Local Area Networks

Lecture #8

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)

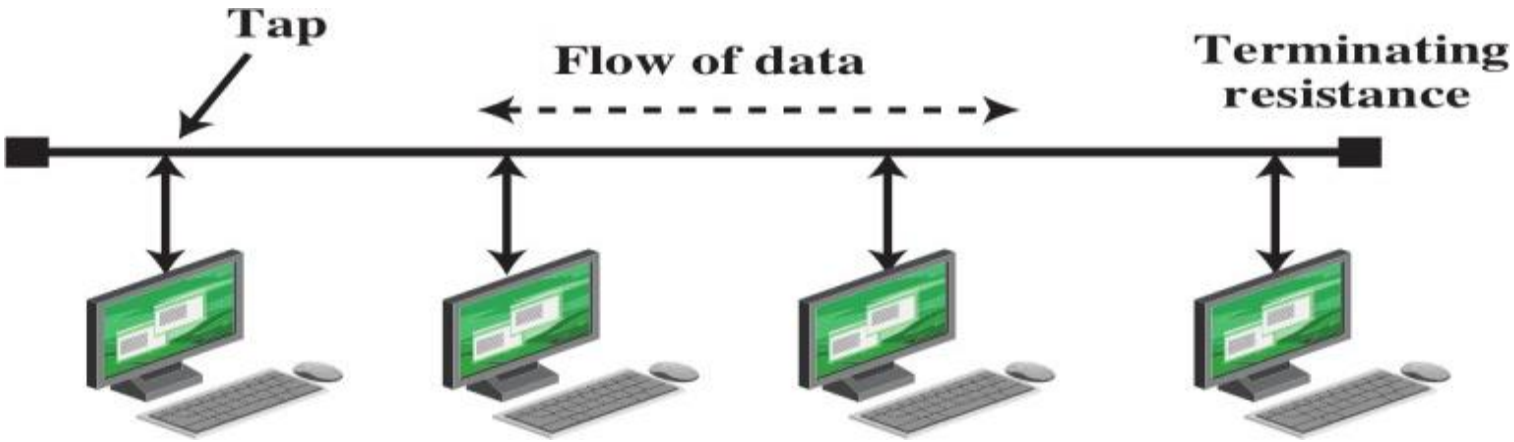
LAN Design Elements

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

1. LAN Topology

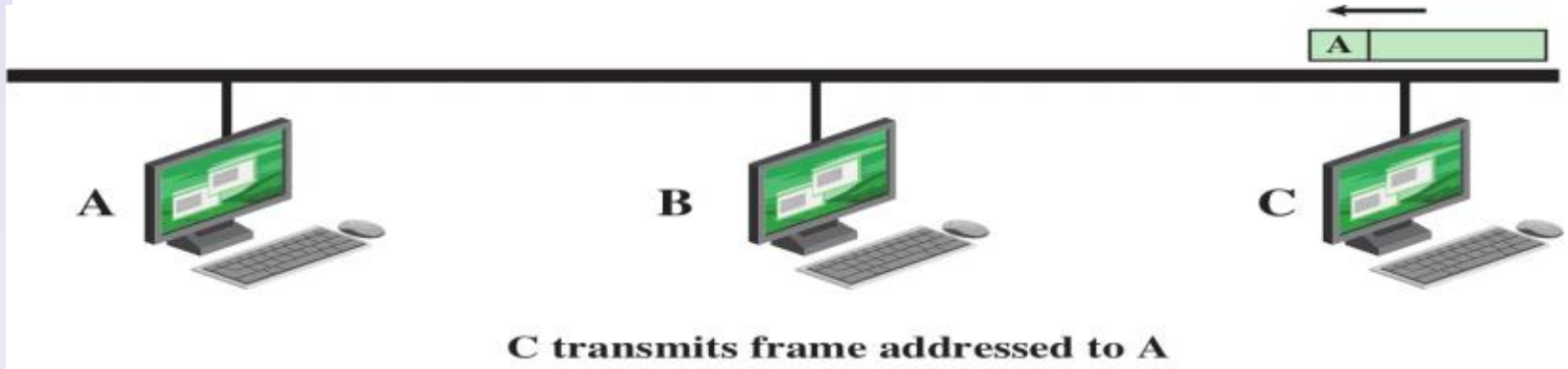
- Recall link configurations: point-to-point and multipoint
- LANs allow multiple users to communicate with each other
- Topology is arrangement of nodes and links
  - Mesh every station has point-to-point link to every other station
  - Bus every station connected via a multipoint link
  - Ring point-to-point 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

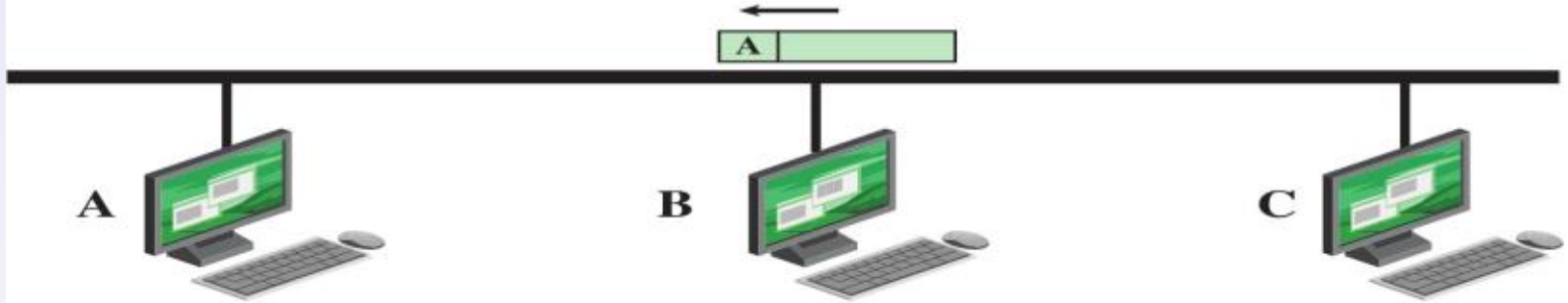


- Single multipoint link connects all stations (via tap)
- Transmission propagates throughout medium and is heard by all stations
- Terminator absorbs frames at end of medium/cable
- Frames need addresses
- Pros: easy installation
- Cons: require protocols to share medium; faulty link stops all communications;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

