Introduction to Data Communication and Networking

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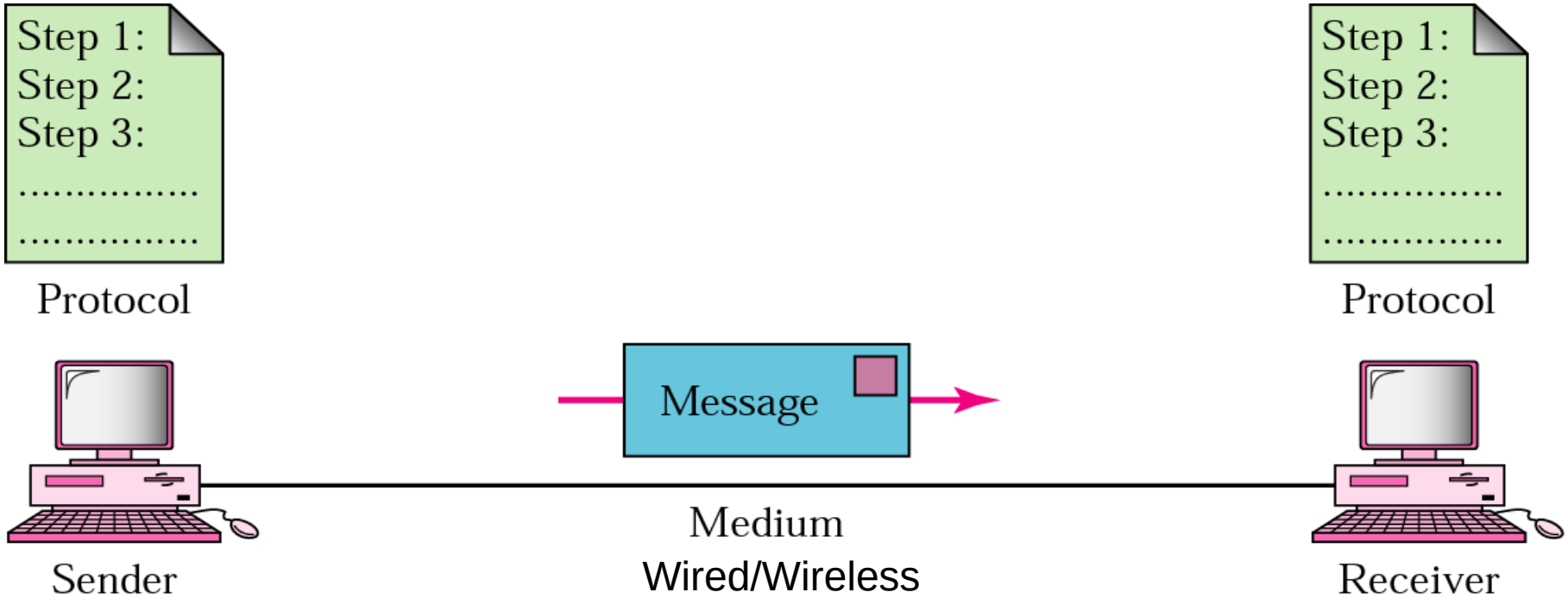
Reading Material for this discussion

- DATA COMMUNICATIONS AND NETWORKING, Fourth Edition by Behrouz A. Forouzan, Tata McGraw-Hill
  - Chapter 1

Data Communication

- Exchange of data between two devices via some form of transmission medium
- Medium can be wired/wireless
- Communicating devices made up of a combination of
  - hardware (physical equipment)
  - software (programs)

Five components of data communication



Can be any electronic device

Can be any electronic device

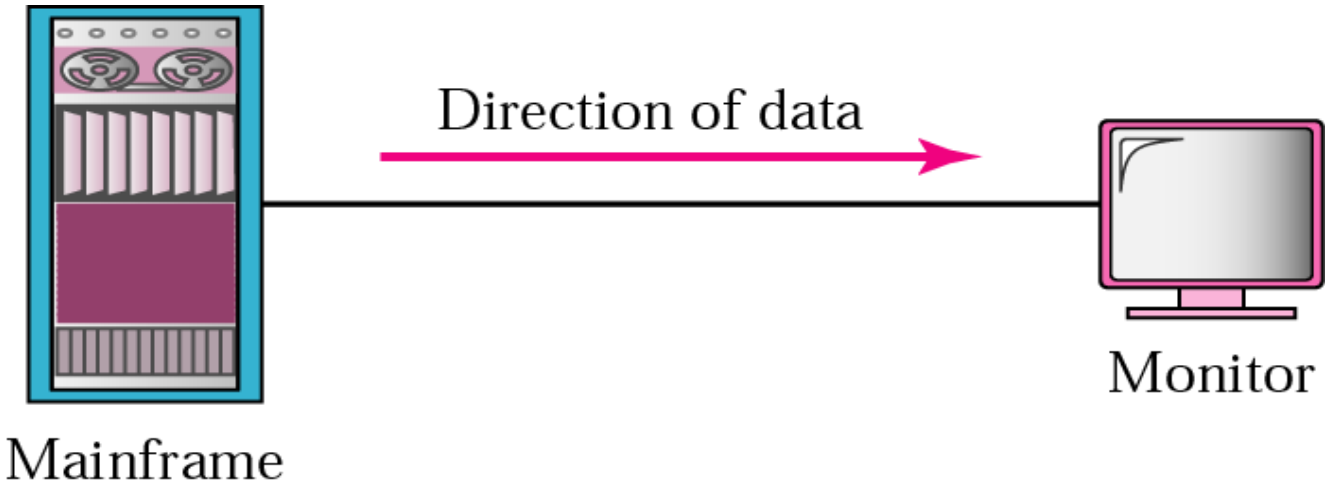
Components of Data Communication

1. Message. The message is the information (data) to be communicated. Popular forms of information include text, numbers, pictures, audio, and video.
2. Sender. The sender is the device that sends the data message. It can be a computer, workstation, telephone handset, video camera, and so on.
3. Receiver. The receiver is the device that receives the message. It can be a computer, workstation, telephone handset, television, and so on.
4. Transmission medium. The transmission medium is the physical path by which a message travels from sender to receiver. Some examples of transmission media include twisted-pair wire, coaxial cable, fiber-optic cable, and radio waves.
5. Protocol. A protocol is a set of rules that govern data communications. It represents an agreement between the communicating devices. Without a protocol, two devices may be connected but not communicating, just as a person speaking French cannot be understood by a person who speaks only Japanese.

Data Flow

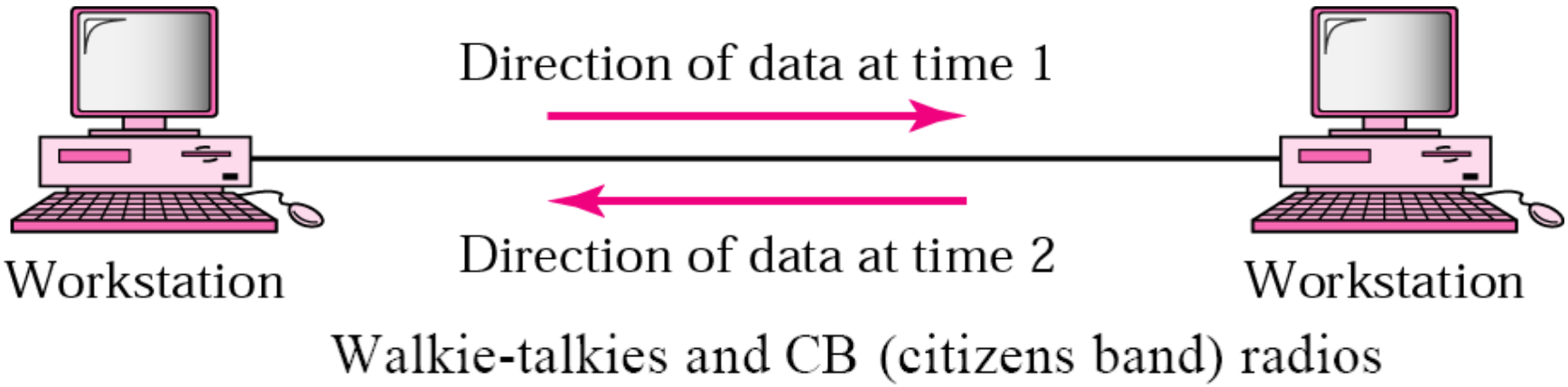
Communication between two devices can be simplex, half-duplex, or full-duplex

Simplex



Keyboards and traditional monitors are examples of simplex devices. The keyboard can only introduce input; the monitor can only accept output. The simplex mode can use the entire capacity of the channel to send data in one direction.

