# Local Area Networks

## ITS323: Introduction to Data Communications

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# Contents

# WANs and LANs

## Wide Area Networks

- Connect devices/networks over large geographical area
- Between campuses, office buildings, cities, countries
- Owned and operated by organisations on behalf of users, e.g. TOT, CAT, TT&T
- Leased to users, e.g. unis, companies, smaller ISPs

## Local Area Networks

- Connect end-user devices over small area
- Within campuses, buildings, homes
- Owned and operated by organisation using the network
- Typically support higher data rates than WANs (internal communications, multiplexing)

# LAN Design Elements

- Topology: what is the arrangement of connections between nodes?
- Transmission medium: what medium is used for the links?
- Medium access control: how to control access for stations on a shared medium?

# LAN Topology

- Recall link configurations: point-to-point and multipoint
- LANs allow multiple users to communicate with each other
- Topology is arrangement of nodes and links

  **Mesh** every station has point-to-point link to every other station

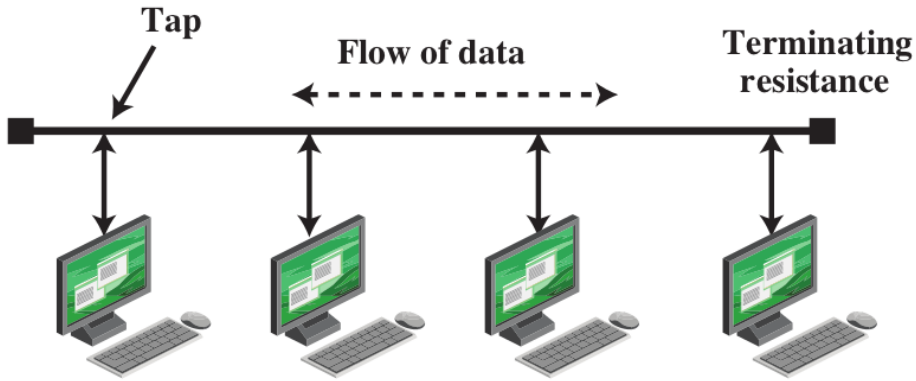
  **Bus** every station connected via a multipoint link

  **Ring** point-to-point links between pairs of stations to form ring

  **Star** every station has point-to-point link to central device

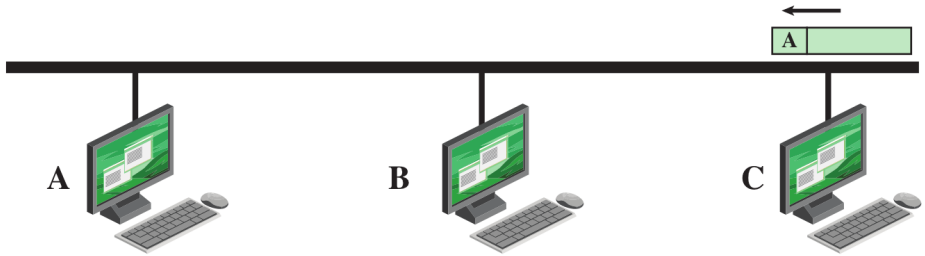
  **Hybrid** combination of 2 or more of above, e.g. tree is combination of star and bus topologies
- Mesh only suitable for very small LANs; requires many links. (Partial mesh used in some WANs)

# Bus Topology

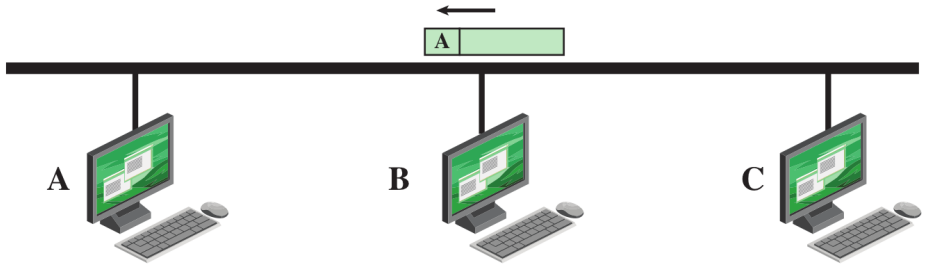



- Single multipoint link connects all stations (via tap)
- Transmission propagates throughout medium and is heard by all stations
- Terminator absorbs frames at end of medium/cable
- Frames need addresses
- Pros: easy installation
- Cons: require protocols to share medium; faulty link stops all communications; limited number of stations
- Usage: Early Ethernet networks, but replaced by star