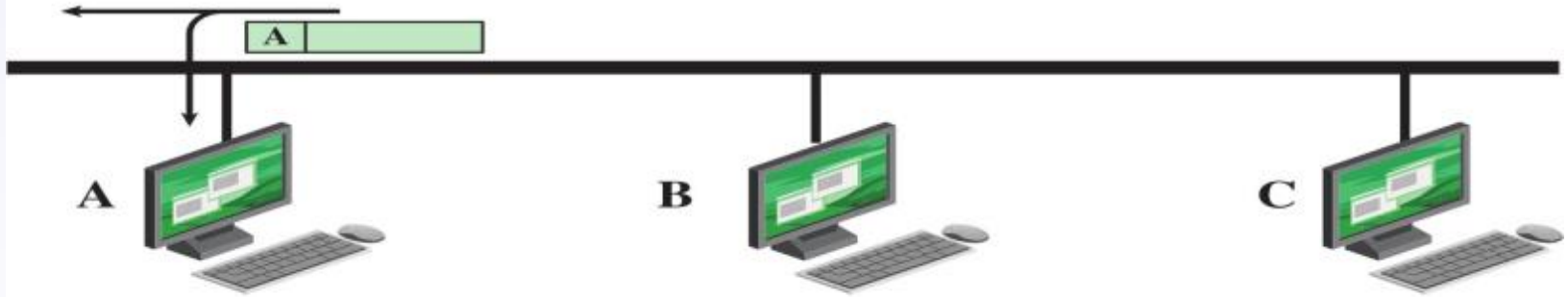
Frame Transmission on a Bus LAN



C transmits frame addressed to A

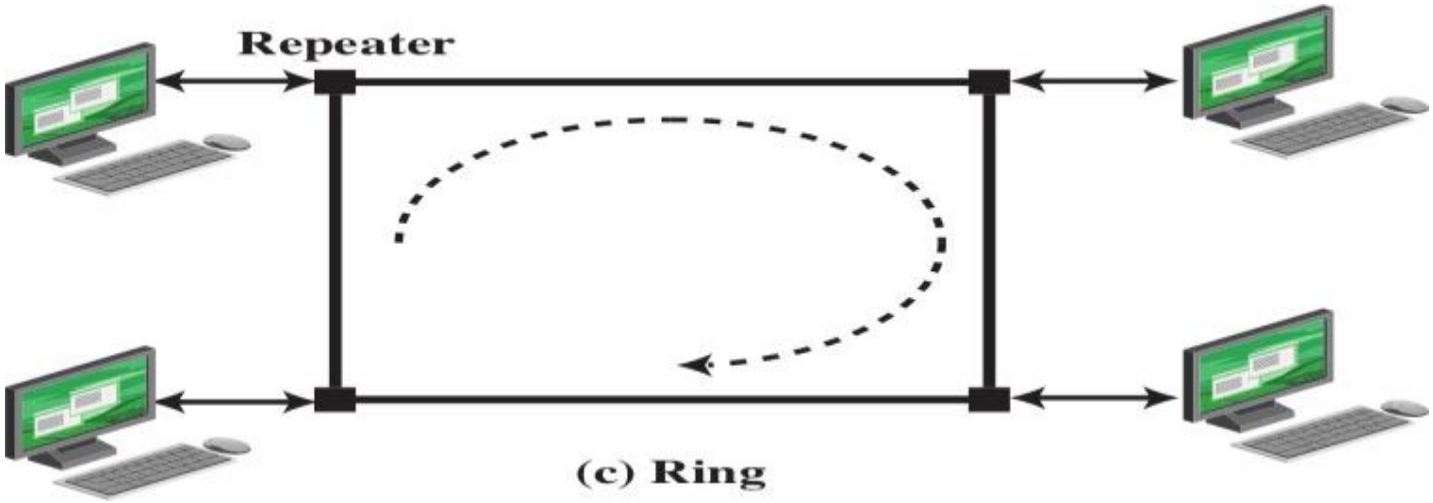


Frame is not addressed to B; B ignores it



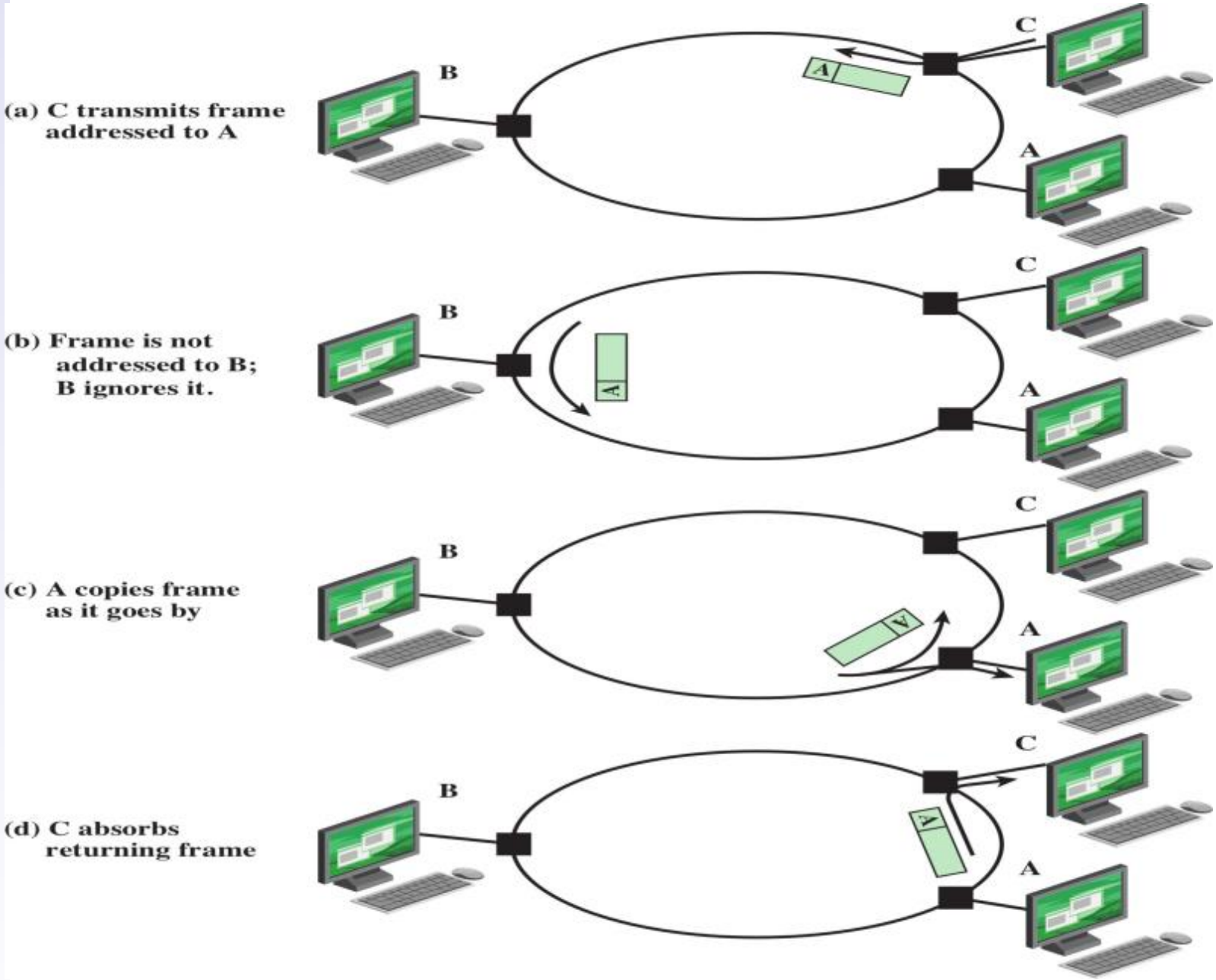
A copies frame as it goes by

Ring Topology

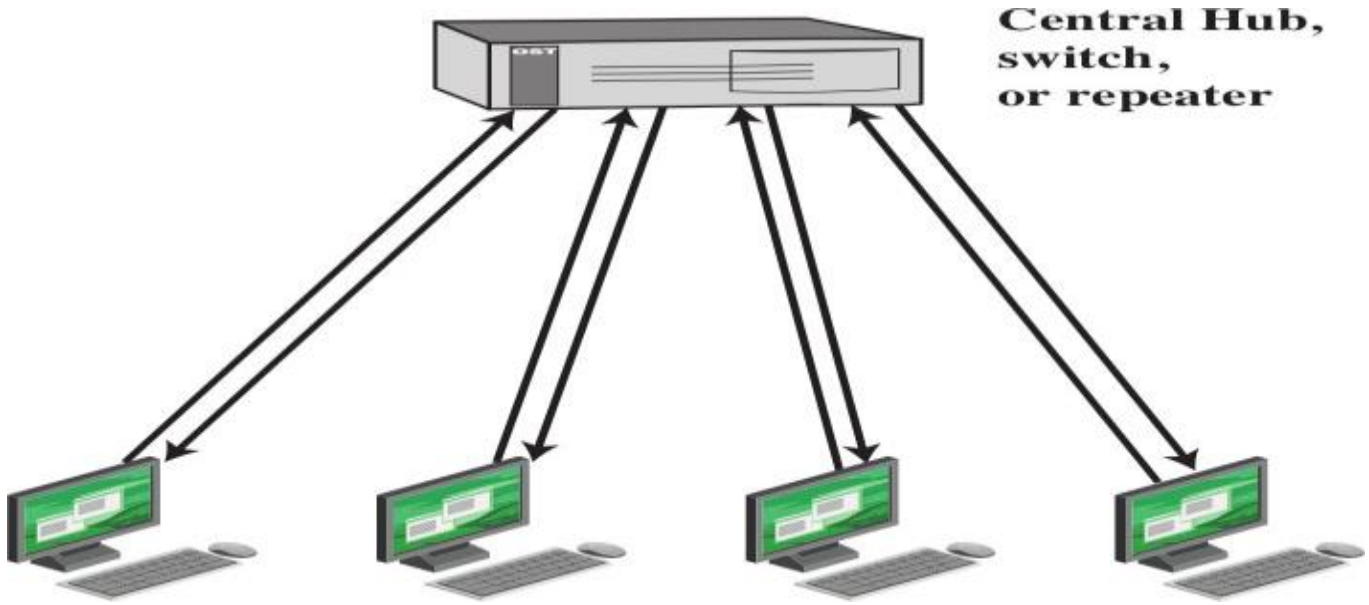


- Unidirectional point-to-point links to form loop
- Stations attach to repeaters
- Frames need addresses
- Pros: simple to install and reconfigure; easy to identify faults