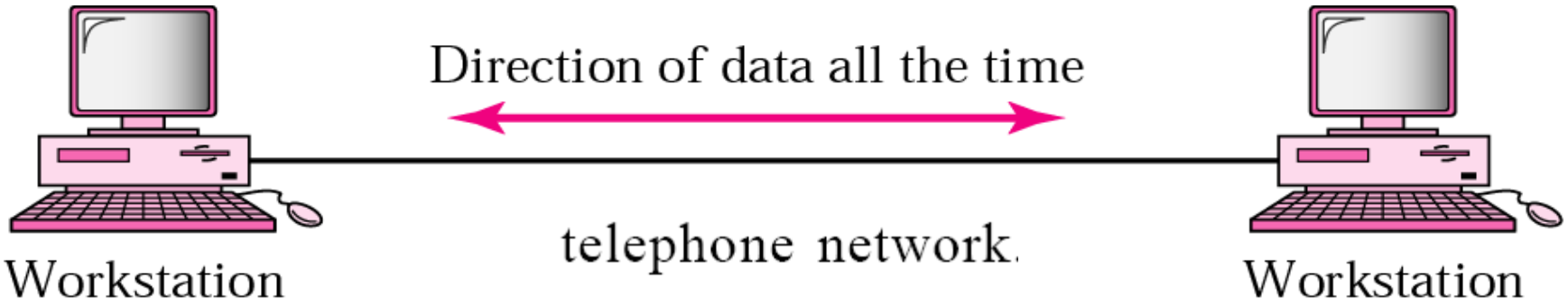
Half-duplex



Walkie-talkies and CB (citizens band) radios

- Entire capacity of a channel is taken over by whichever of the two devices is transmitting at the time.
- Used in cases where there is no need for communication in both directions at the same time
- Entire capacity of channel can be utilized for each direction.

Full-duplex

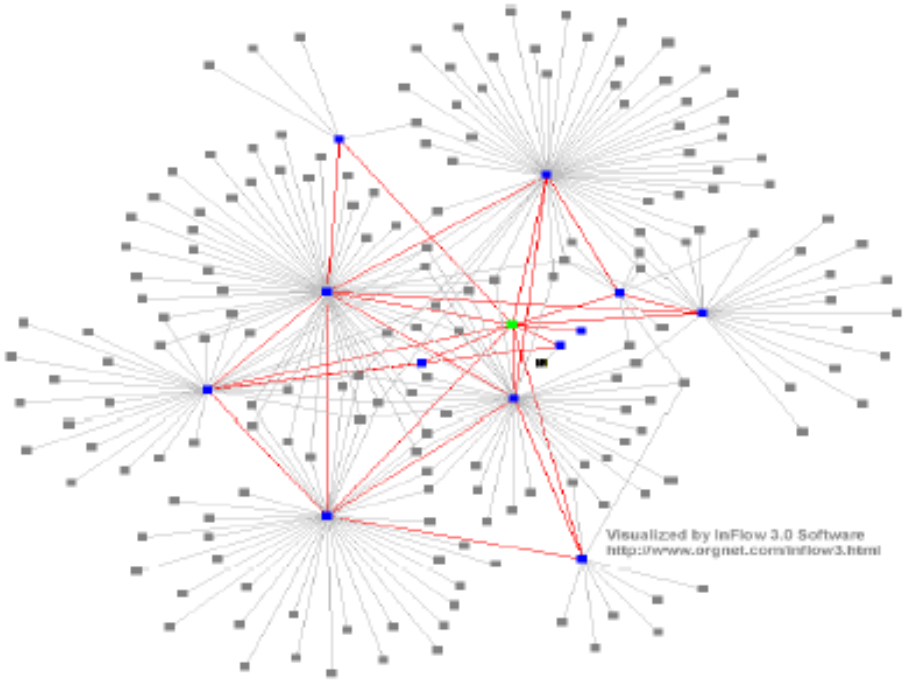


In full-duplex mode, signals travelling in one direction share the capacity of the link with signals travelling in the other direction.

This sharing can occur in two ways:
Either the link must contain two physically separate transmission paths,
or the capacity of the channel is divided between signals traveling in both directions.

Network

- A set of devices (often referred to as *nodes)* connected by communication links.
- A node can be a computer, printer, or any electronic device capable of sending and/or receiving data generated by other nodes in the network



Network Type

- Computer networks are classified according to various parameters:

1) Type of connection

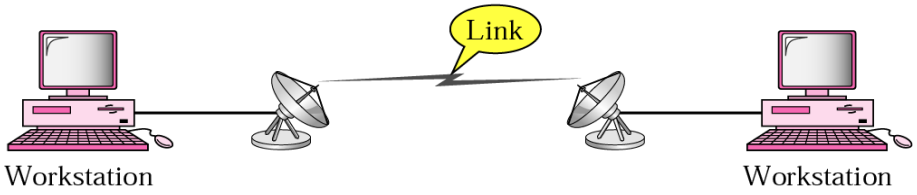
2) Physical topology

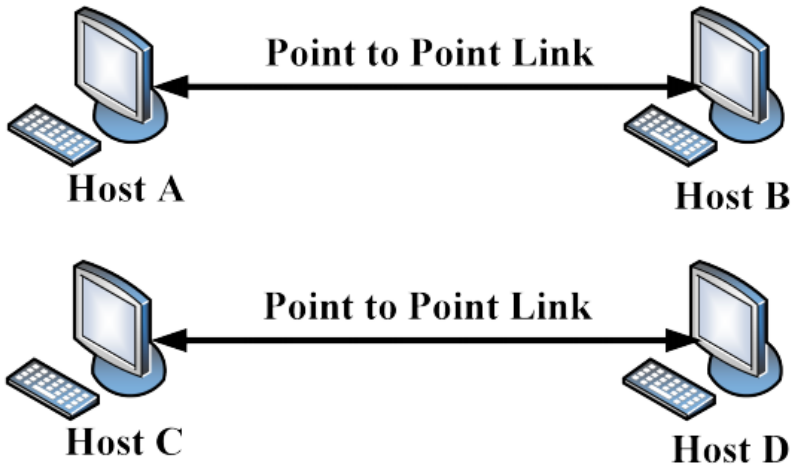
3) Network reachability

- These classifications are helpful in deciding the requirements of a network setup
- Provide insights into the appropriate selection of a network type for the setup

Types of Connections

- A link is a communications pathway that transfers data from one device to another.
- Point-to-point connection: A dedicated communications pathway that transfers data from one device to another





Point-to-Point Connection

- A point-to-point connection provides a dedicated link between two devices.
- The entire capacity of the link is reserved for transmission between those two devices.
- Point-to-point connections use wire/wireless connections
- TV, Light, Fan and remote
- PC to PC data transfer through Ethernet Network

Point-to-Point Connection

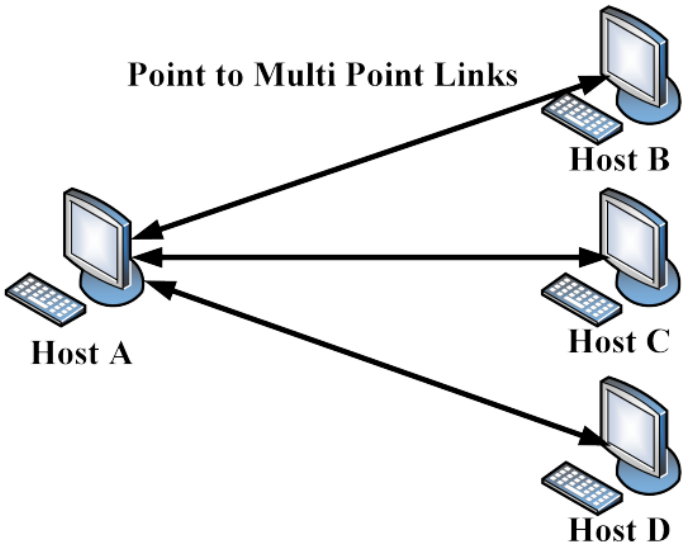
- These networks were designed to work over duplex links
- And are functional for both synchronous as well as asynchronous systems.
- usage for specific purposes in optical networks.

