradigms well
- May not be able to send data to every destination of interest without other assistance
- Network software provides high-level interface to applications

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A set of related protocols that are designed for compatibility is called a ***protocol suite***

- Protocol suite designers:
  - Analyze communication problem
  - Divide problems into sub-problems
  - Design a protocol for each sub-problem
- A well-designed protocol suite
  - Is efficient and effective - solves the problem without redundancy and makes best use of network capacity
  - Allows replacement of individual protocols without changes to other protocols

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Why layering

Dealing with complex systems:

- *Layering model* is a solution to the problem of complexity in network protocols
- Model suggests dividing the network protocol into *layers*, each of which solves part of the network communication problem

- These layers have several constraints, which ease the design problem
- Network protocol designed to have a protocol or protocols for each layer

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Functions of Layer's in OSI

Many modern protocols do not exactly fit the ISO model, and the ISO protocol architecture is mostly of historic interest

Concepts are still largely useful and terminology persists

- Layer 7: Application - Application-specific protocols such as FTP and SMTP (electronic mail)
- Layer 6: Presentation - Common formats for representation of data
- Layer 5: Session - Management of sessions such as login to a remote computer
- Layer 4: Transport - Reliable or Unreliable delivery of data between computers
- Layer 3: Network - Address assignment, routing, forwarding and data delivery across a network
- Layer 2: Data Link - Format of data in frames and delivery of frames through network interface
- Layer 1: Physical - Basic network hardware – to transmit bits

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