- Cons: require protocols to share medium; traffic flows in one direction
- Usage: old LANs (e.g. IBM Token Ring); MANs and WANs

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

2. 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)

3. 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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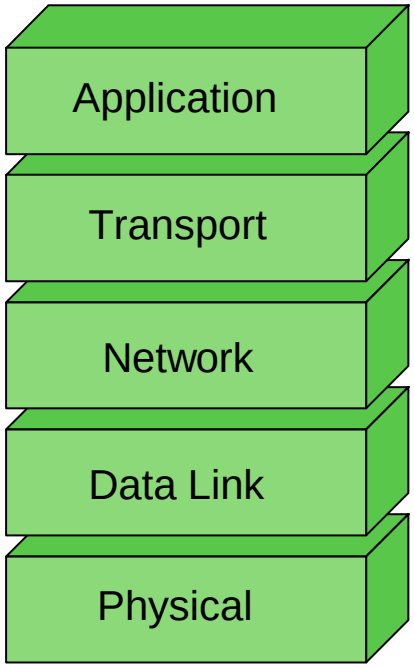
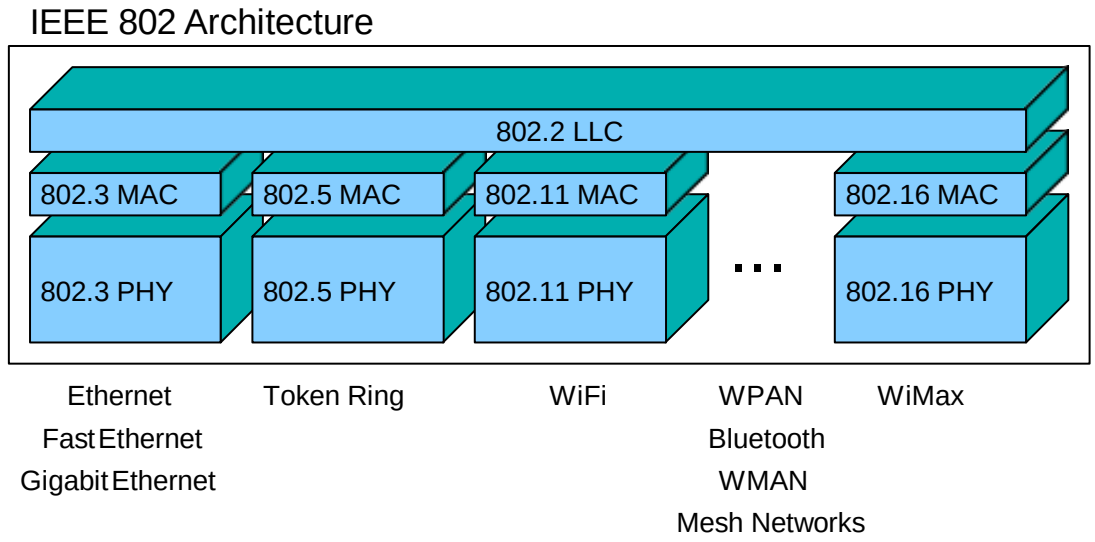
IEEE 802 LAN Architecture