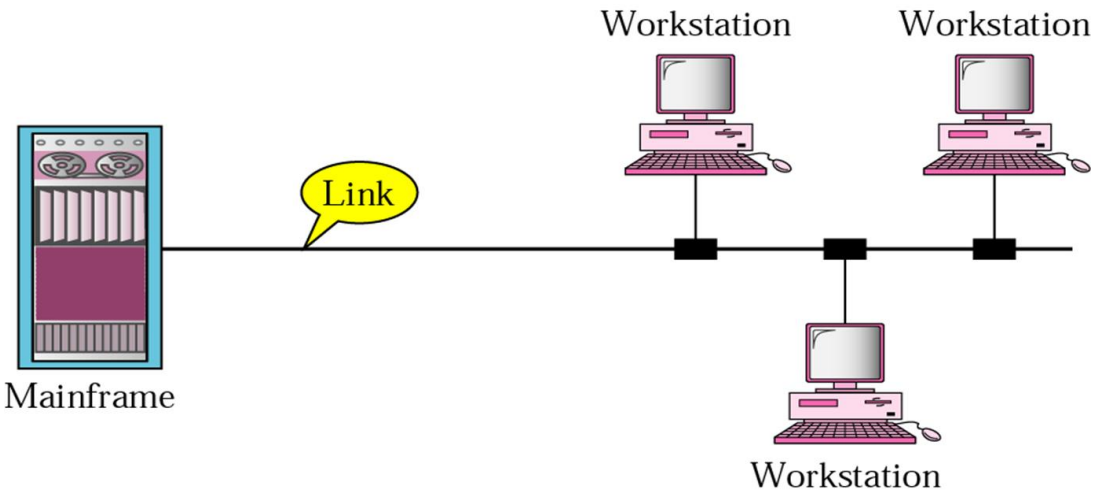
Point-to-point Requests for Comments (RFCs)

- (RFCs) associated with point- to-point communication and its derivatives – Recommendations from Internet Authorities
- **RFC 1332**: point-to-point (PPP) Internet protocol control protocol (IPCP);
- **RFC 1661**: PPP;
- **RFC 5072**: IP Version 6 over PPP;
- **RFC 2516**: PPP over Ethernet;
- **RFC 1963**: PPP serial data transport protocol;
- **RFC 1962**: PPP compression control protocol (CCP);
- **RFC 1990**: PPP multilink protocol (MP);
- **RFC 2615**: PPP over SONET/SDH (synchronous optical networking/synchronous digital hierarchy).

Point to Multipoint Connection

- More than two specific devices share a single link





Point to Multipoint Connection

- In a multipoint environment, capacity of channel is shared, either spatially (space) or temporally (time)
- If several devices can use the link simultaneously,

  it is a *spatially shared* connection (FDMA)
- If users must take turns, it is a *timeshared* connection (TDMA)

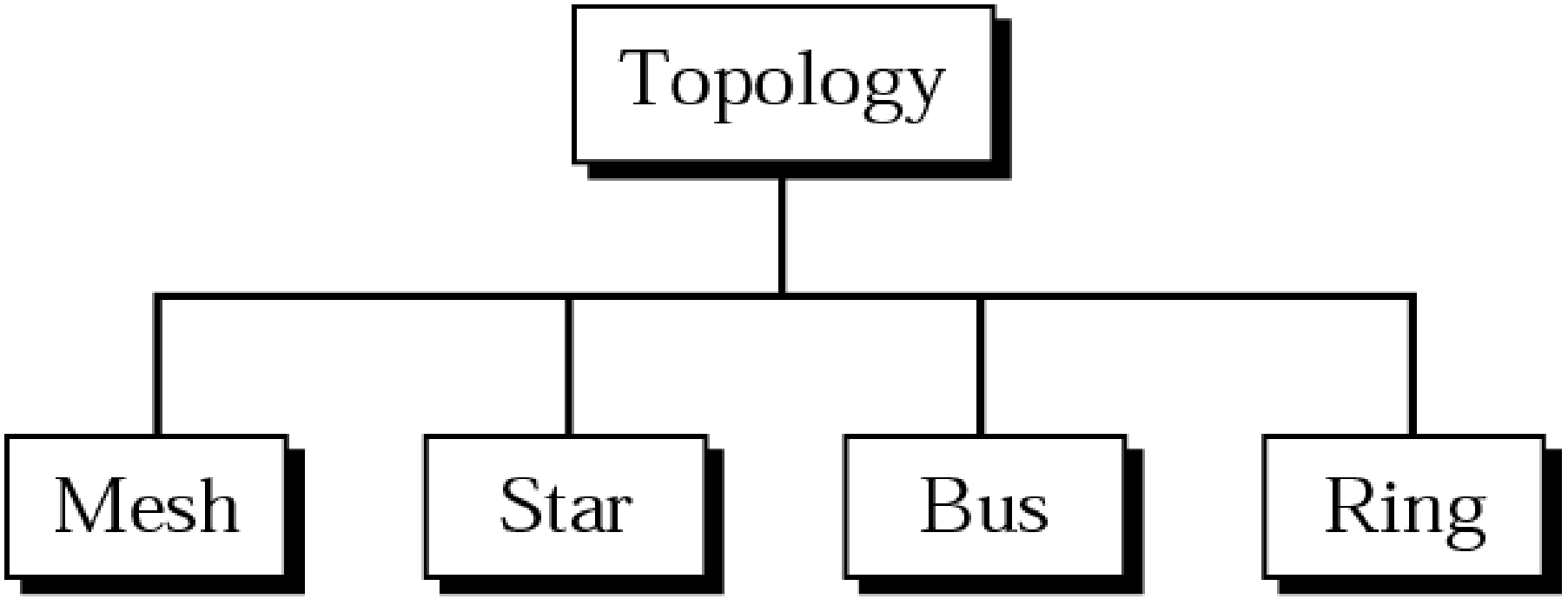
Point to Multipoint Connection

- Point-to multipoint connections find popular use in present-day networks.
- Especially while enabling communication between a massive number of connected devices.

Topology

- Topology refers to the way in which a network is laid out physically
- Two or more devices connect to a link; two or more links form a topology.
- Is geometric representation of relationship of all the links and linking devices (nodes) to one another.

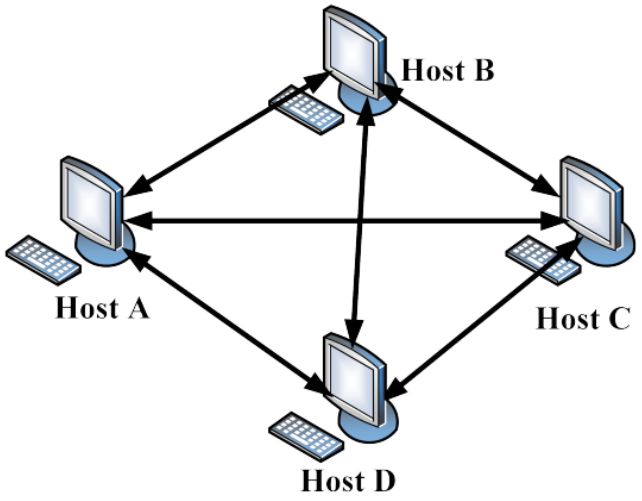
Topology and its Types



Mesh Topology

- Every device has a dedicated point-to-point link to every other device.
- *Dedicated* means link carries traffic only between the two devices it connects.