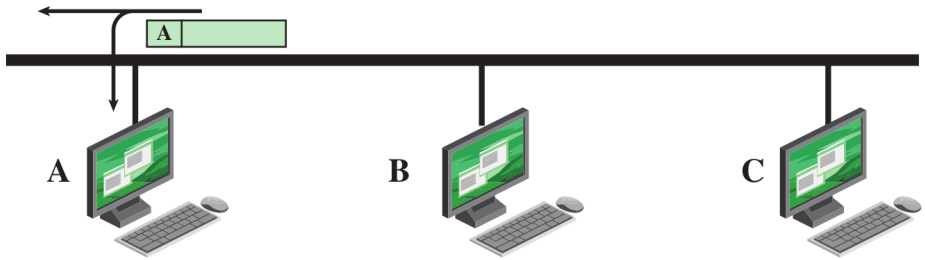
# Frame Transmission on a Bus LAN




C transmits frame addressed to A

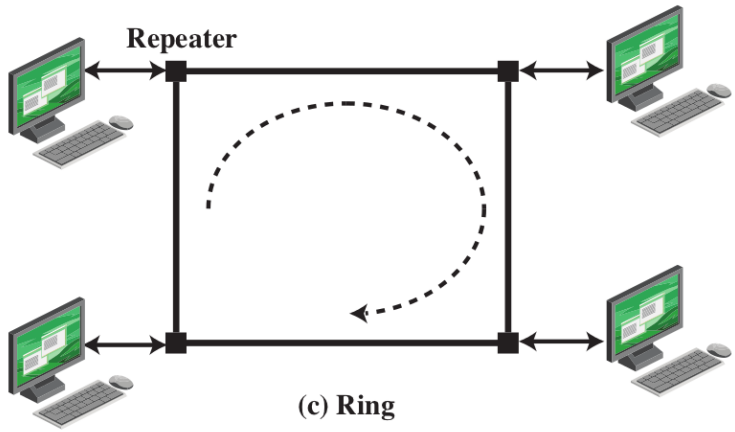



Frame is not addressed to B; B ignores it



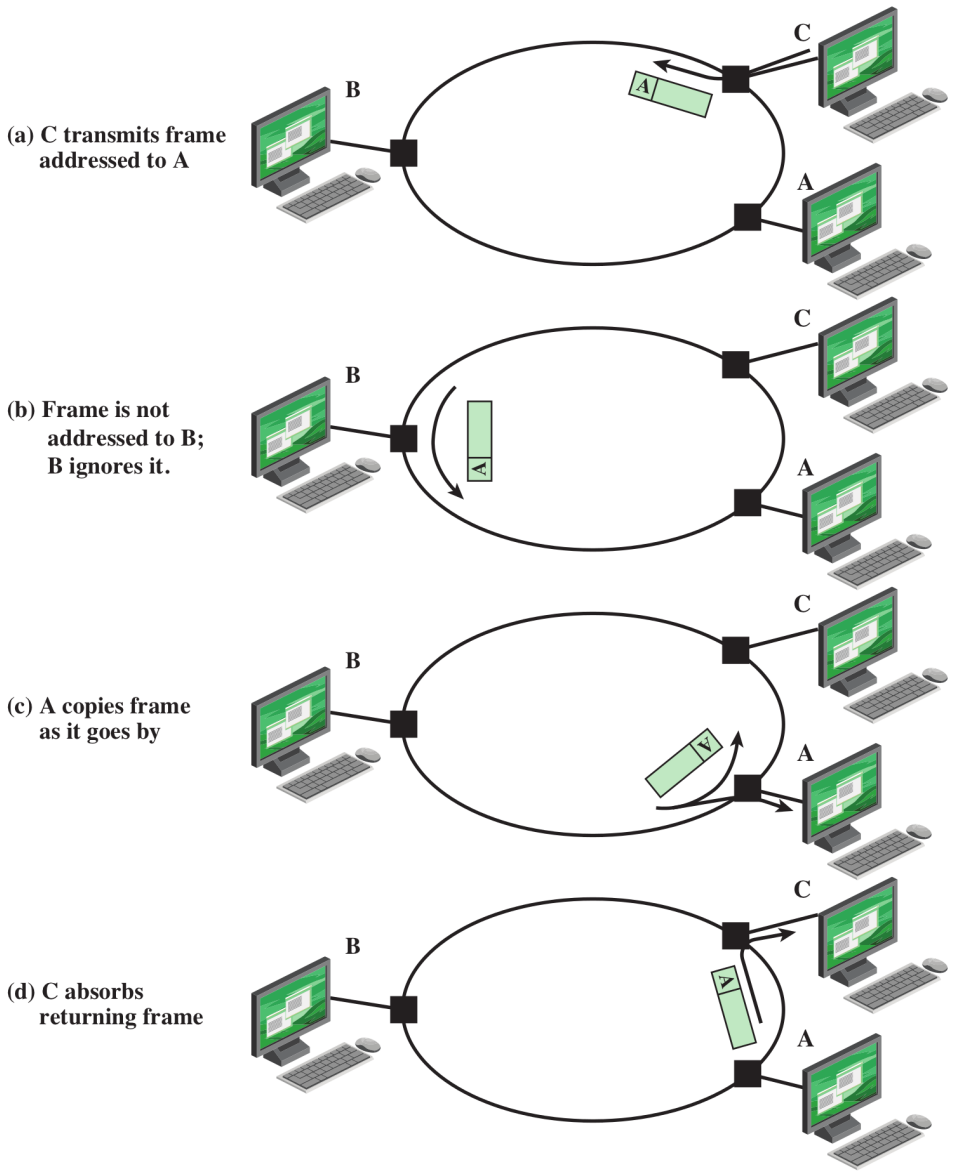

A copies frame as it goes by

# Ring Topology

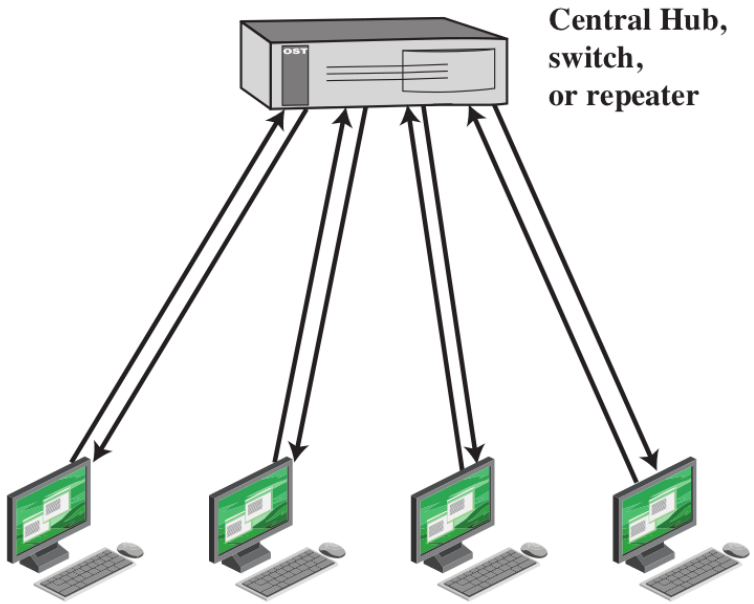



- Unidirectional point-to-point links to form loop
- Stations attach to repeaters
- Frames need addresses
- Pros: simple to install and reconfigure; easy to identify faults
- Cons: require protocols to share medium; traffic flows in one direction
- Usage: old LANs (e.g. IBM Token Ring); MANs and WANs

# Frame Transmission on a Ring LAN



# Star Topology




- Traffic between stations goes via the central node
- Usually two point-to-point links between station and central node (or duplex link)
- Frames needed addresses
- Pros: easy to install; fault tolerance for links
- Cons: depends on central node
- Usage: Most LANs today

# Transmission Medium

- Many factors impact on the most appropriate transmission medium for a LAN: reliability, expandability, performance, building layout, medium availability
- Common cases include:
  - Coaxial cable often used for bus topology
  - Optical fibre for ring topology; usually the highest speed networks
  - Twisted pair for star topologies; often well-suited for LANs in buildings (cheap, easy to install)

# Medium Access Control

- In a shared medium, if two (or more) stations transmit at the same time, there is a chance the two transmissions will interfere with each other
- Collision of frames: receiver receives two or more frames partially overlapping in time; assume all frames are corrupted/lost
- Medium Access Control: allow one station to use the shared medium at a time (avoiding collisions)
- MAC techniques must give stations opportunities to transmit: fair and efficient
- Techniques can be:
  - Centralised or distributed
  - Fixed or dynamic

