# EE400 Telecommunication Networks

## Lecture 2: Network Topology

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## Identifying a Network Type

- Communications medium
  - Wire cable, fiber-optic cable, radio waves, microwaves
- Protocol
  - How networked data is formatted into discrete units
  - How each unit is transmitted and interpreted
- Topology
  - Physical layout of cable and logical path
- Network type
  - Private versus public

## Network Topology

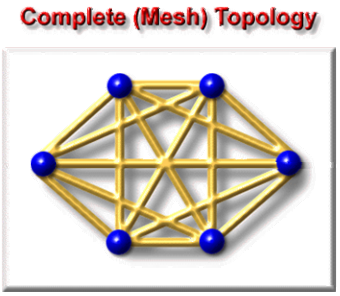
- The study of location
- Two types – Physical and Logical
- Physical – describes the wiring scheme
- Logical – describes how data flows through the network
- Network can have different physical and logical topologies



## Types of Topologies

- Fully connected (mesh)
- Bus
- Ring
- Star
- Extended Star
- Tree
- Irregular
- Cellular

# Mesh Topology

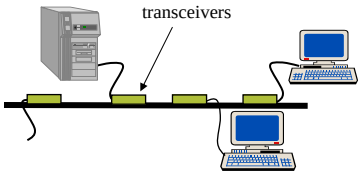


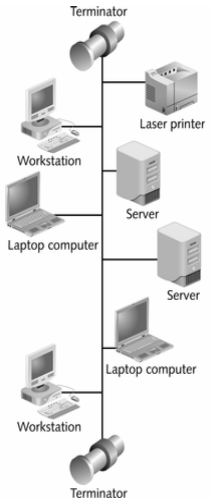

- **Mesh topology**:
  every node is linked directly to every other node.
- Simple, straight forward operation
- Redundant connection,
  should any link fail to function,
  information can flow through any number of other links to reach its destination.
- Very costly [N users require Nx(N-1) links]
- Not practical for geographically distributed users



# Bus Topology

- Single cable connects all computers
- Each computer has connector to shared cable
- Terminators signal the physical end to the segment
- Logical – all devices can see all communications
- Physical – each device is on the same wire
- Computers must synchronize and allow only one computer to transmit at a time



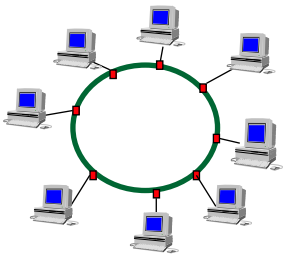
# Bus Topology

- Advantages of Bus Topology
  - Works well for small networks
  - Relatively inexpensive to implement
  - Easy to add to it
- Disadvantages of Bus Topology
  - Management costs can be high
  - Potential for congestion with network traffic



# Ring Topology

- Computers connected in a closed loop
- First passes data to second, second passes data to third, and so on
- Continuous path for data with no logical beginning or ending point, and thus no terminators
- Logical – each station passes data to adjacent station
- Physical – devices wired in a daisy chain

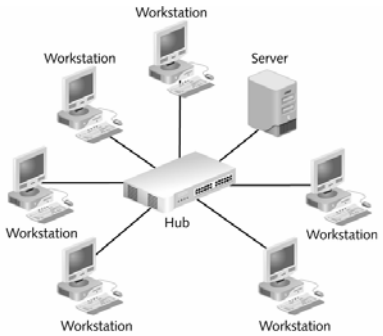
# Ring Topology

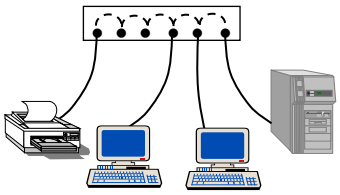
- Advantages of Ring Topology
  - Easier to manage; easier to locate a defective node or cable problem
  - Well-suited for long distances on a LAN
  - Handles high-volume network traffic
  - Enables reliable communication
- Disadvantages of Ring Topology
  - Expensive
  - Requires more cable and network equipment at the start
  - Not used as widely as bus topology



# Star Topology

- Oldest and most common network design
- Multiple nodes attached to a central hub
- Physical – all nodes connected to center node
- Logical – all data passes through center node



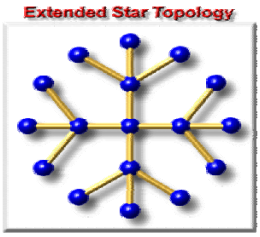
# Star Topology

- Advantages of Star Topology
  - Easy to design and install
  - Low startup costs and easy to manage and maintain
  - Layout is easy to modify and troubleshoot
  - Reliable
  - Easily scalable (Easy to add hosts)
- Disadvantages of Star Topology
  - Hub is a single point of failure
  - Requires more cabling than the bus



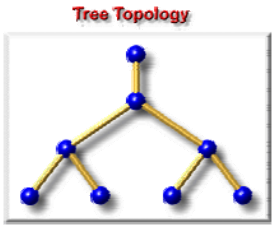
# E-Star Topology

- An extended star topology repeats a star topology, where each node that links to the center node is, also, the center of another star.