- 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

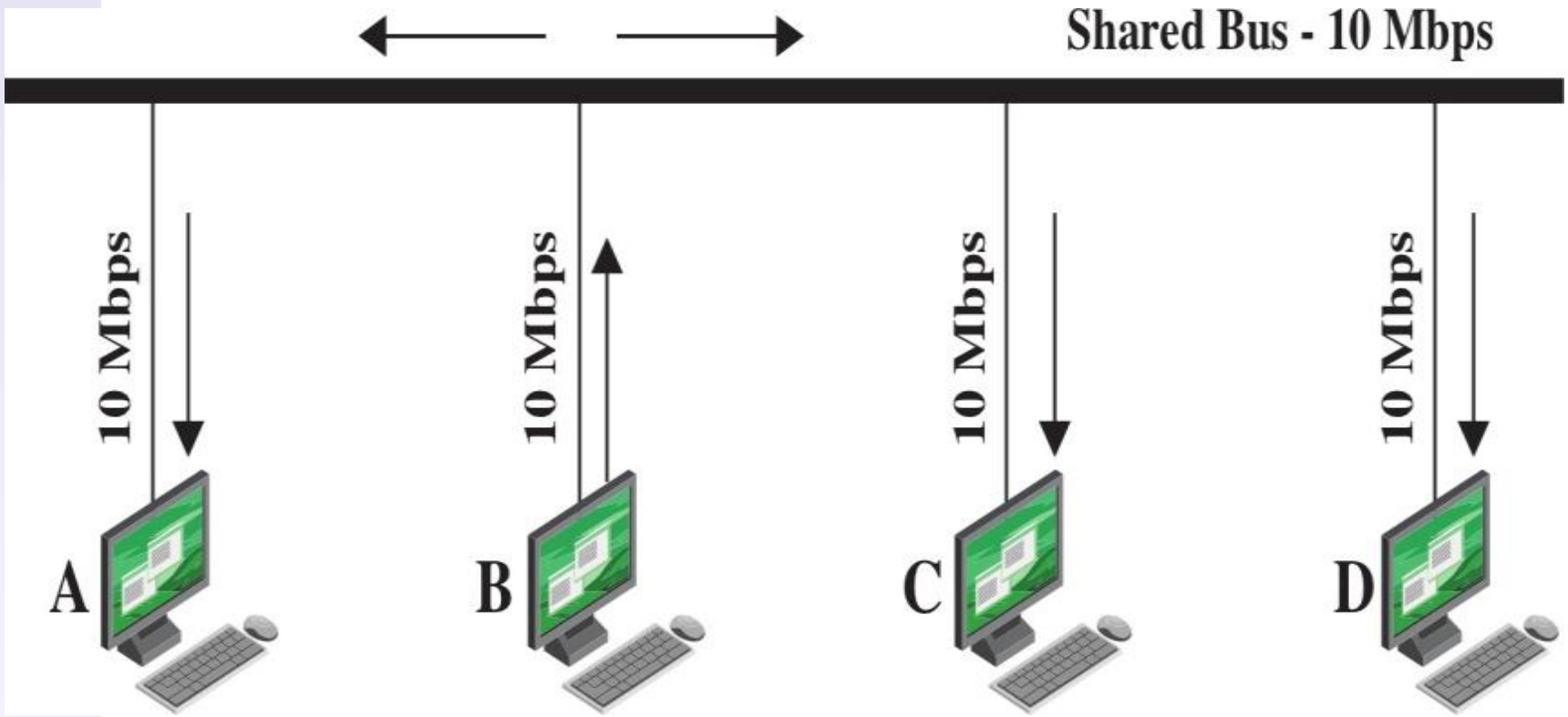
IEEE 802.3: Ethernet

- 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

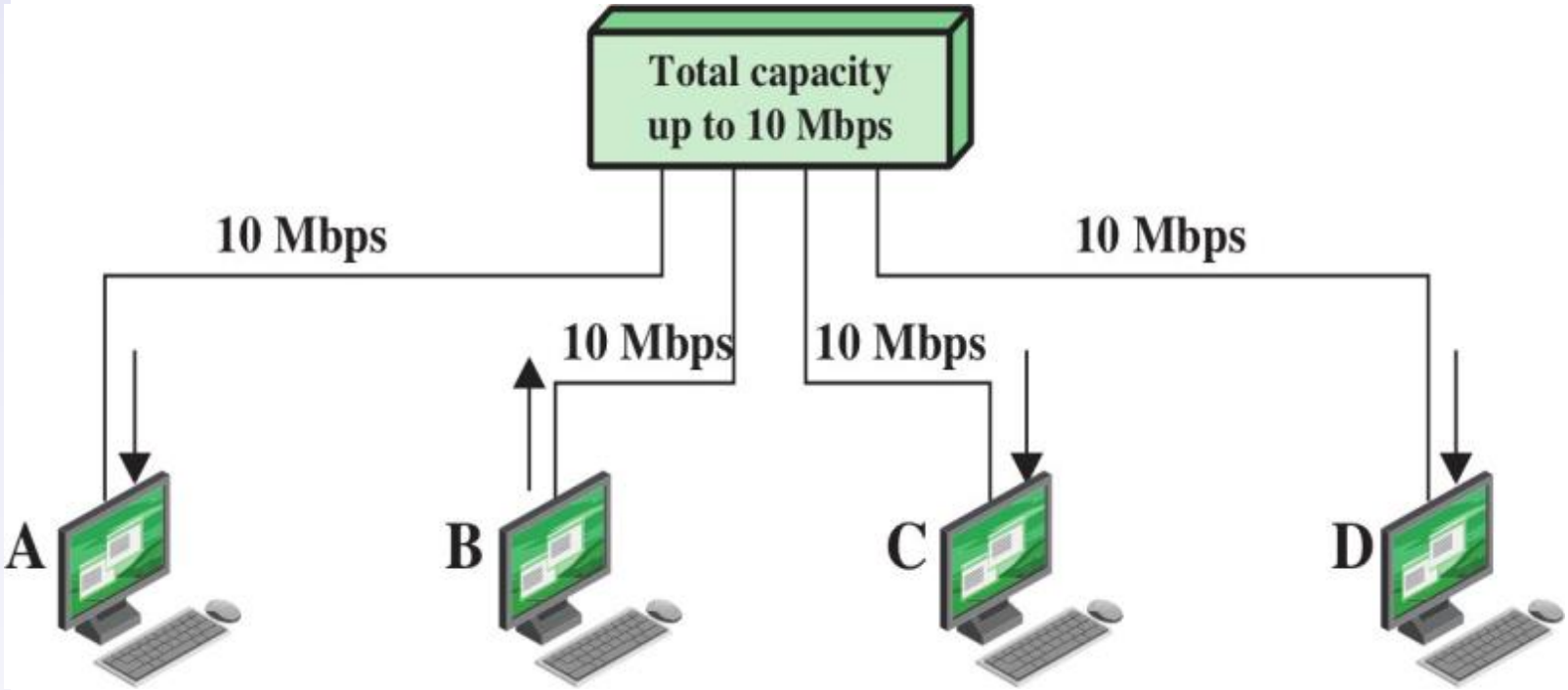
	10BASE5	10BASE2	10BASE-T	10BASE-FP
Transmission medium	Coaxial cable (50 ohm)	Coaxial cable (50 ohm)	Unshielded twisted pair	850-nm optical fiber pair
Signaling technique	Baseband (Manchester)	Baseband (Manchester)	Baseband (Manchester)	Manchester/on-off
Topology	Bus	Bus	Star	Star
Maximum segment length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