# MAC Examples

- Round-Robin MAC
- Reservation-based MAC
- Random-access MAC

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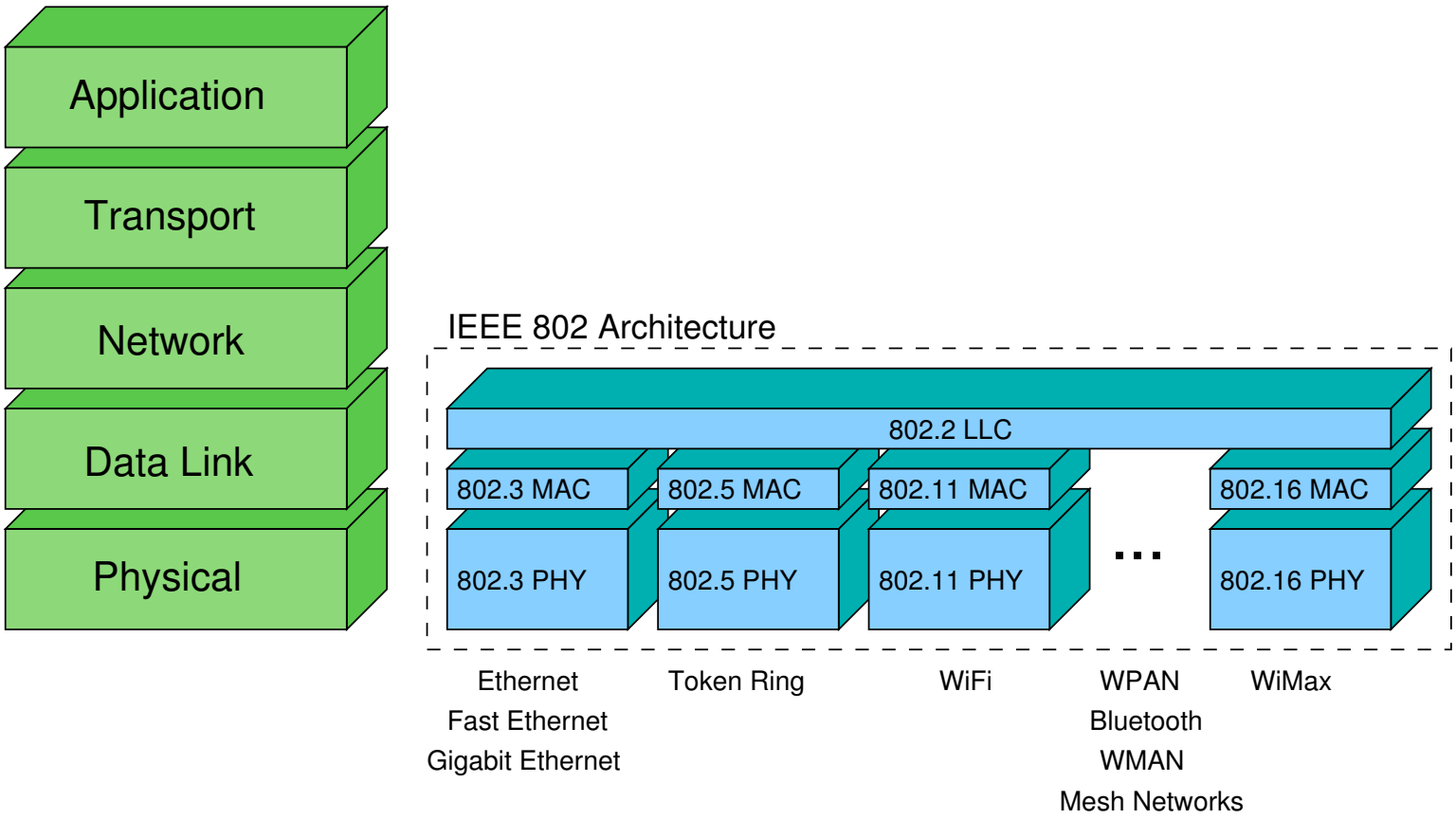
# IEEE 802 LAN Architecture

- IEEE 802 LAN/MAN standards committee has developed the majority of the LAN standards in use including:
  - Ethernet, Fast Ethernet, Gigabit Ethernet, Token Ring, Wireless LAN (WiFi), ...
- 802 series of standards follow common architecture
- Standardised only at Physical layer and Data Link layer
- Data Link layer divided into: Logical Link Control (LLC) and Medium Access Control (MAC)
- 802 can support many MAC/Physical protocols, and uses one common LLC protocol

# IEEE 802 LAN Architecture




LLC = Logical Link Control
MAC = Medium Access Control
PHY = Physical

# Characteristics of Some High-Speed LANs

| | Fast Ethernet | Gigabit Ethernet | Fibre Channel | Wireless LAN |
|---|---|---|---|---|
| **Data Rate** | 100 Mbps | 1 Gbps, 10 Gbps, 100 Gbps | 100 Mbps - 3.2 Gbps | 1 Mbps - 54 Mbps |
| **Transmission Media** | UTP, STP, optical fiber | UTP, shielded cable, optical fiber | Optical fiber, coaxial cable, STP | 2.4-GHz, 5-GHz microwave |
| **Access Method** | CSMA/CD | Switched | Switched | CSMA/Polling |
| **Supporting Standard** | IEEE 802.3 | IEEE 802.3 | Fibre Channel Association | IEEE 802.11 |

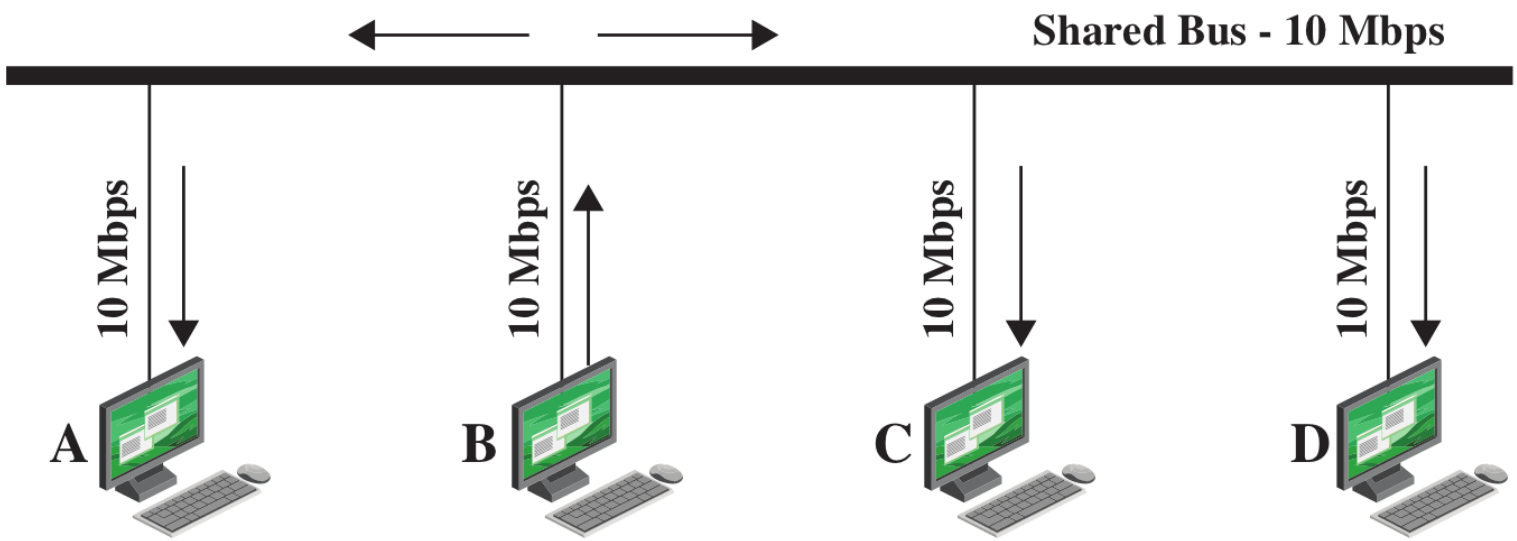
# IEEE 802.3: Ethernet

- IEEE 802.3 defines one of the most commonly used LAN standards in the world
- Ethernet developed in 1970's; standardised as IEEE 802.3
- Various improvements: Fast Ethernet, Gigabit Ethernet, 10Gb/s Ethernet
- Support various physical media: UTP, STP, coaxial cable, optical fibre
- Original popular Ethernet:
  - Bus topology
  - Coaxial cable
  - 10Mb/s
  - Contention-based Random-Access MAC (CSMA/CD)
  - Half-duplex
- Replaced by star topology with twisted pair