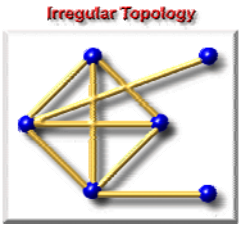


# Tree & Irregular Topologies

- The tree topology is similar to the extended star topology, the primary difference being that it does not use one central node. Instead, it uses a trunk node from which it, then, branches to other nodes.
- Example: Telephone networks.



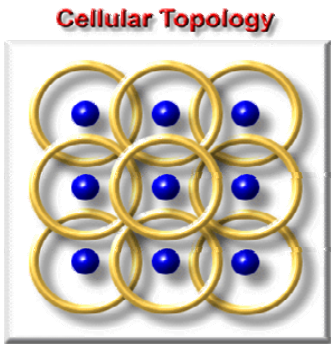

- Irregular Topology: there is no obvious pattern to the links and nodes. The wiring is inconsistent; the nodes have varying numbers of wires leading from them.






# Cellular Topology

- The cellular topology consists of circular or hexagonal areas, each of which has an individual node at its center.
- Used in wireless cellular networks



# Topology-Design Related Issues

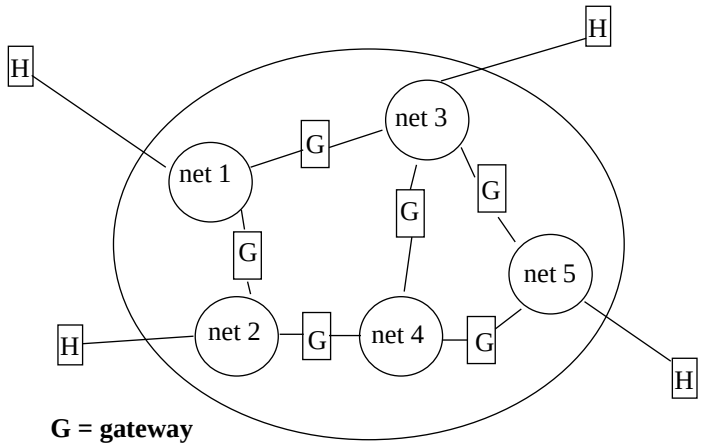
- Cost of installation and maintenance
- Redundancy
- Reliability (no single point of failure)
- Expandability (scalability)
- Need for Switching
  - Process of directing traffic through the network based on a pre-defined route
- Need for Routing
  - Process of finding the best route for the traffic
- Delay
- ….



# Sub-networking

- Organize a large network in smaller networks
- Provide a connection between subnetworks
- Use multiplexing to share the connection between subnetworks.

# Internetworks




**G = gateway**

**H = Host**



# Media Sharing Techniques

- Channelization Schemes
  - Time Division
  - Frequency Division
- Random Access Schemes
  - ALOHA
  - CSMA
- Scheduling Schemes
  - Polling
  - Token Ring

# Telephone Networks

- Traffic characteristics:
  - Communication sessions in minutes
  - Information flow is uniform
  - Real time
- Connection: Circuit Switching
  - A circuit/path is set up prior to the session
  - It is maintained for the session duration
  - All traffic flows along this path.

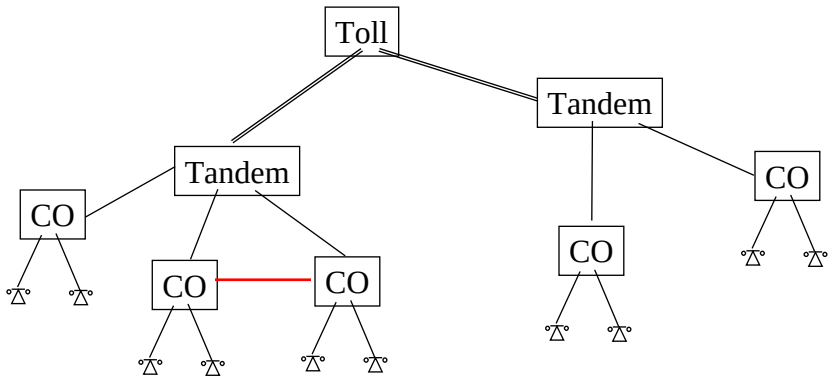


# Circuit-Switched Networks

- A switched dedicated circuit is created to connect two (or more) parties
- Similar to a direct physical path between senders and receivers
- Three phases to circuit-switched communication:
  - Creation of the temporary circuit
  - Information transmission
  - Circuit termination
- Users may not be able to initiate communication sessions during peak usage times because of limited number of circuits at a time (Blocking Probability)
- Since it is a dedicated path, it is expensive