Shared Medium Bus



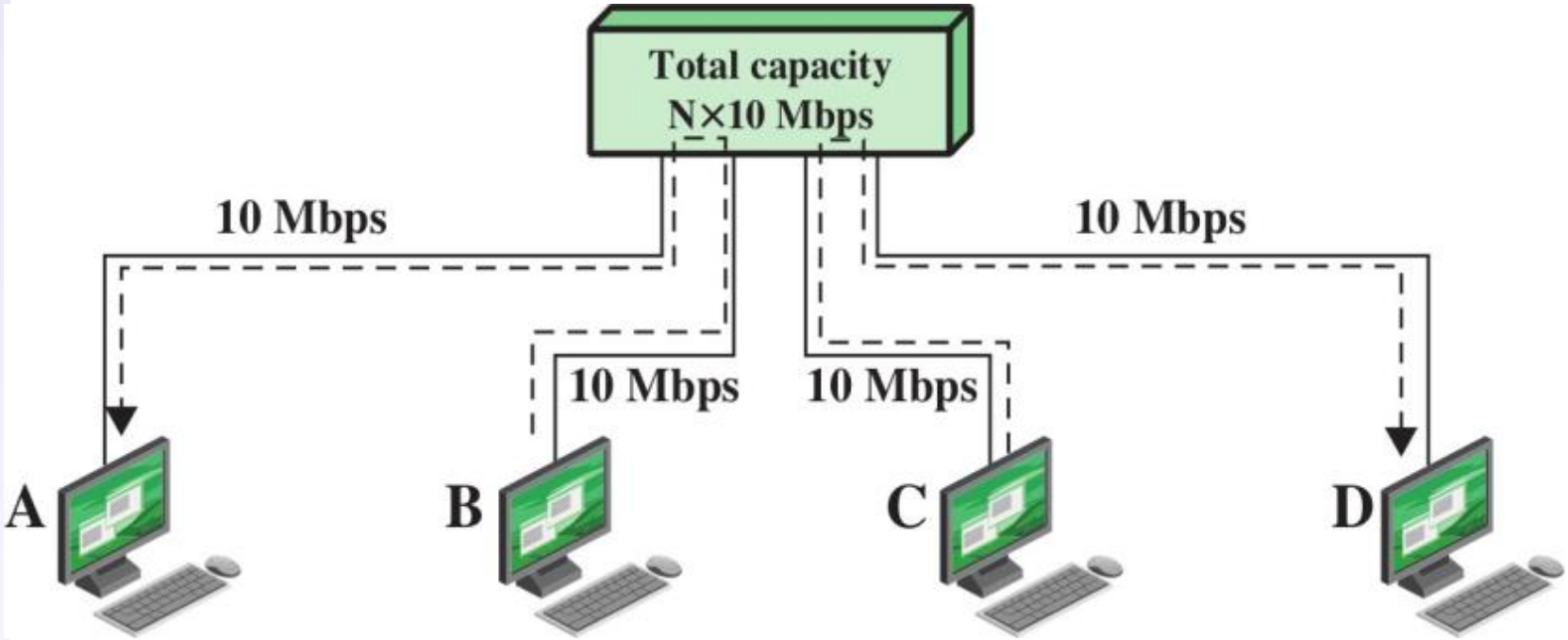
Shared Medium Hub

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



Layer 2 Switch

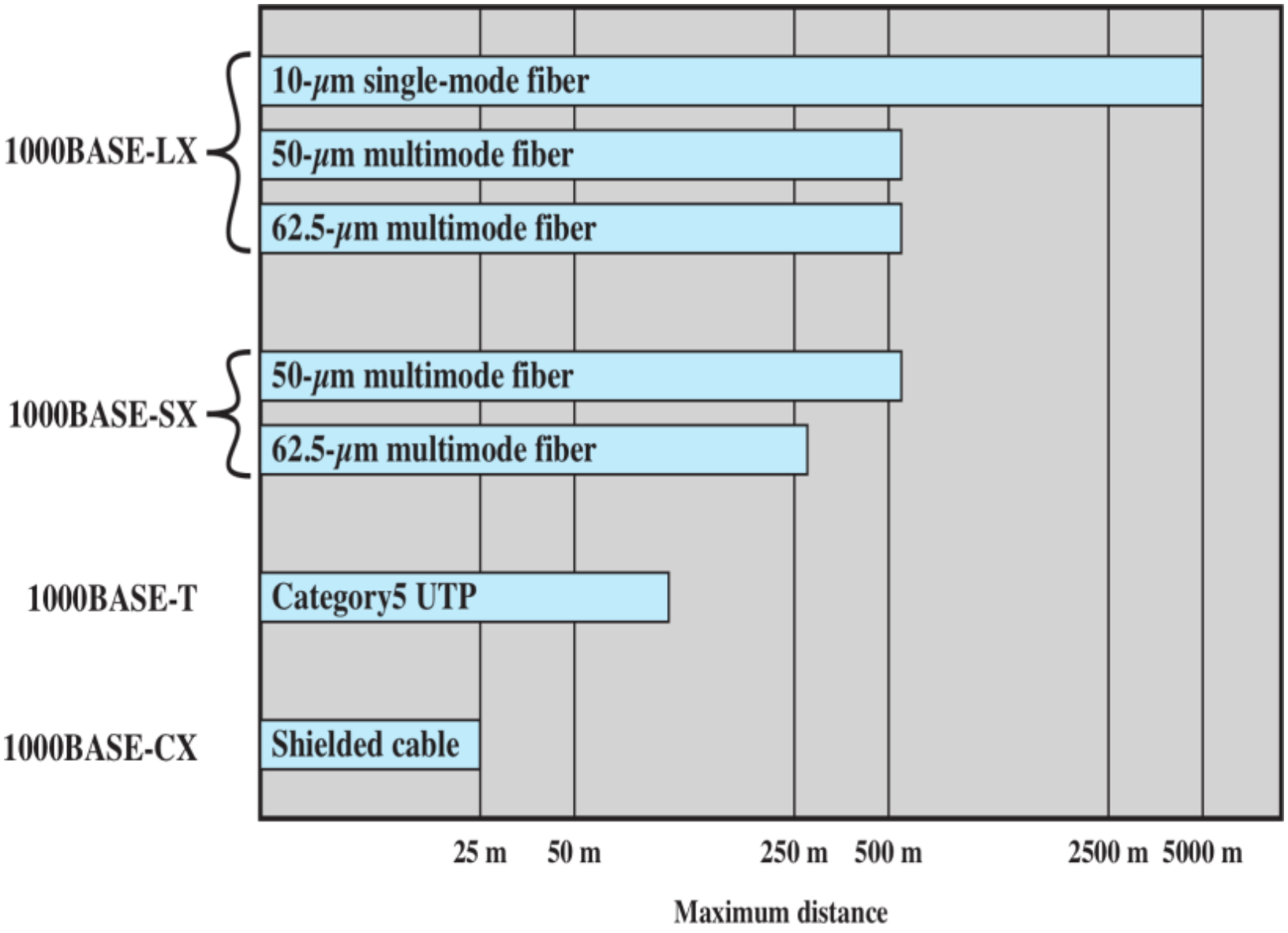
Switch: receives a frame on an input link, looks at the destination address, and transmits the frame on the intended output link