# IEEE 802.3 10-Mbps Physical Layer Medium Alternatives

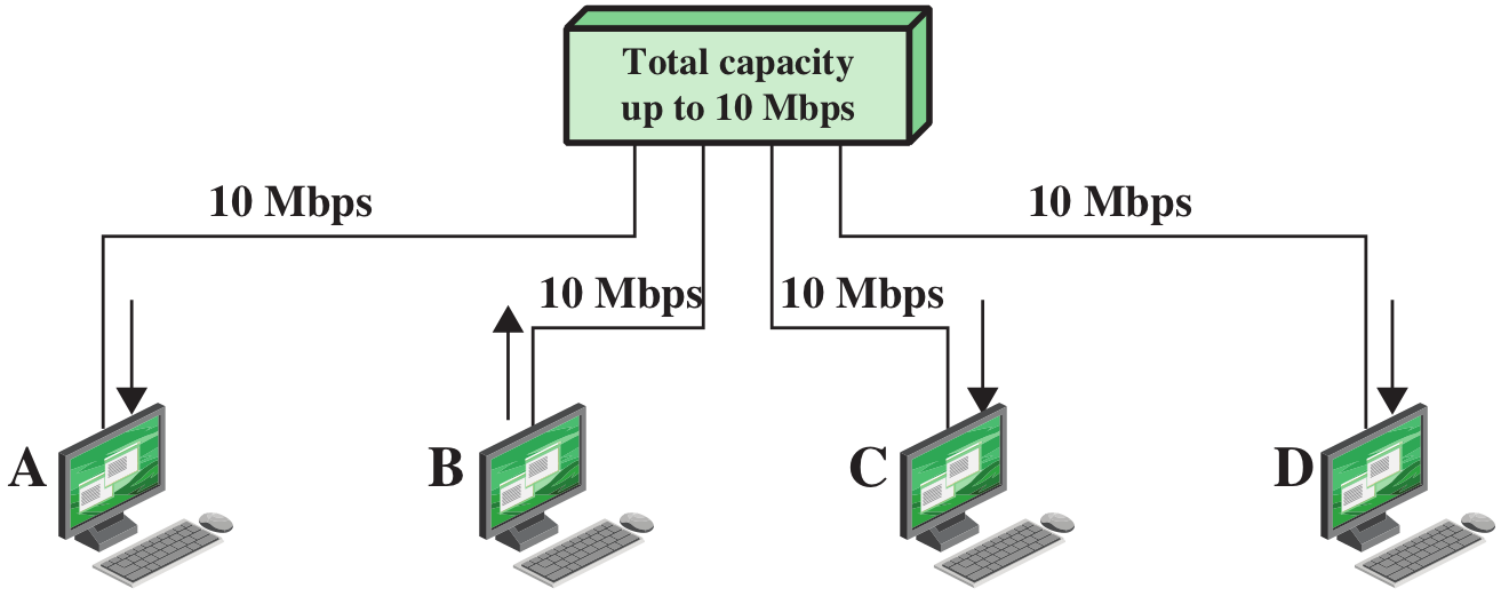
| | 10BASE5 | 10BASE2 | 10BASE-T | 10BASE-FP |
|---|---|---|---|---|
| **Transmission medium** | Coaxial cable (50 ohm) | Coaxial cable (50 ohm) | Unshielded twisted pair | 850-nm optical fiber pair |
| **Signaling technique** | Baseband (Manchester) | Baseband (Manchester) | Baseband (Manchester) | Manchester/on-off |
| **Topology** | Bus | Bus | Star | Star |
| **Maximum segment length (m)** | 500 | 185 | 100 | 500 |
| **Nodes per segment** | 100 | 30 | — | 33 |
| **Cable diameter (mm)** | 10 | 5 | 0.4 to 0.6 | 62.5/125 $\mu$m |

# Shared Medium Bus



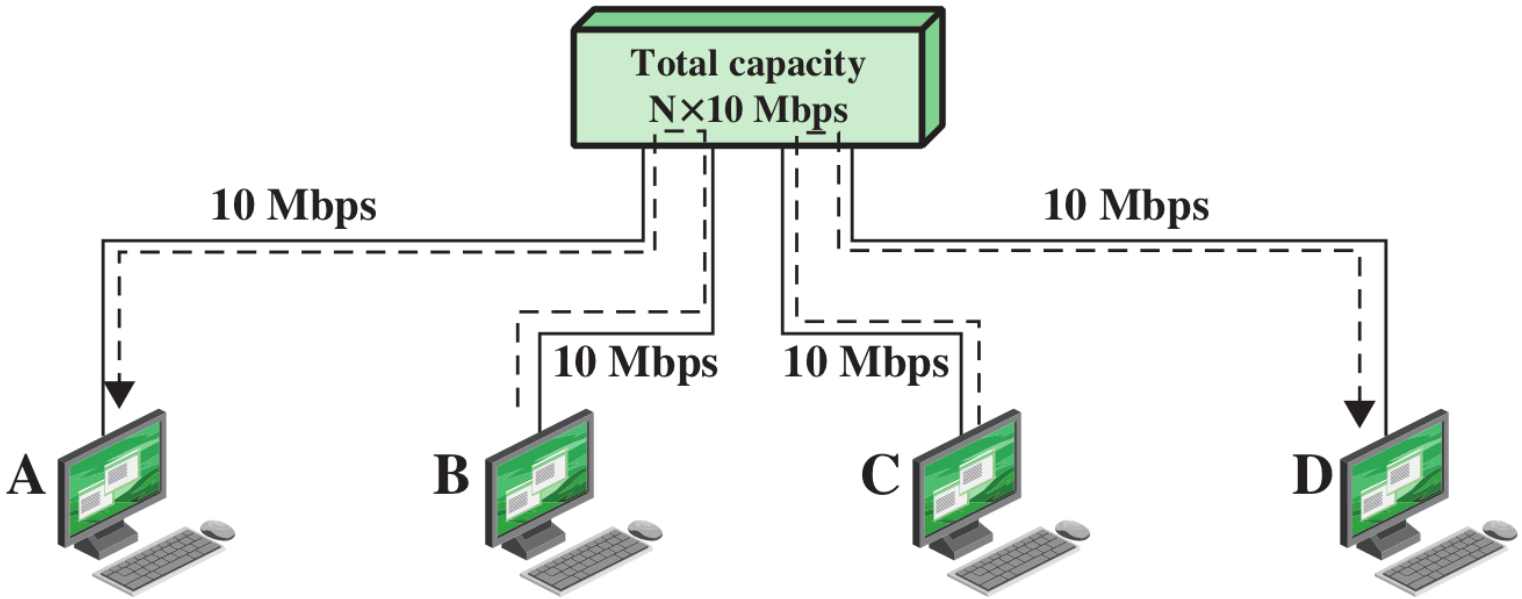
# Shared Medium Hub

Hub: receives a frame on an input link, and transmits a copy of that frame on all other output links