Can be any electronic device



Mesh Topology Connections

- Node 1 must be connected to *n* - I nodes, node 2 must be connected to *n* – 1 nodes, and finally node *n* must be connected to *n* - 1 nodes.
- We need *n(n* - 1) physical links.
- If each physical link allows communication in both directions (duplex mode), we can divide the number of links by 2.
- Thus in a mesh topology, we need

  n(n -1) /2 duplex-mode links.
- We need *n* – 1 input/output ports

Advantages of Mesh

- Dedicated links guarantees that each connection can carry its own data load, thus eliminating traffic problems
- Topology is robust. If one link becomes unusable, it does not the entire system.
- Advantage of privacy or security.
- Point-to-point links make fault identification and fault isolation easy
- Each node takes responsibility of its traffic
- Used in industrial environment and backbone networks
- Good option for Machine to Machine Communication

Disadvantages of Mesh

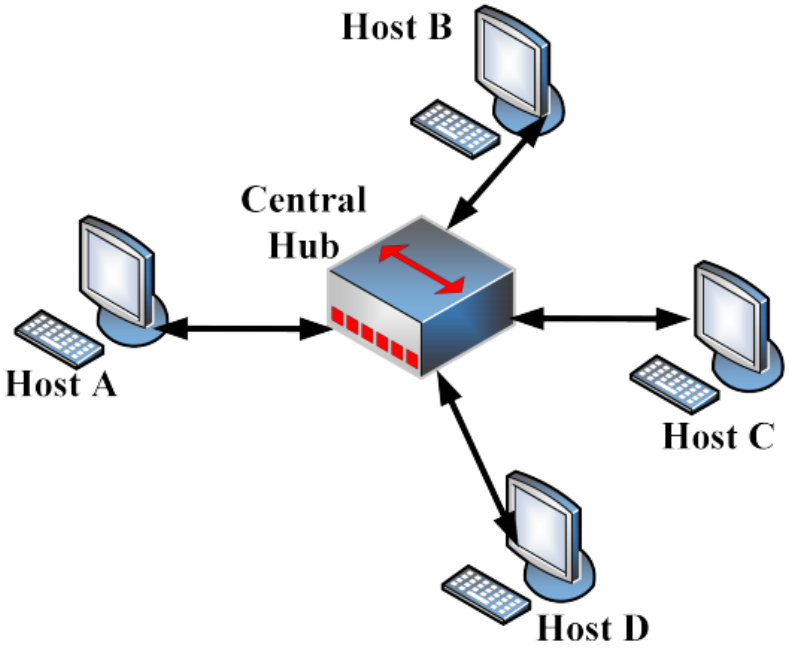
- amount of cabling and number of input/output ports required
- installation and reconnection are difficult
- Example: connection of robots in an industrial environment
- Zigbee/Bluetooth supports Mesh Topology

Applications of Mesh

- As a backbone connecting main computers of hybrid network that can include several other topologies
- eg connection of telephone regional offices

Star Topology

- Every host has a point-to-point link to a central controller or hub.
- Hosts cannot communicate with one another directly; can only do so through the central hub.
- The hub acts as the network traffic exchange.
- For large-scale systems, the hub, essentially, has to be a powerful server to handle all the simultaneous traffic flowing through it.



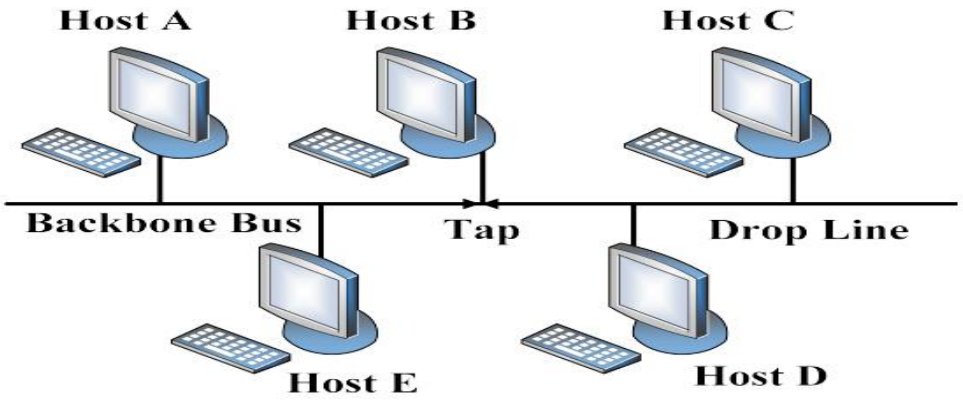
Advantages/Disadvantages of Star

- less expensive than a mesh topology
- only one link and one input/output port to connect it to any number of others
- easy to install and reconfigure and easy fault finding
- additions, moves, and deletions of nodes is easy
- dependency of whole topology on one single point, the hub
- used in local-area networks (LANs)

Applications of Star

- High-speed LANs often use a star topology with a central hub

Bus topology



- Follows point to Multipoint connection
- One long cable acts as a backbone to link all the devices in a network
- As a signal travels along the backbone, some of its energy is transformed into heat.
- It becomes weaker and weaker as it travels farther and farther.
- Hence bus supports a limited number of taps

Advantages of a bus topology

- Ease of installation
- Uses less cabling than mesh or star topologies
- Each drop line has to reach only as far as the nearest point on the backbone.

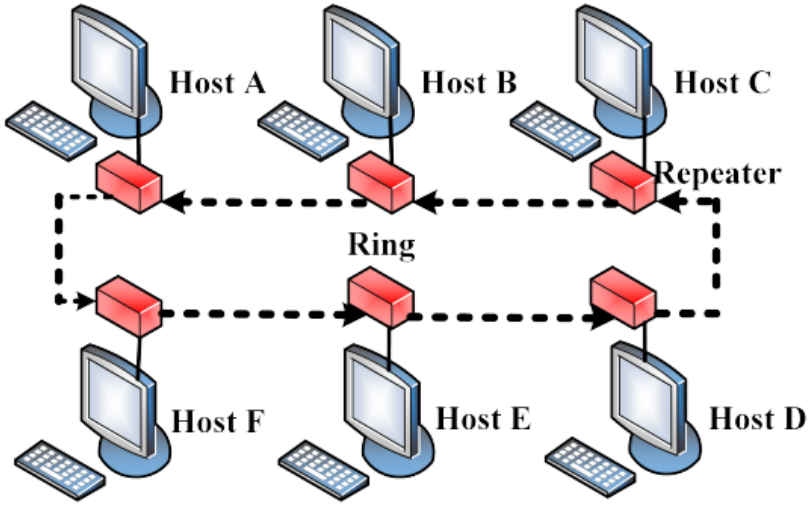
Disadvantages of bus topology

- Difficult reconnection and fault isolation.
- Designed to be optimally efficient at installation.
- Difficult to add new devices.
- Fault or break bus cable stops all transmission, even between devices on the same side of the problem.

Applications of Bus

- Ethernet LANs

Ring topology



- each device has a dedicated point-to-point connection with two devices on either side of it.
- A signal is passed along the ring in one direction, from device to device, until it reaches its destination.
- Each device in the ring incorporates a repeater.
- When a device receives a signal intended for another device, its repeater regenerates the bits and passes them along

Advantages of Ring

- Easy to install and reconfigure
- To add/delete device requires changing only two connections.
- Constraints are maximum ring length and number of devices
- Fault isolation is simplified.
  - A signal is circulating at all times.
  - If one device does not receive a signal within a specified period, it can issue an alarm.

Disadvantages of Ring

- A break in ring (such as a disabled station) can disable the entire network.
  - Can be solved by using a dual ring or a switch capable of closing off the break.