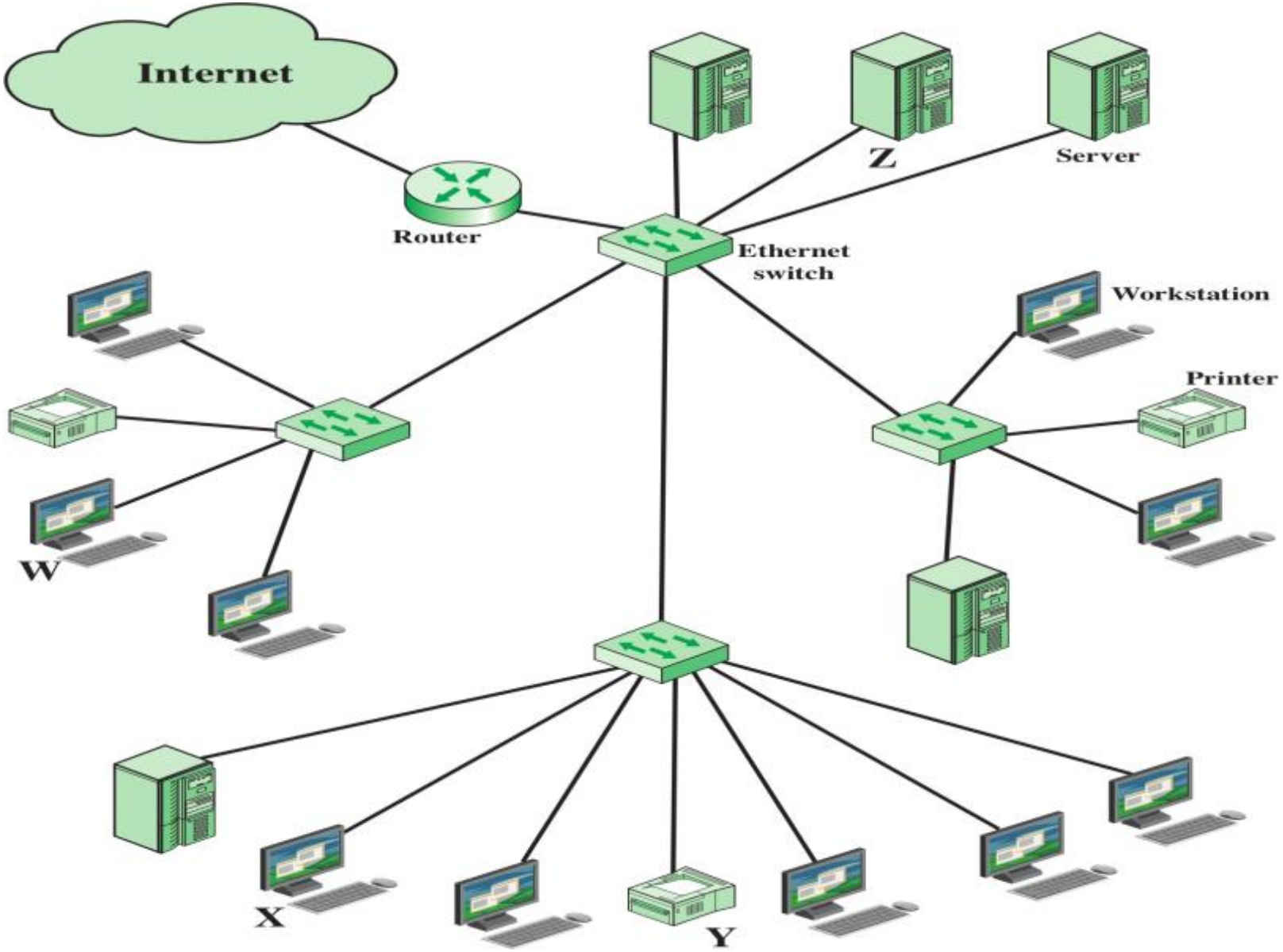
IEEE 802.3 100BASE-T Physical Layer Medium Alternatives

	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

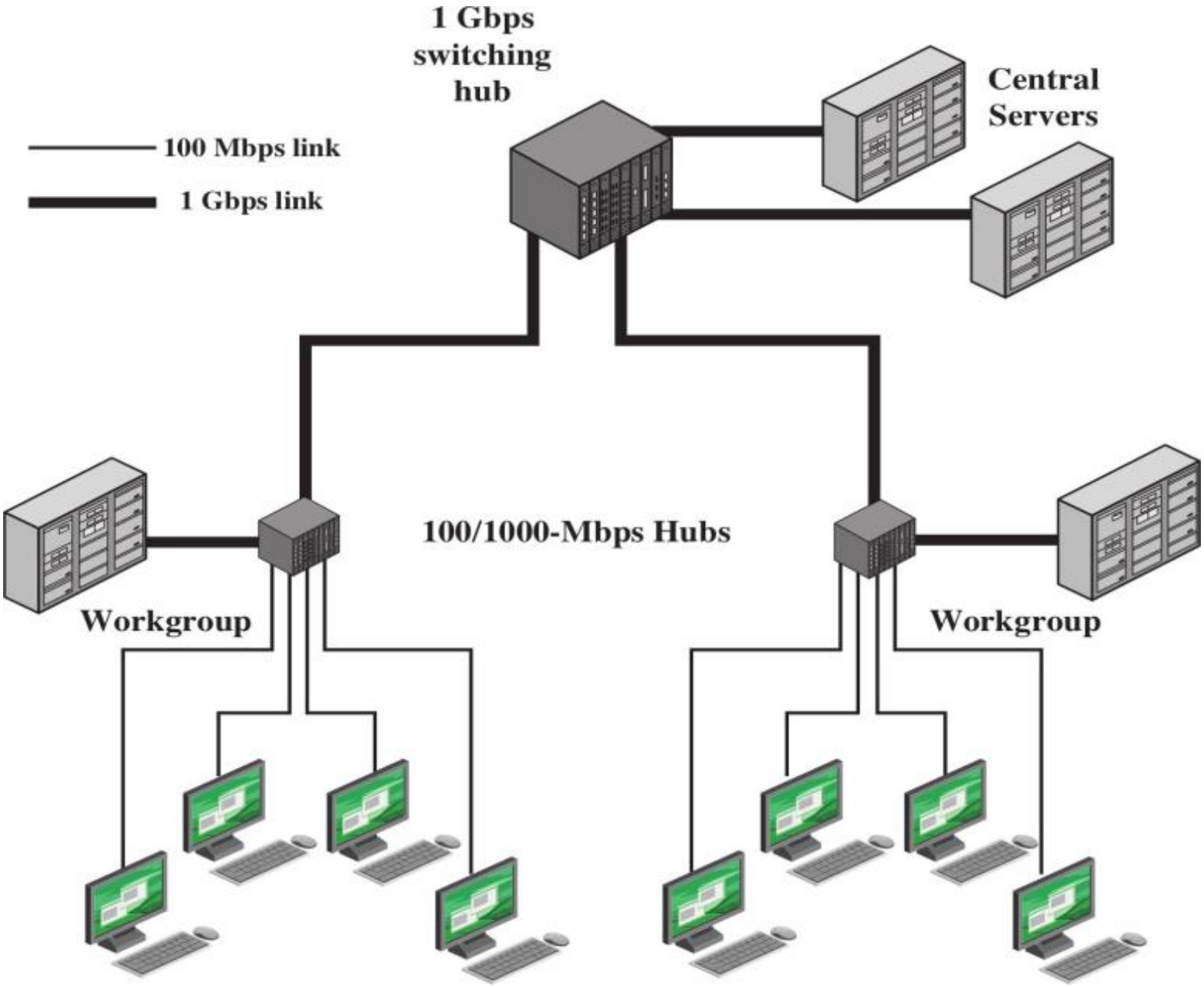
Gigabit Ethernet Medium Options (log scale)