# Layer 2 Switch

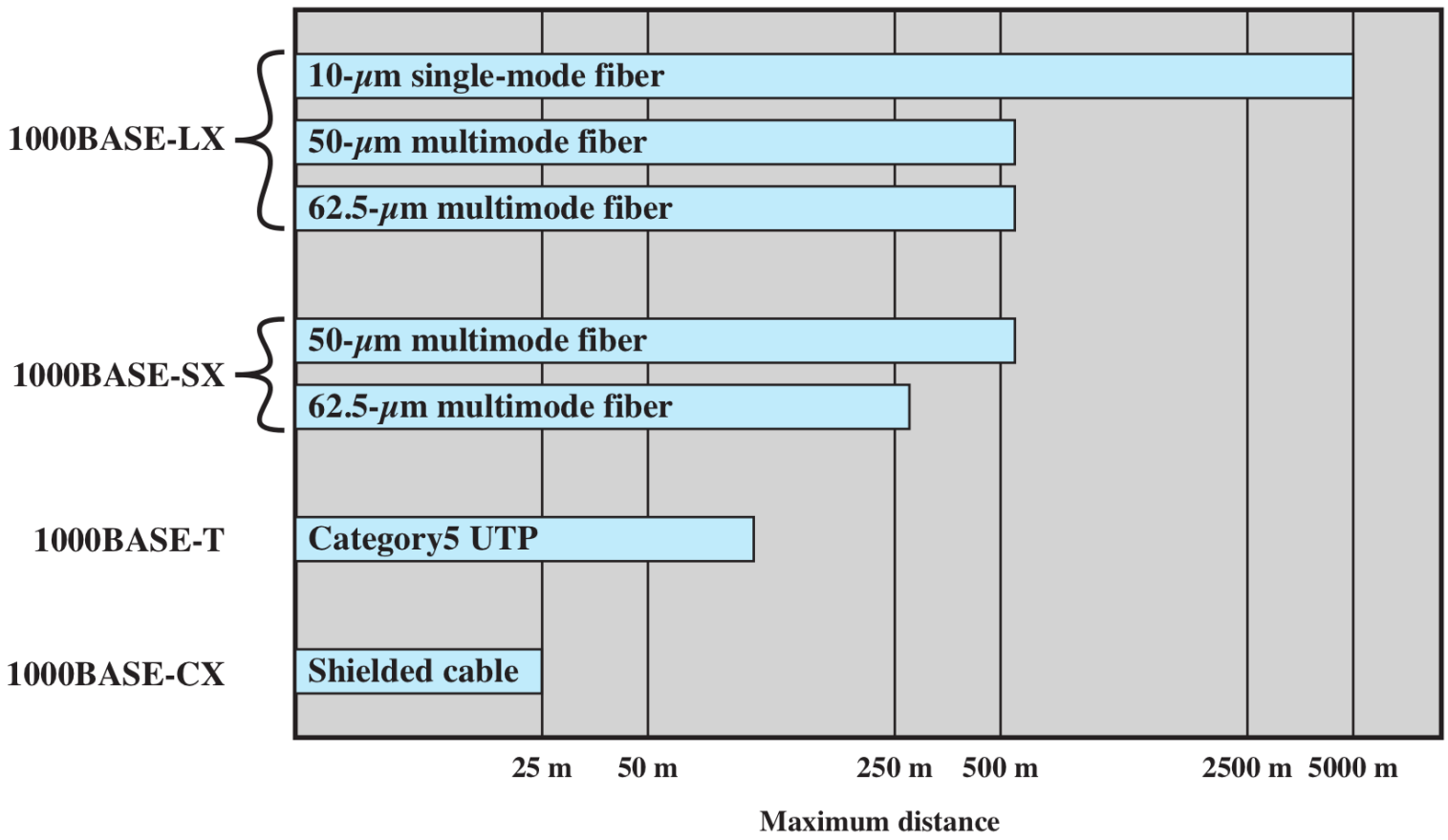
Switch: receives a frame on an input link, looks at the destination address, and transmits the frame on the intended output link



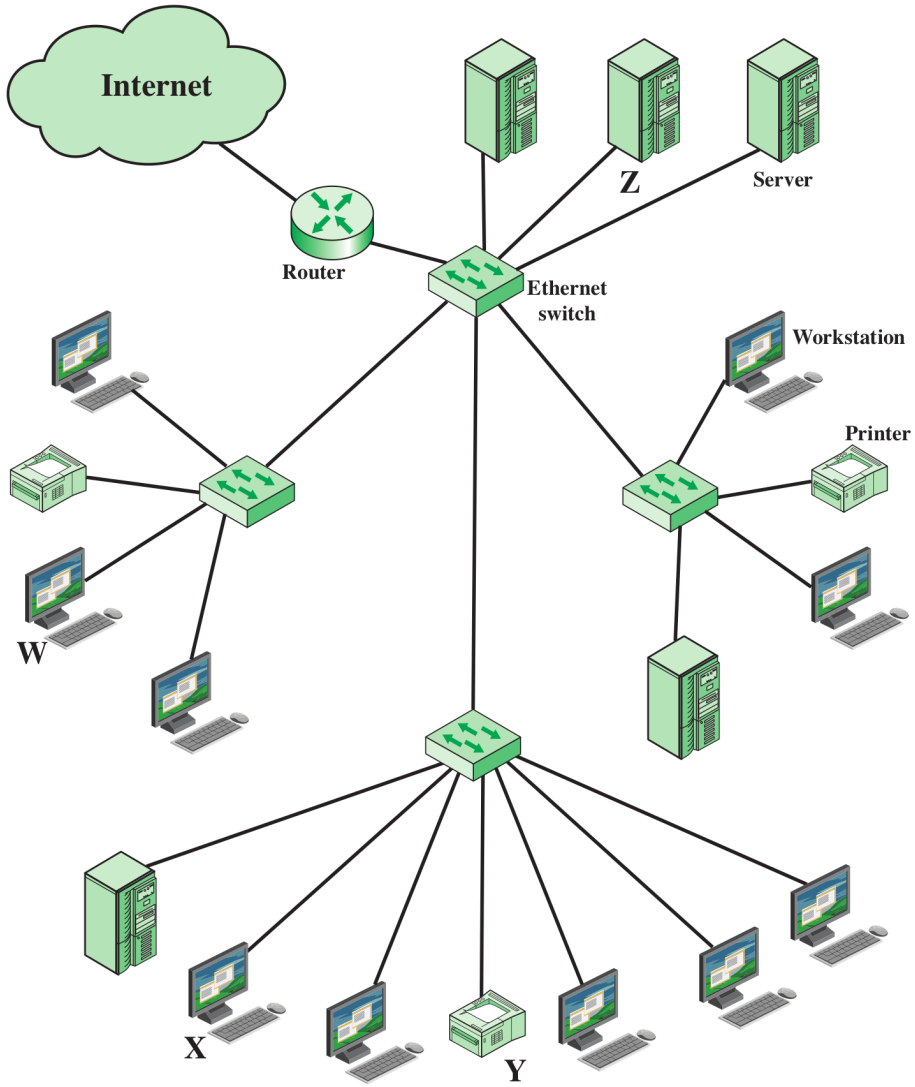
# IEEE 802.3 100BASE-T Physical Layer Medium Alternatives

