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, straightforward operation
- Redundant connection, should any link fail to function, information can flow through any number of other links to reach its destination.
- Very costly \([N \text{ users require } N\times(N-1) \text{ links}]\)
- 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.
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

![Telephone Network Diagram]

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/disassembler (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

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### Circuit vs. Packet Switching

<table>
<thead>
<tr>
<th>ITEM</th>
<th>Circuit switching</th>
<th>Packet switching</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>connectionless</td>
<td>connection</td>
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<tr>
<td>Path set up</td>
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<td>No</td>
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<tr>
<td>Dedicated path</td>
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<td>Information flow</td>
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<td>Dynamic</td>
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<td>Addressing</td>
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<td>Yes (destination)</td>
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<td>Out of sequence arrival</td>
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<td>Yes</td>
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<tr>
<td>Routing</td>
<td>Not required</td>
<td>Required</td>
</tr>
<tr>
<td>Delay</td>
<td>Call set up</td>
<td>Packet transmission</td>
</tr>
</tbody>
</table>
Timing Sequence for Service Primitives

Connection-Oriented Service

Connectionless-Oriented Service

Request

WANs

Response