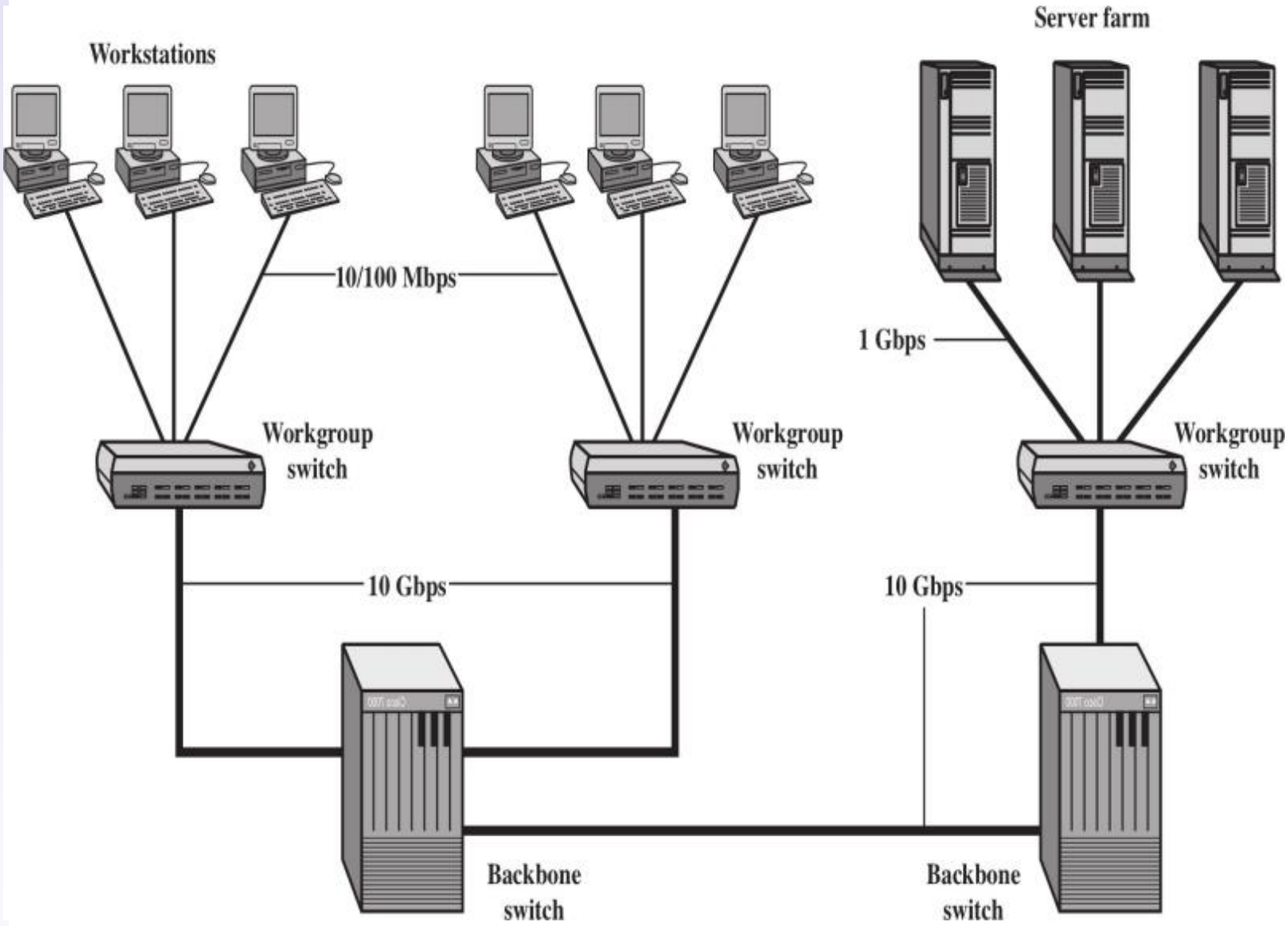
Example LAN Configuration



Example Gigabit Ethernet Configuration

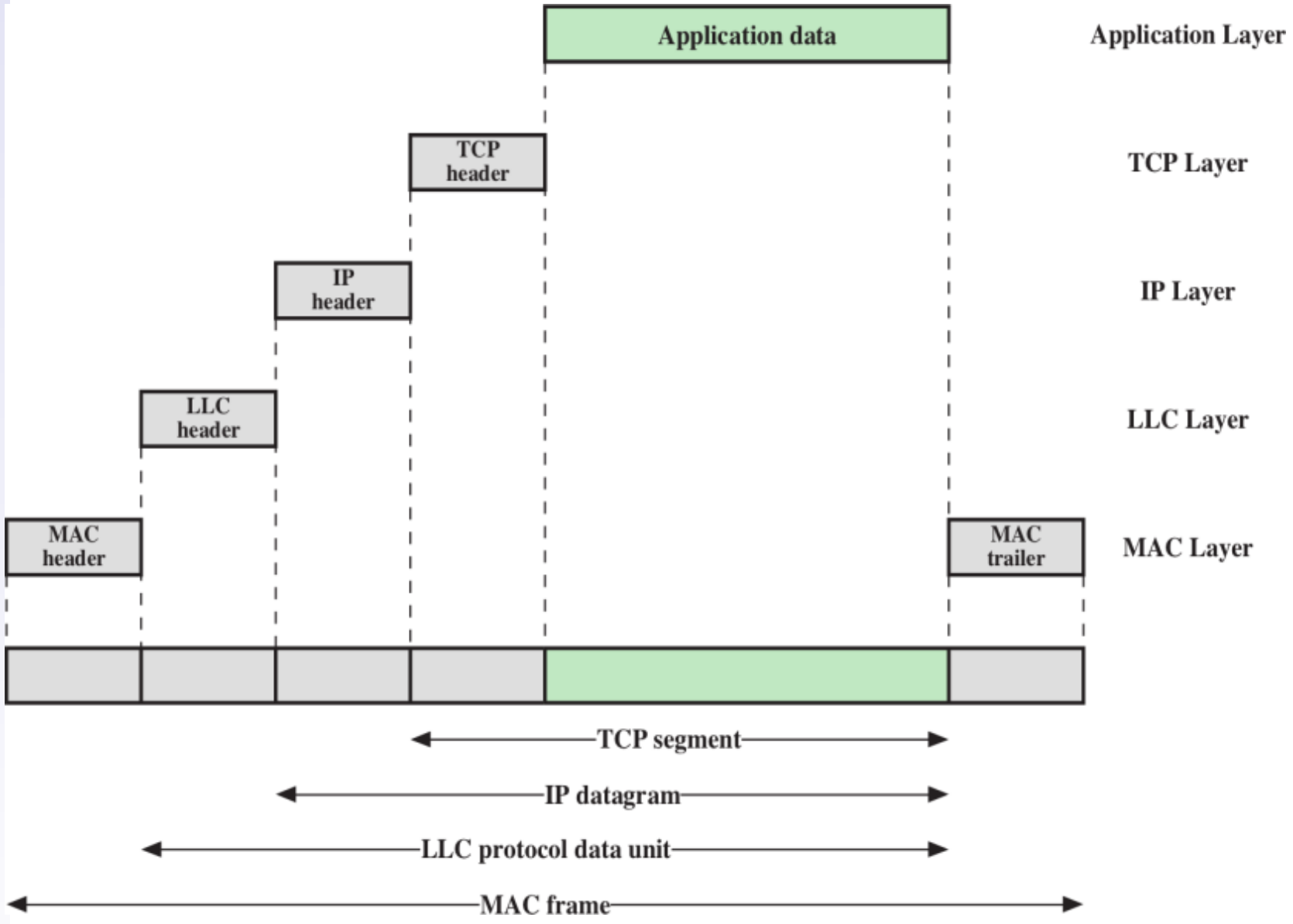


Example 10 Gigabit Ethernet Configuration

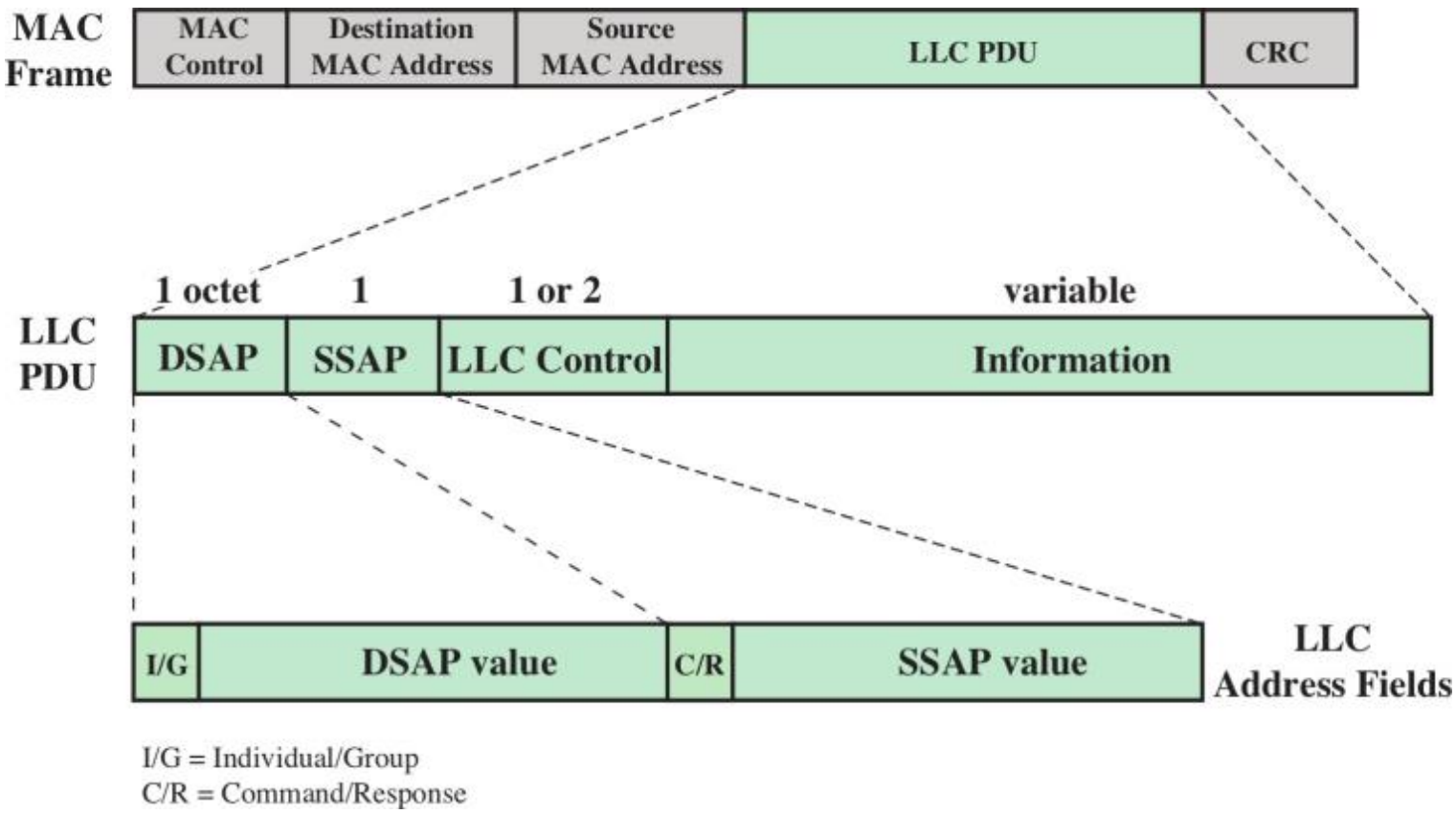


Contents

MAC Frame Compared to Other Layers