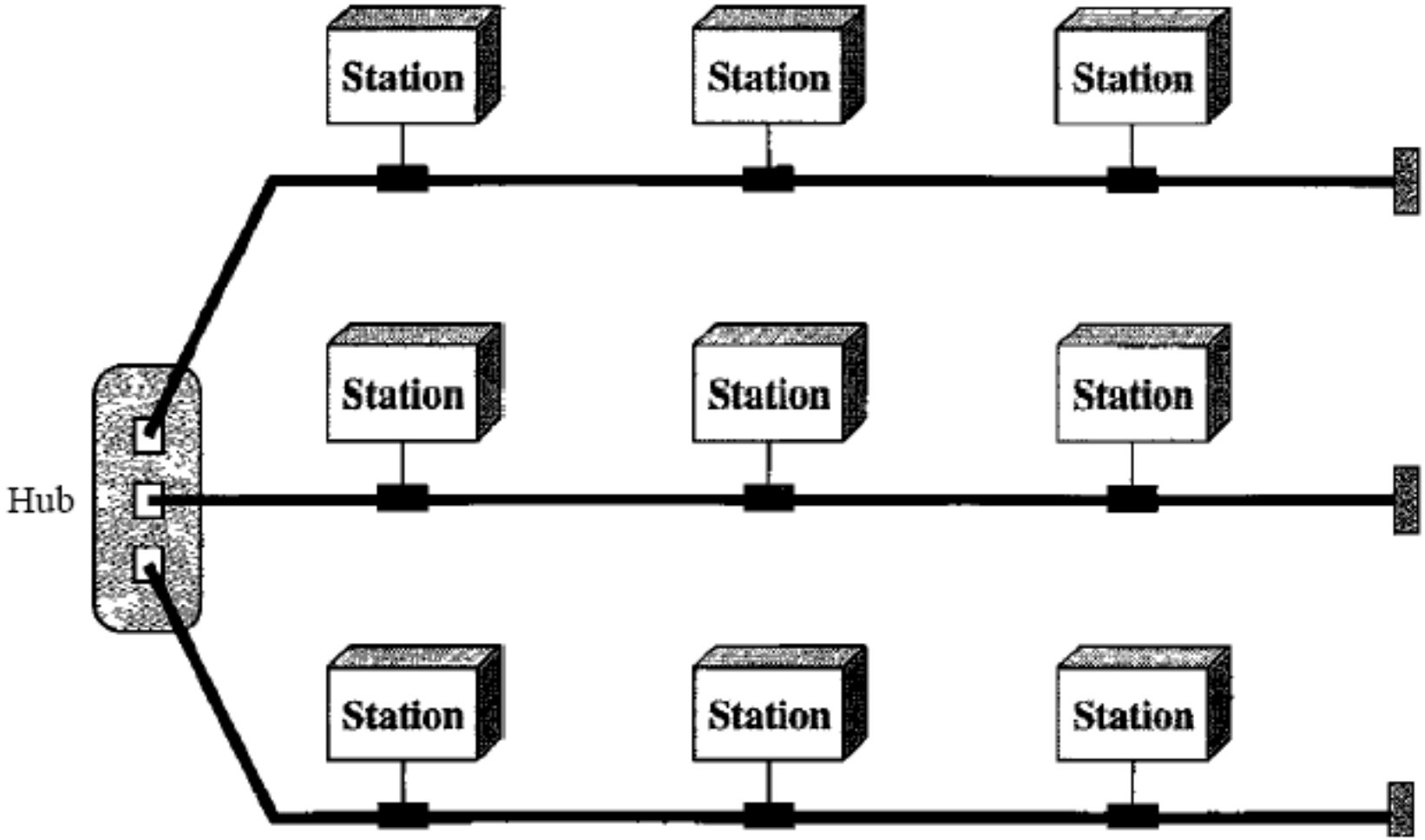
Application of Ring Topology

- Back bone network
- Token ring network

Hybrid Topology

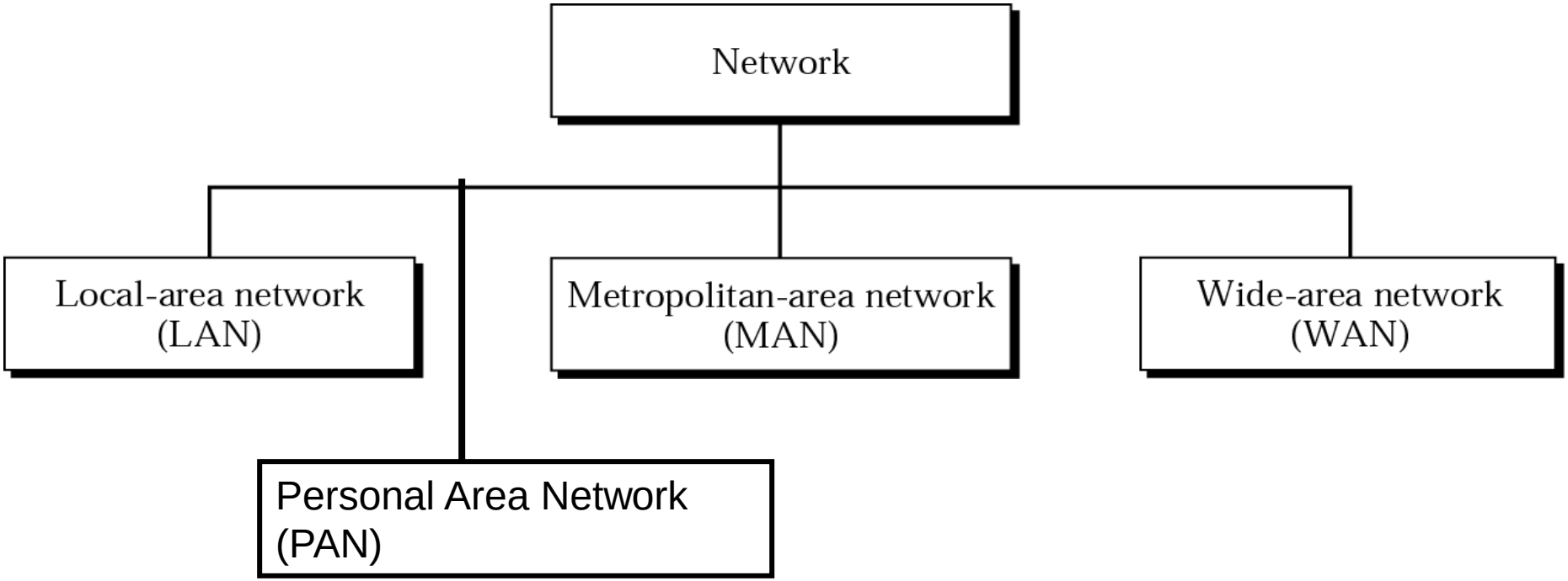
- A network can be hybrid.
- For example, we can have a main star topology with each branch connecting several stations in a bus topology

A *hybrid topology: a star backbone with three bus networks*



Topology	Feature	Advantage	Disadvantage
Star	Point-to-point	Cheap; ease of installation; ease of fault identification	Single point of failure; traffic visible to network entities
Mesh	Point-to-point	Resilient against single point of failures; scalable; traffic privacy and security ensured	Costly; complex connections
Bus	Point-to-multipoint	Ease of installation; cheap	Length of backbone cable limited; number of hosts limited; hard to localize faults
Ring	Point-to-point	Ease of installation; cheap; ease of fault identification	Prone to single point of failure

Network Reachability



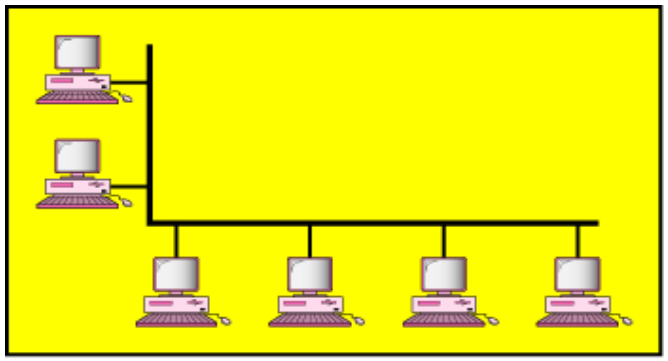
Personal Area Networks (PAN)

- mostly restricted to individual usage.
- example of PANs may be connected wireless headphones, wireless speakers, laptops, smartphones, wireless keyboards, wireless mouse, and printers within a house.
- PANs are wireless networks, which make use of low-range and low-power technologies such as Bluetooth, Zigbee
- Reachability is in the range of a few centimeters to a few meters.

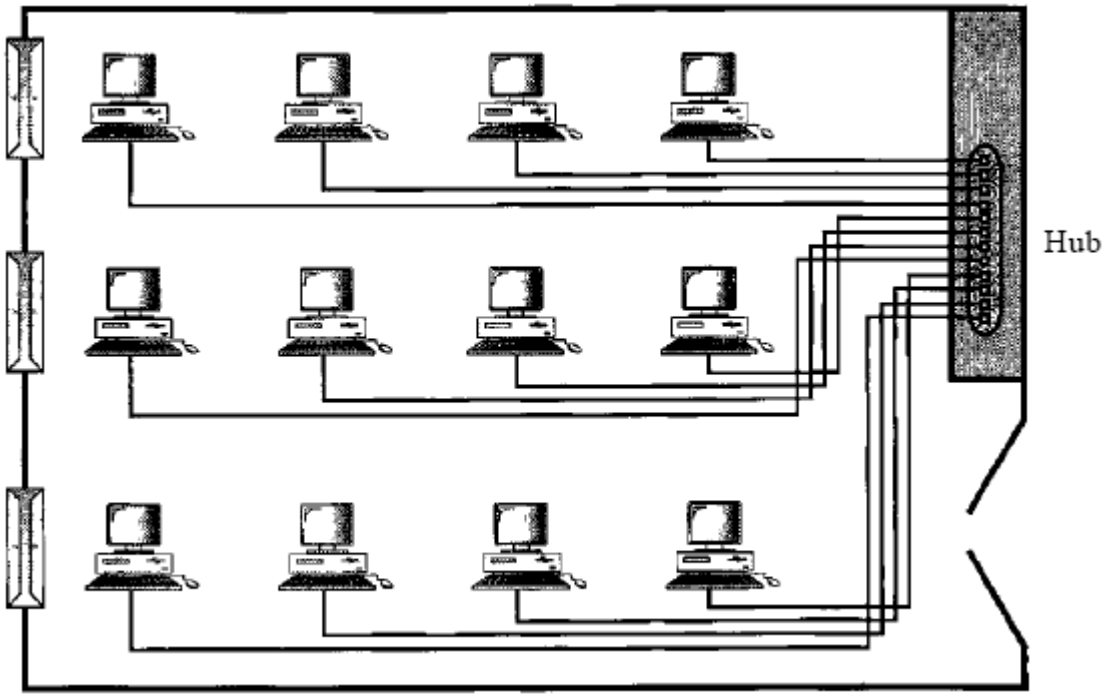
Local Area Network (LAN)