| | 100BASE-TX | | 100BASE-FX | 100BASE-T4 |
|---|---|---|---|---|
| **Transmission medium** | 2 pair, STP | 2 pair, Category 5 UTP | 2 optical fibers | 4 pair, Category 3, 4, or 5 UTP |
| **Signaling technique** | MLT-3 | MLT-3 | 4B5B, NRZI | 8B6T, NRZ |
| **Data rate** | 100 Mbps | 100 Mbps | 100 Mbps | 100 Mbps |
| **Maximum segment length** | 100 m | 100 m | 100 m | 100 m |
| **Network span** | 200 m | 200 m | 400 m | 200 m |

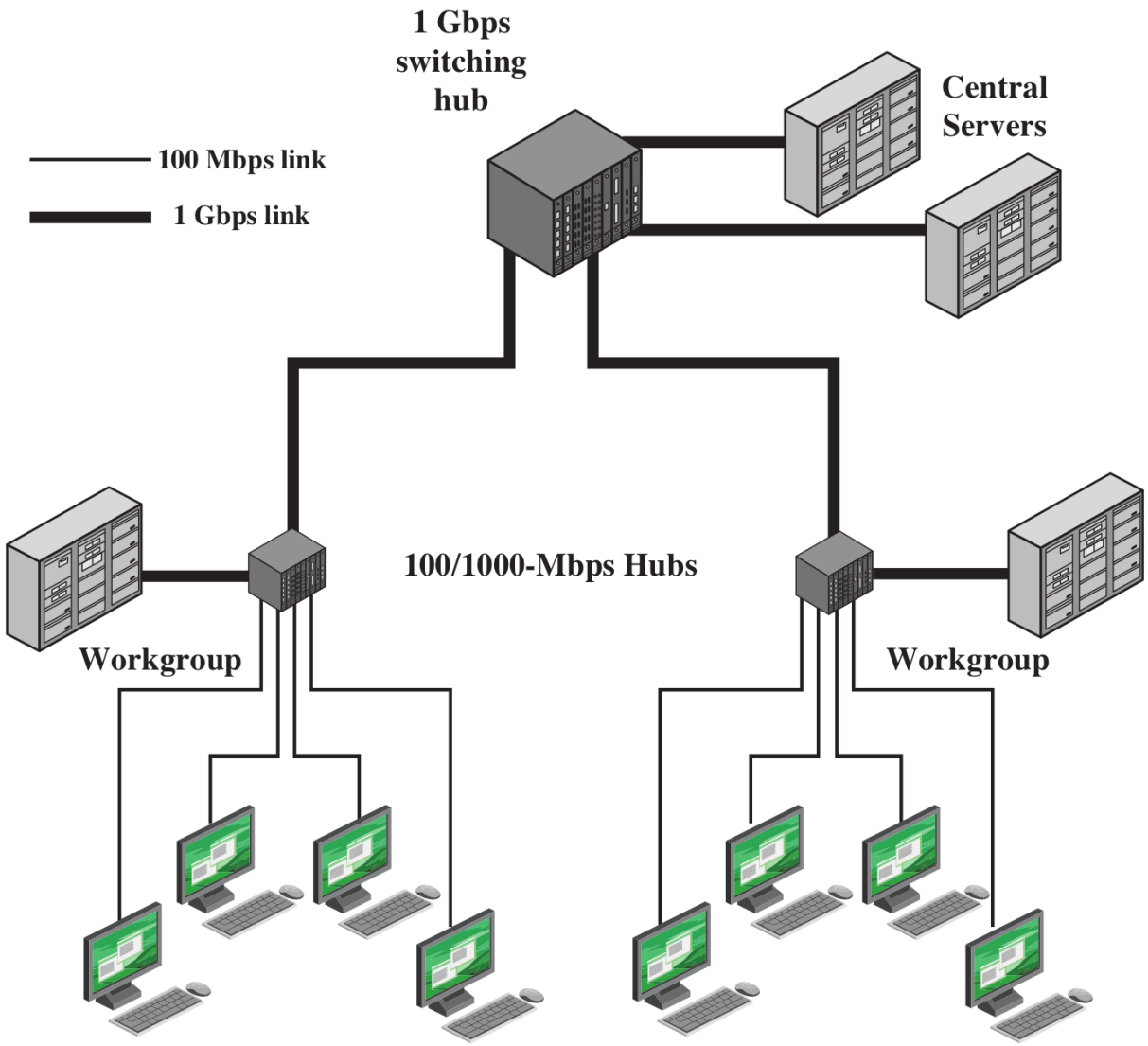
# Gigabit Ethernet Medium Options (log scale)