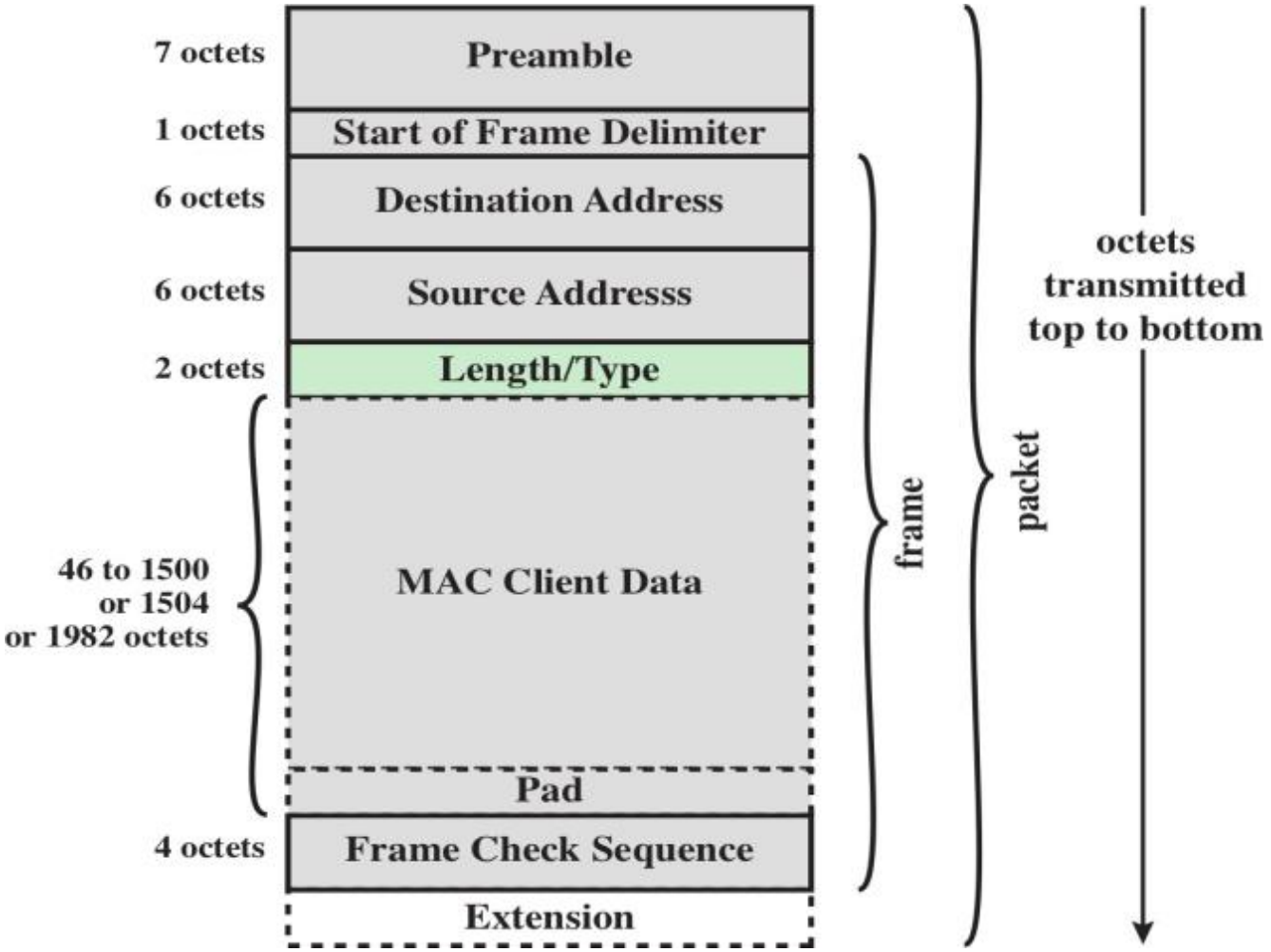


LLC PDU in a Generic MAC Frame Format



- 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 × 2 digit hexadecimal numbers
- Common in other standards: Bluetooth, ATM, FDDI, FibreChannel
- IEEE 64-bit address is new format: Firewire, ZigBee, IPv6