- usually privately owned and links the devices in a single office, building, or campus
- LAN can extend throughout a company and include audio and video peripherals
- LAN size is limited to a few kilometers.
- a few leased lines connected to the Internet provide web access to the whole organization or a campus;
- Leased lines are further redistributed to multiple hosts within the LAN enabling hosts.
- The hosts are much more in number than the actual direct lines to the Internet to access the web from within the organization

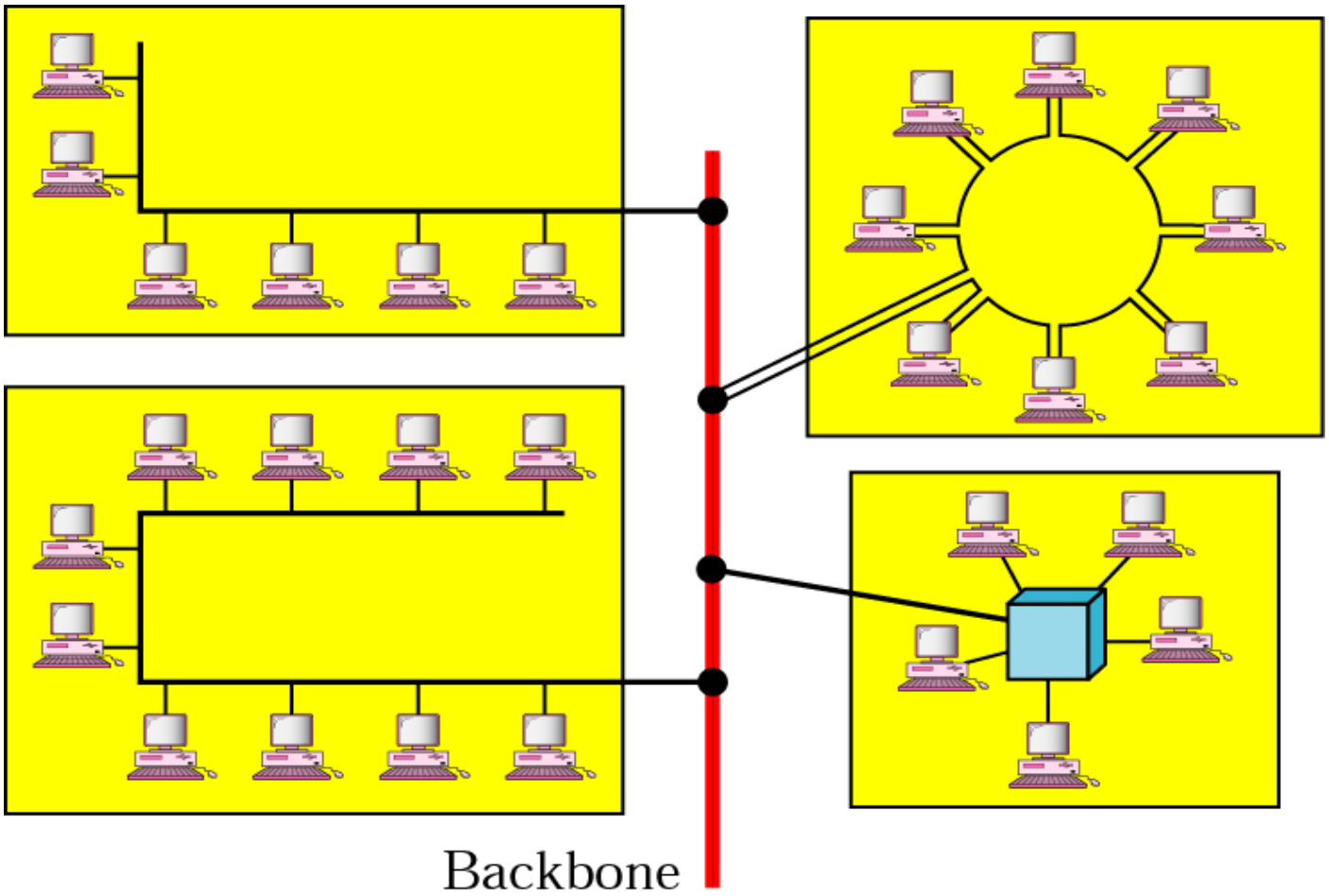
LAN



a. Single-building LAN



LAN (Continued)

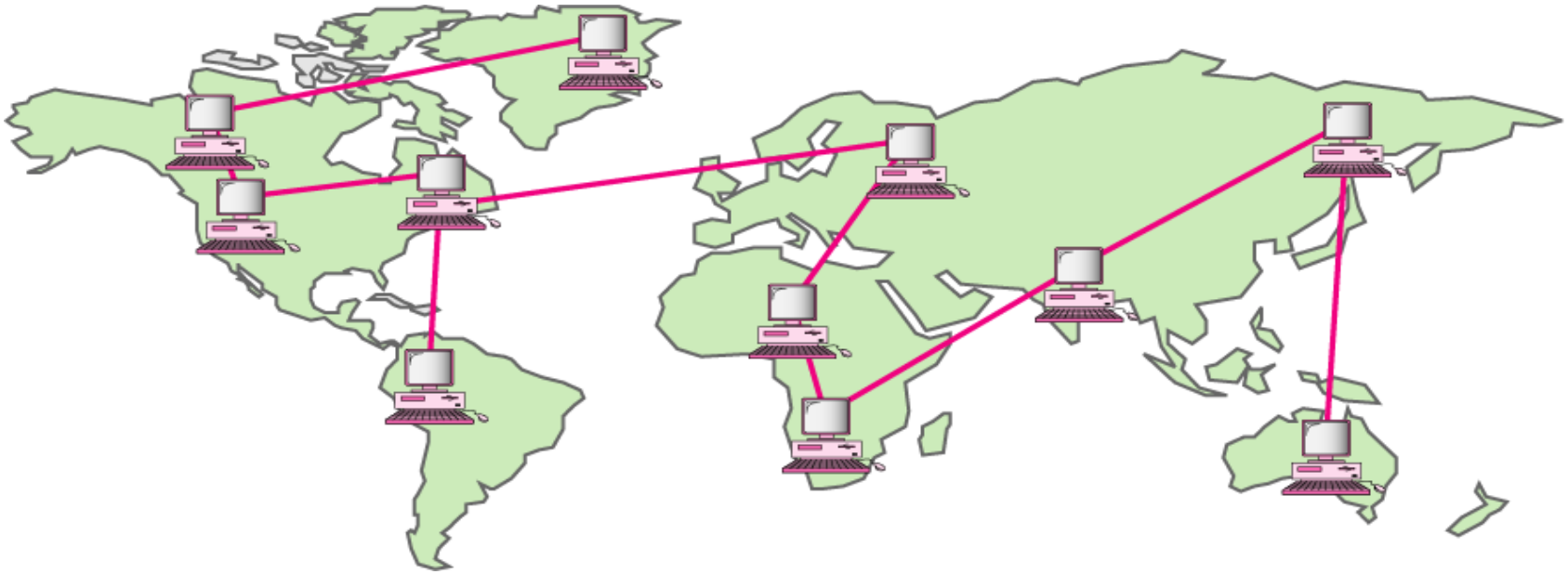


b. Multiple-building LAN

Wide Area Network (WAN)

- WANs typically connect diverse geographic locations.
- However, they are restricted within the boundaries of a state or country.
- The data rate of WANs is in the order of a fraction of LAN's data rate.
- WANs connecting two LANs or MANs may use public switched telephone networks (PSTNs) or satellite-based links.
- Due to long transmission ranges, WANs tend to have more errors and noise during transmission and are very costly to maintain.
- The fault tolerance of WANs are also generally low.