# Telephone Networks

**Topology:** Hierarchical tree, with shortcuts if needed






# Computer Networks: Traffic Characteristics

- Bursty traffic (e.g. Internet browsing)
  ➔Multiple users can share the same channel
- Non-real time
  ➔Packet switching is used instead of circuit switching

# Packet-Switched Networks

- Data is **packetized** prior to transmission such that:
  - Each *packet* is a group of bits organized in a certain structure
  - Each packet contains data bits as well as additional overhead information to ensure error-free transmission
  - **Packets** may be called **blocks**, **cells**, **datagrams**, **data units**, or **frames**
- **Packet assembler/disassemblers (PADs)** are responsible for:
  - Assembling outgoing data into packets for transmission
  - Unpacking incoming packets so that data can be delivered to intended recipients



# Packet-Switching Advantages

- A single-link between packet-switching nodes can be simultaneously shared by multiple senders and receivers
- Senders are not denied access to the network during peak usage periods
- Packet-priority systems can be established (Quality of Service) as in voice-over-IP (VoIP).
- Packet-switching users are charged based on the volume of data (number of packets) transmitted rather than connection time (cheaper)

## Packet-Switching Disadvantages

- Variable transmission delays caused by packet processing and packet queues at packet switches
- Some packet-switching networks support variable packet sizes => longer packet processing times at packet switches
- The inclusion of overhead data in packets reduces data transmission efficiency and throughput compared to circuit-switched networks



## Packet-Switching: Datagram

- Connectionless-Oriented:
  - No set up
  - Each packet must carry the destination address
  - Each packet is routed independently
  - Packets may arrive out of sequence
  - Modeled after postal service
  - Example: Internet Protocol (IP)

# Packet-Switching: Virtual Circuit

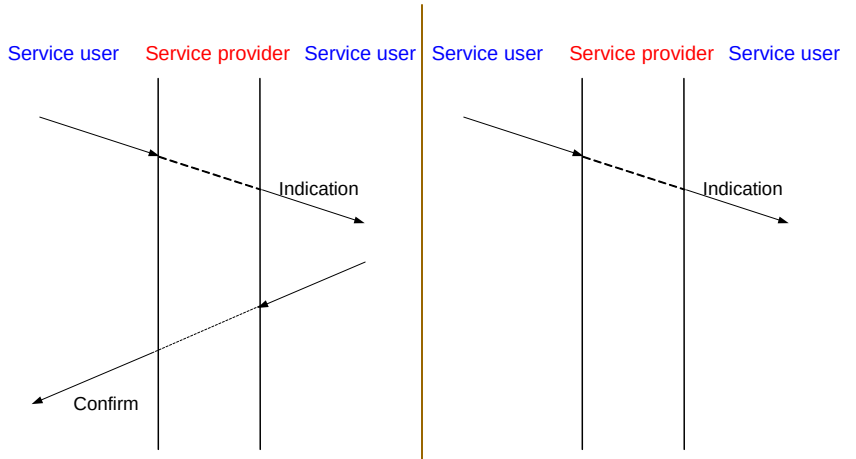
- Connection-Oriented:
  - A *virtual* circuit (end-end connection) is set up before transmission of the message (sequence of packets)
  - All packets are routed through the same virtual circuit
  - Since the links of the circuit are shared, each packet must carry the virtual circuit (VC) number.
  - The VC number is checked at each node along the route.
  - Packets may be buffered along the way.
  - Example: ATM Networks



# Circuit vs. Packet Switching

| ITEM | Circuit switching | Packet switching | |
|---|---|---|---|
| | | connectionless | connection |
| **Path set up** | Yes | No | Yes |
| **Dedicated path** | Yes | No | No |
| **Information flow** | continuous | Store-and-forward | Store-and-forward |
| **Bandwidth available** | Fixed | Dynamic | Negotiated |
| **Addressing** | No | Yes (destination) | Yes (VC) |
| **Out of sequence arrival** | No | Yes | No |
| **Routing** | Not required | Required | Required |
| **Delay** | Call set up | Packet transmission | Both |

# Timing Sequence for Service Primitives

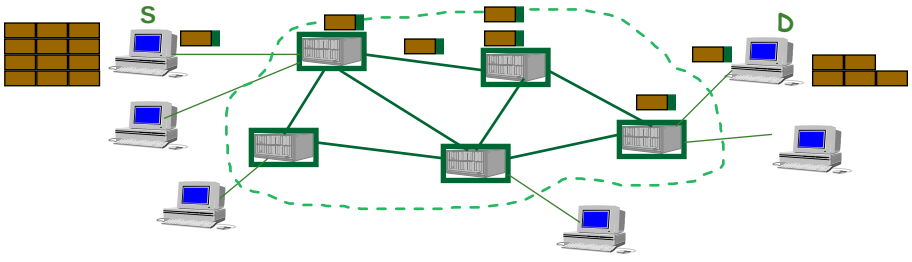



**Connection-Oriented Service** **Connectionless-Oriented Service**



Request

# WANs






Response