

## Networks

- A *network* is a communication system that provides correct, efficient, and robust data exchange between 2 or more hosts
- *Local area network* (LAN) — connects nodes in a small geographic area (e.g., single building, single campus)
  - Must be fast with low error rate
  - Media — twisted-pair, coaxial cable, fiber optic cable
- *Wide area network* (WAN) — connects nodes in a wide geographic area (e.g., across the country)
  - May be slower with higher error rate
  - Media — leased telephone lines (T1 & T3 service), microwave links, satellite channels

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## Network Topologies (cont.)

- Point-to-point — links to specific nodes
  - Fully connected — each node connects to all other nodes
    - ✓ Each message is fast; it takes only a single “hop” to reach its destination
    - ✓ Failure of any one node does not affect communication except to it
    - ✗ Expensive!
  - Partially connected — each node connects to some, but not all, nodes
    - ✓ Less expensive
    - ✗ A message may have to go through several other nodes
    - ✗ Less tolerant to failure
  - Tree — network hierarchy
    - ✓ Messages between direct descendants are fast
    - ✗ Messages between “cousins” must go up to a common ancestor and back down
    - ✗ Not tolerant of failures

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## Network Topologies (cont.)

- Star — all nodes connect to a single centralized node
  - Central node is generally dedicated to network traffic
  - ✓ Inexpensive
  - ✓ Each message takes only two hops
  - ✗ Failure of central node disconnects entire network
- Ring — all nodes connect in a circle
  - One directional ring — each node can send in only one direction
    - ✓ Inexpensive
    - ✗ Message may need to take  $n$  hops
    - ✗ Not tolerant of failures
  - Bi-directional ring — each node can send in either direction
    - ✓ Inexpensive
    - ✓ Tolerates a single failure
    - Message may need at most  $n/2$  hops

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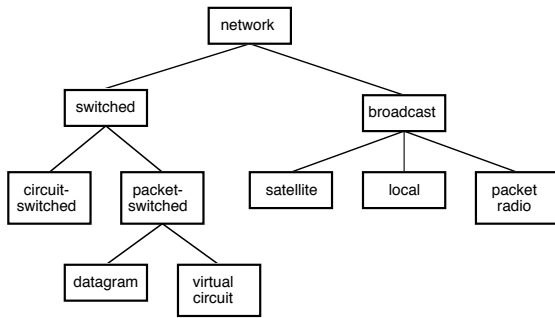
## Network Topologies (cont.)

- Ring — all nodes connect in a circle
  - Doubly linked ring — each node connects to 1-node and 2-node-away neighbors
    - ✓ Message may need at most  $n/4$  hops
    - ✓ Tolerates multiple failures
    - ✗ Expensive
- Bus — all nodes connect to common network
  - Nodes connect directly to each other over a shared common bus using multiaccess bus technology
  - ✓ Inexpensive, linear in number of nodes
  - ✓ Tolerant of node failures
  - ✗ Only one node can send data at a time

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## Network Communication



- **Connection-oriented communication**
  - Information delivered as a *stream* of bytes, in correct order
  - Connect, exchange data, release
- **Connectionless communication**
  - Information delivered as a set of *packets*
  - Packets may be delivered out of sequence, must be reassembled

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## Switching Technologies

- In a *broadcast* (or *multiaccess*) network, all hosts directly connect to a single shared communication medium
  - Each host check the destination address on every message to decide whether or not to read that message
- In a *switched* network, there is a partially-connected topology, and there may be multiple paths between two hosts
  - Messages may have to pass through intermediate nodes to reach destination
- **Circuit switching** — a dedicated communication path is reserved, and then used to send the entire message
  - Connection occupies a fixed (not necessarily entire) capacity of each link for the entire lifetime of the connection
    - Connection-oriented communication

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## Switching Technologies(cont.)

- **Packet switching** — data is broken up into a sequence of fixed-size *packets*
  - Each packet is passed through the network from source to destination along some (possibly different) *route* (path)
  - At each node, the entire packet is received, stored briefly, and then forwarded to the next node
  - **Datagram package switching**
    - Packets are called *datagrams*
    - Each packet is routed independently
      - A sequence of packets can be received out of order
    - Connectionless communication
  - **Virtual circuit package (message) switching**
    - All packets from one packet stream are sent along the same path (= *virtual circuit*)
      - Guarantees packets are received in sequence
    - Connection-oriented communication

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## Routing

- **Routing** software decides *which* path to use to move a message from the destination to source
- Routing is usually *hop-by-hop*, meaning each host chooses the next host to send the message to
- **Static (fixed) routing** — routing tables are stored, and change very infrequently (e.g., after major the network changes)
  - ✓ Low setup cost, packets arrive in order
  - ✗ Can't react to changes in network load
- **Dynamic routing** — routing tables are updated frequently
  - ✓ Can react to changes in network load
  - ✗ Higher setup cost for each packet
  - ✗ Packets can arrive out of order

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