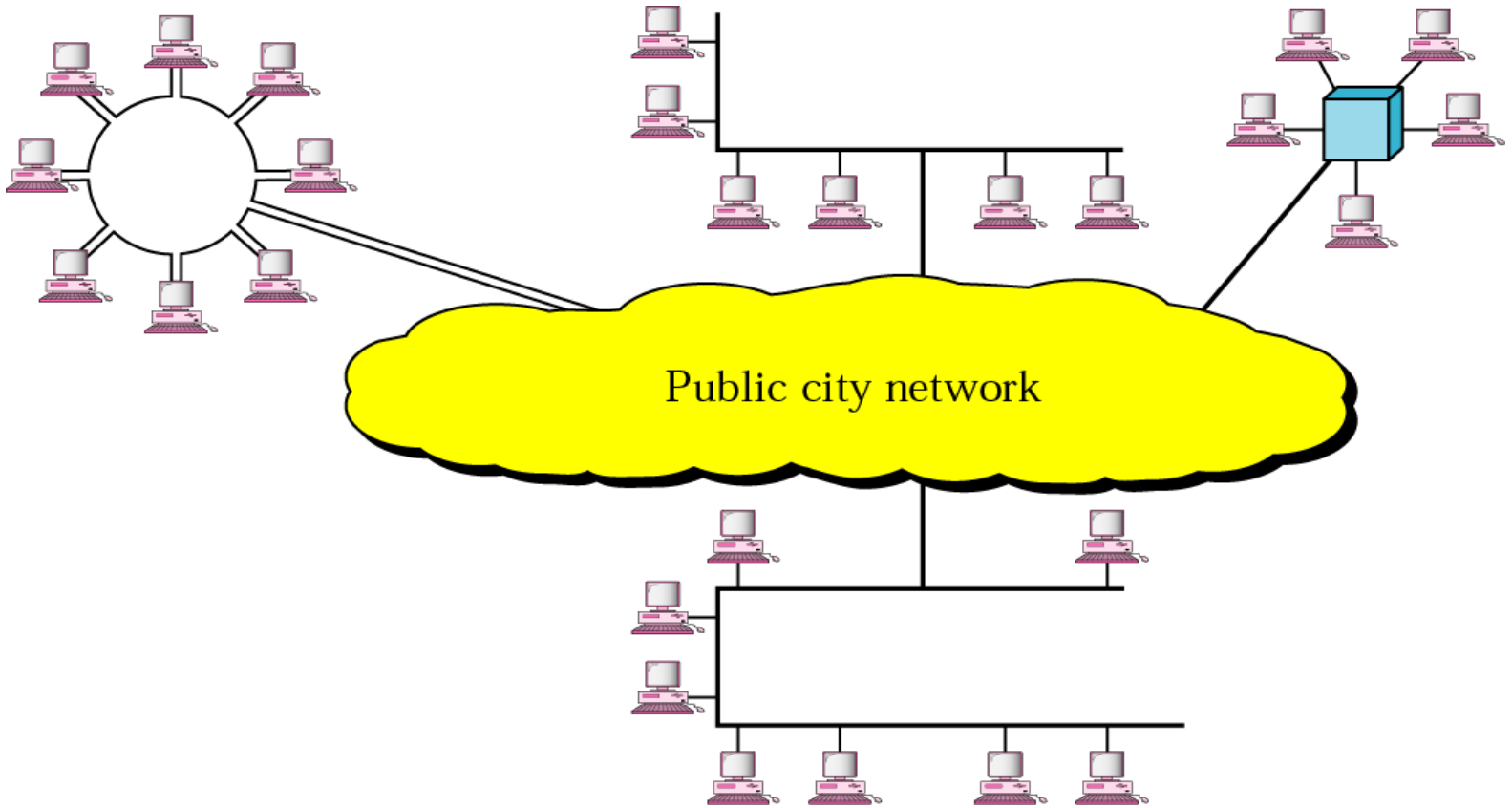
Figure 1.15 *WAN*



Metropolitan Area Networks (MAN)

- network with a size between a LAN and WAN.
- Covers area inside a town or a city
- for customers who need connectivity, to Internet, and have endpoints spread over a city or part of city.
  - example of a MAN is an Internet service provider (ISP)
  - Telephone company network that provides a high-speed DSL line to the customer
  - Cable TV network that originally was designed for cable TV, but today can also be used for high-speed data connection to the Internet.
- As MANs are costly, they may not be owned by individuals or even single organizations.

MAN



Interconnection of Networks: Internetwork

- LAN, a MAN, or a LAN in isolation are connected to one another.
- When two or more networks are connected, they become an internetwork, or internet

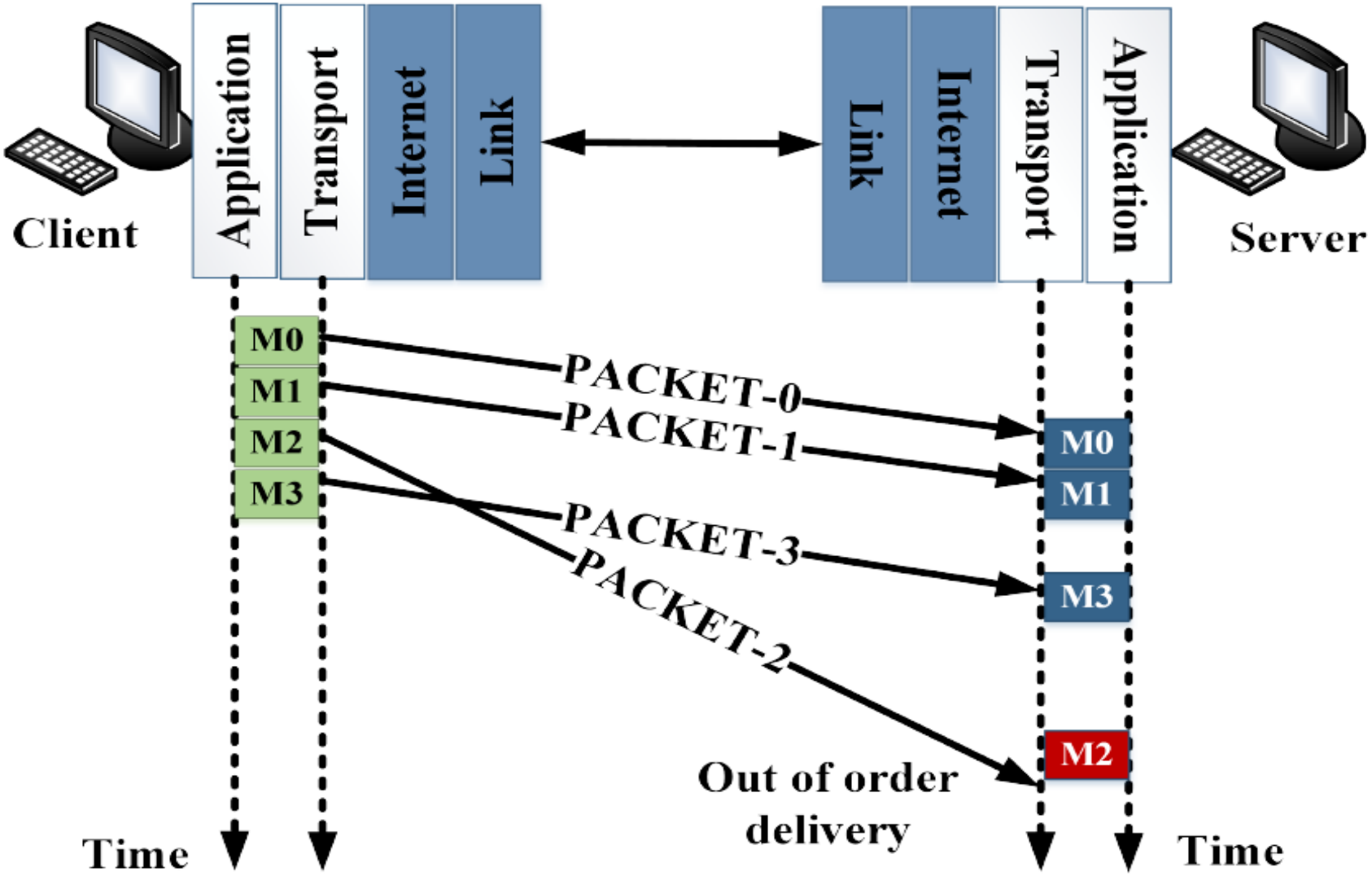
Connection Types

- (i) **Unicast/Point to Point**:
- For meant for one-to-one communication.
- Data flow from a transmitting host is restricted to only one receiving host in the link.
- (ii) **Multicast**:
- for one-to-many communication within a single link.
- Data flow from a transmitting host is intended for multiple hosts within the same link.
- More than one host can transmit data streams, which are designed for multiple receiving hosts in the link.
- (iii) **Broadcast**: This addressing is meant for one-to-all communication within a link.
- Data from a transmitting host is received by all other hosts connected to that link.