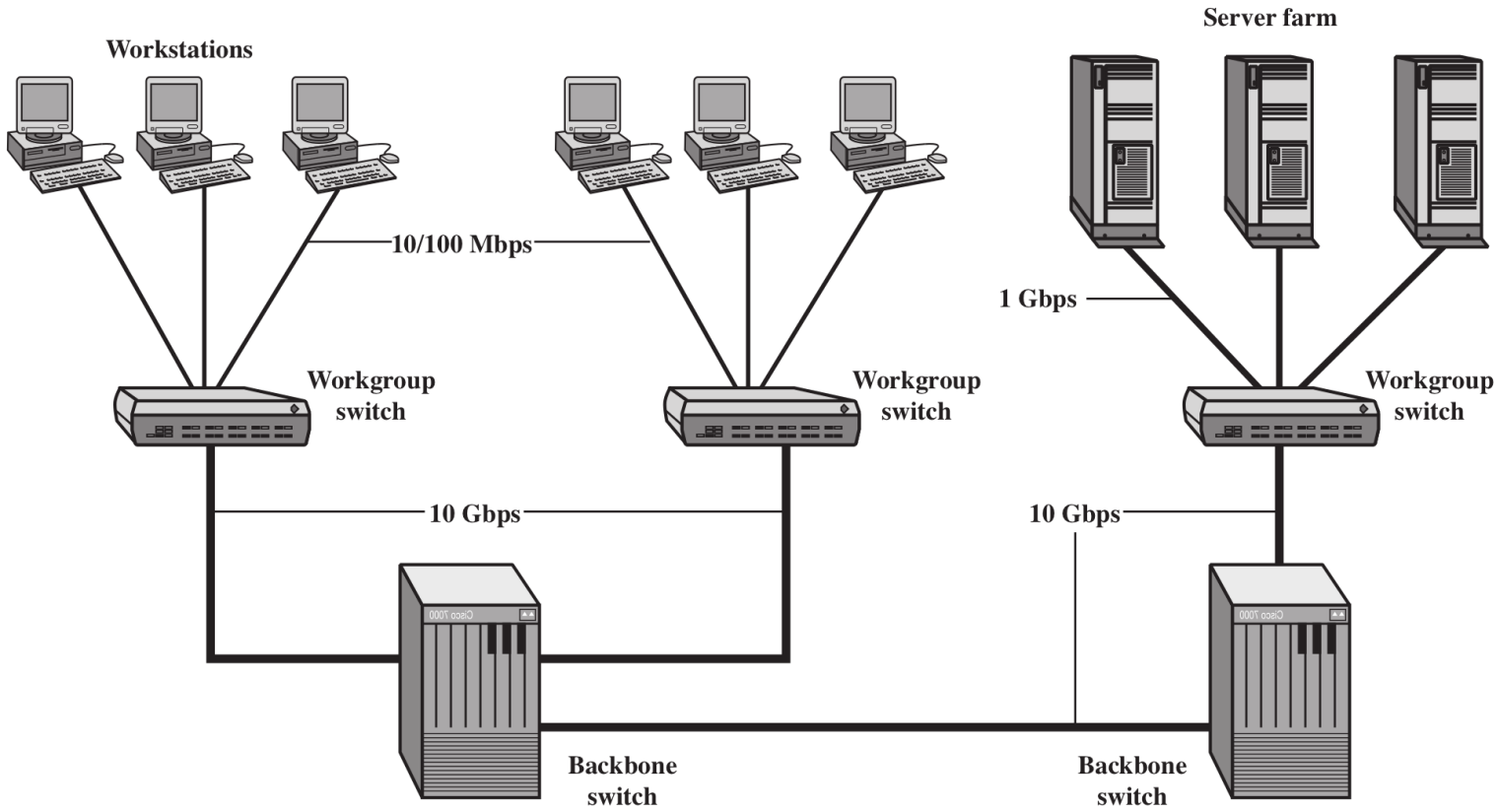
# Example LAN Configuration



# Example Gigabit Ethernet Configuration

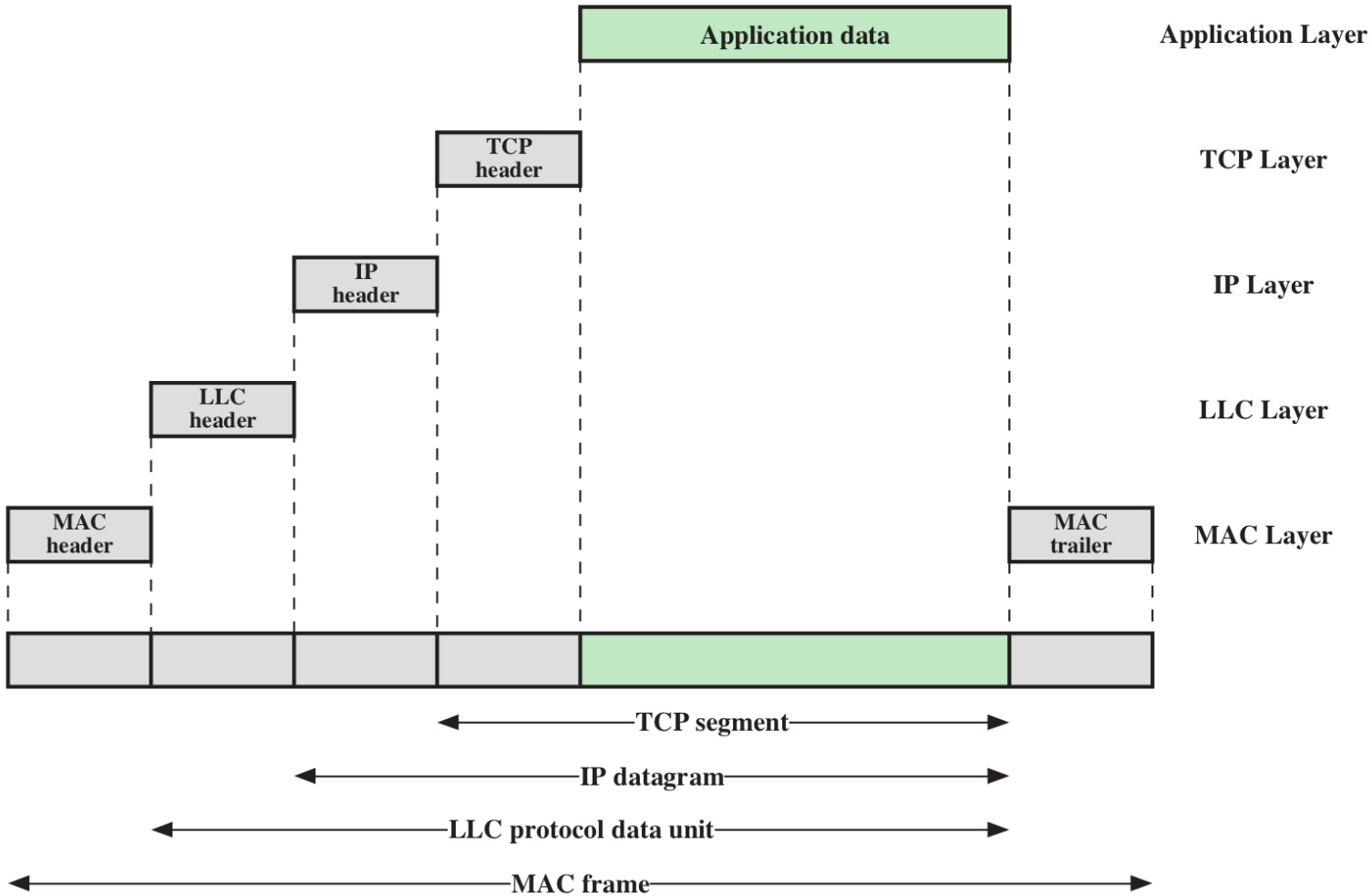


# Example 10 Gigabit Ethernet Configuration

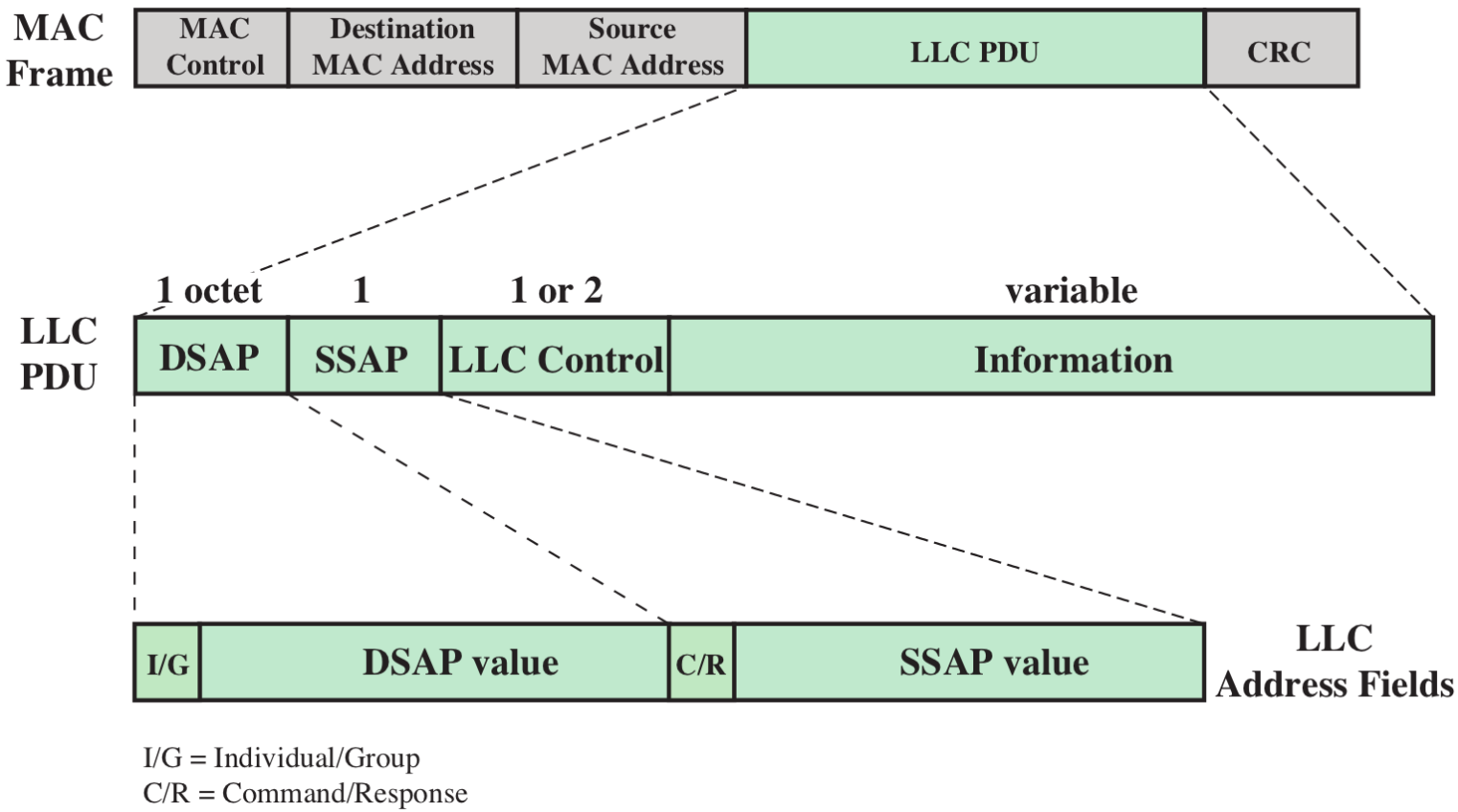


# Contents

# MAC Frame Compared to Other Layers

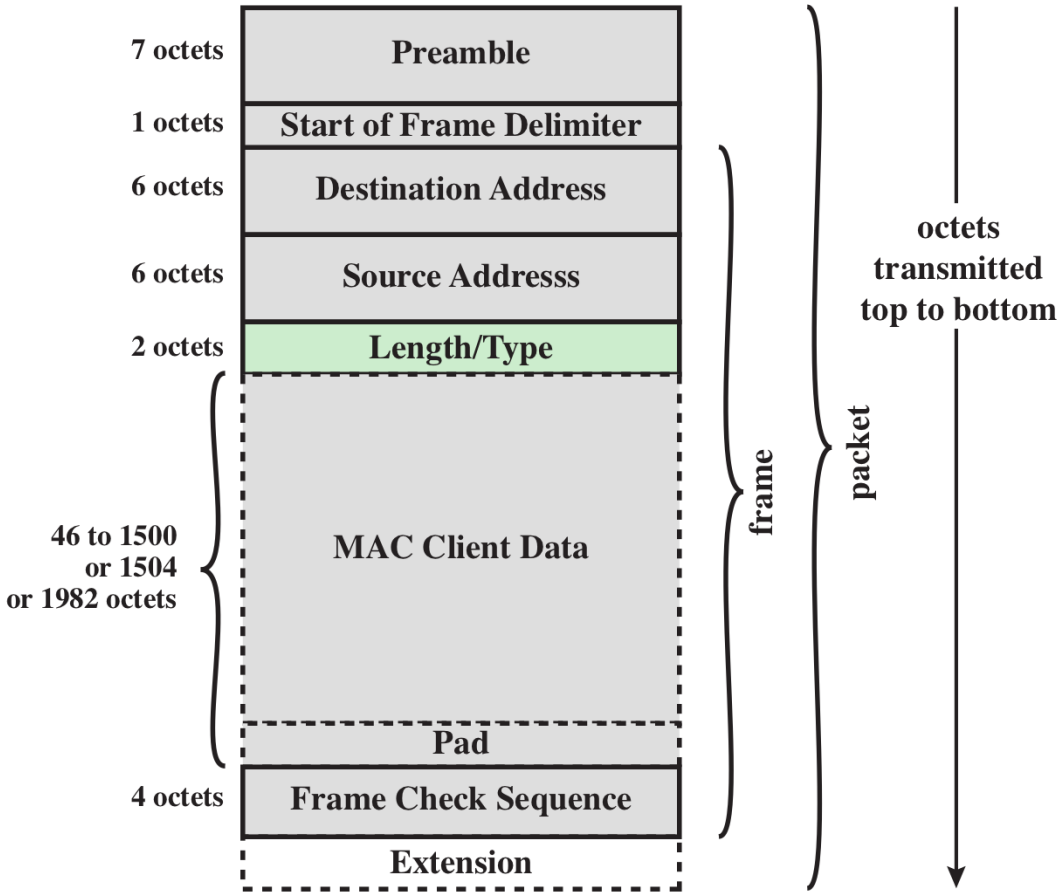


# LLC PDU in a Generic MAC Frame Format




- LLC traditionally provided link level flow and error control and multiplexing
- Today, in many IP networks LLC features are not needed; IP datagram encapsulated directly into MAC frame with 2 Byte EtherType field

# IEEE 802.3 MAC Frame Format




- Typical maximum data size is 1500 Bytes
- 1st 8 bytes (preamble, delimiter) sometimes considered part of Physical layer

# IEEE 802 Addresses

- IEEE 802 standards use common IEEE 48-bit address format
- Globally unique (ideally)
  - First 24-bits assigned by IEEE to manufacturer `http://standards.ieee.org/regauth/oui/`
  - Second 24-bits assigned by manufacturer to device
- For simplicity, represented as $6 \times 2$ digit hexadecimal numbers
- Common in other standards: Bluetooth, ATM, FDDI, FibreChannel
- IEEE 64-bit address is new format: Firewire, ZigBee, IPv6

# IEEE Addressing Example

Find the 48-bit IEEE address of your computer.