Connectionless Service

- A service for data transfer without connection establishment or termination.
- No dedicated connection is established between the client and the server processes
- No Acknowledgement
- If the packets at receiving end arrive out of order, they are submitted to receiving host’s application layer as it is, without any sequence maintenance
- Voice-over-IP (VoIP) is a popular usage of this service type.
- The most famous protocol associated with this service type is the user datagram protocol (UDP)

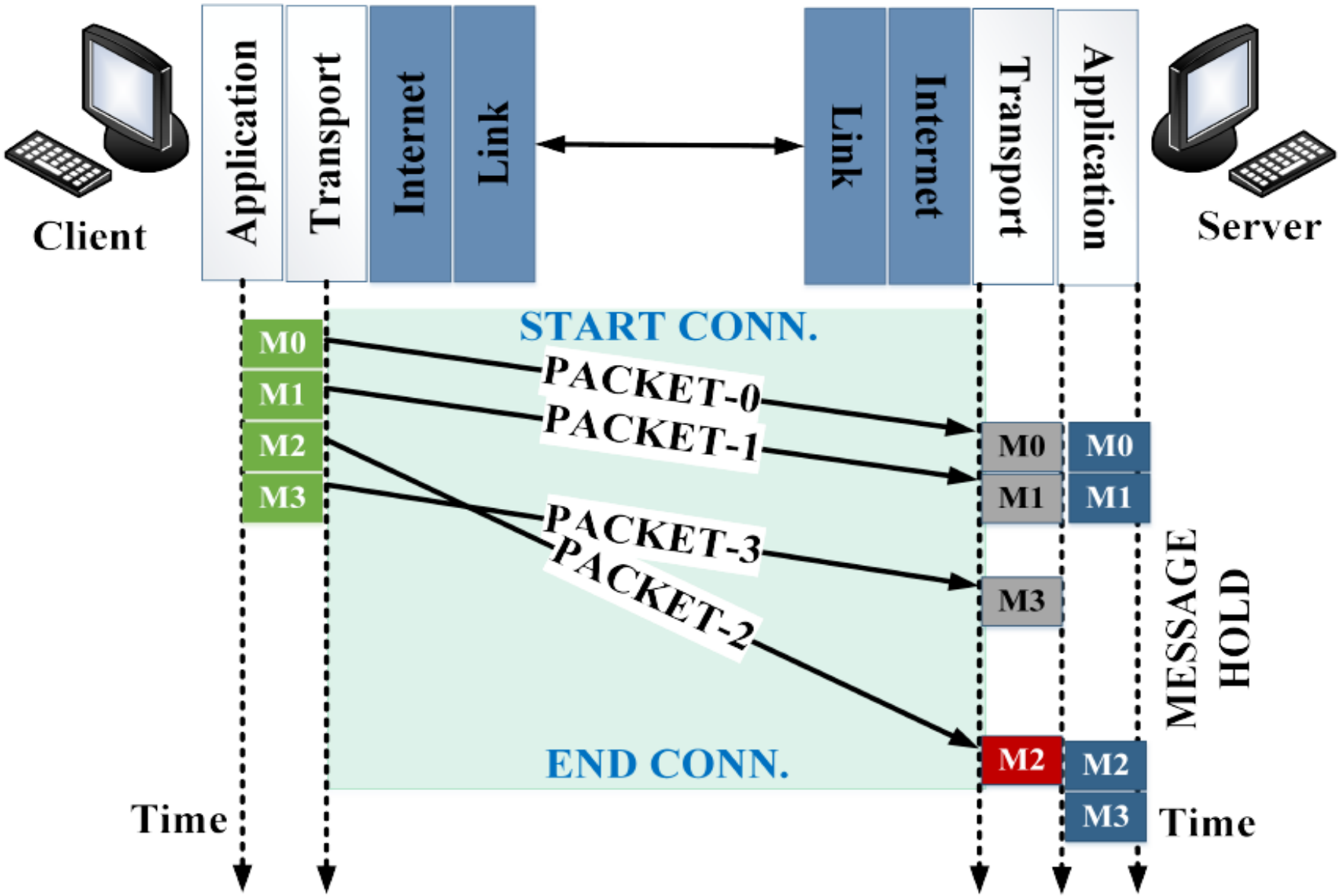
Connectionless service



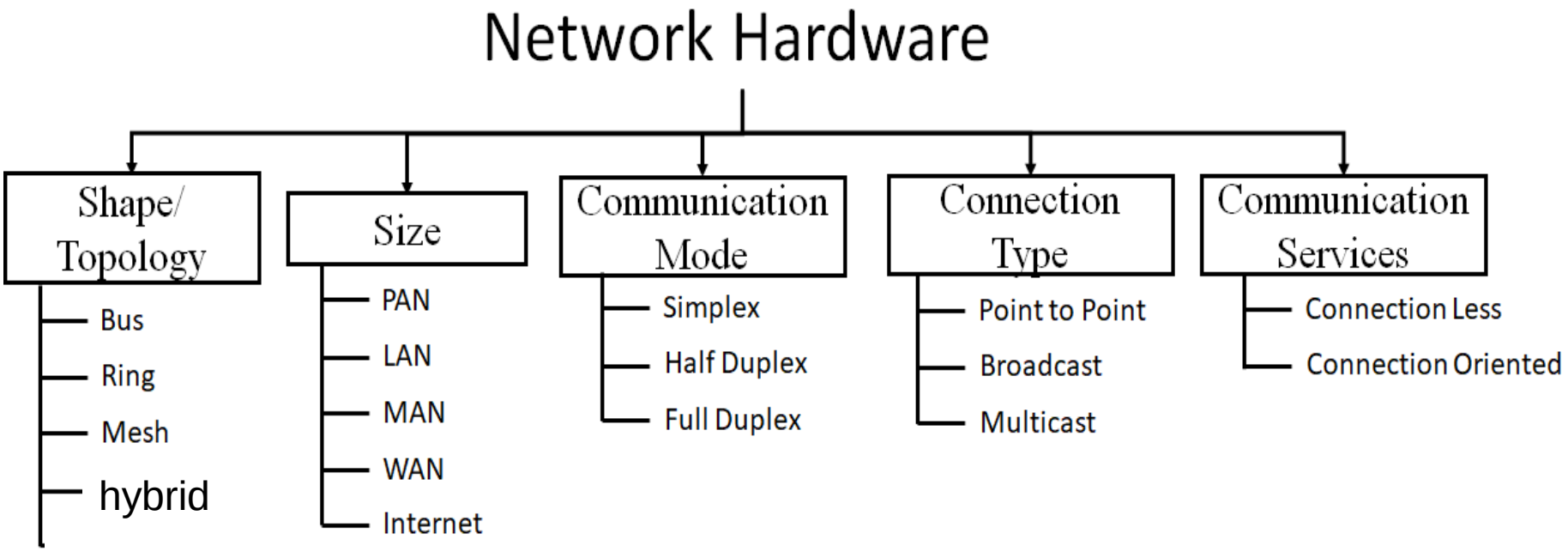
Connection oriented Service

- A service for data transfer with connection establishment, data transfer and connection termination phases
- Client and server establish a connection employing handshaking using SYN and ACK frames
- Once the data transmission is complete, the connection is terminated
- ACK for data transmitted
- Packets arriving at the client's transport layer from its application layer are delivered in the exact sequence as in the server's application layer
- This ensures the quality of service (QoS) for the connection.
- Service is slow in comparison to connectionless services
- Eg. Transmission control protocol (TCP) at Transport layer

Connection Oriented service



Summary


Network Hardware
Shape/ Topology
Bus
Ring
Mesh
hybrid
Size
PAN
LAN
MAN
WAN
Internet
Communication Mode
Simplex
Half Duplex
Full Duplex
Connection Type
Point to Point
Broadcast
Multicast
Communication Services
Connection Less
Connection Oriented

Thank You!