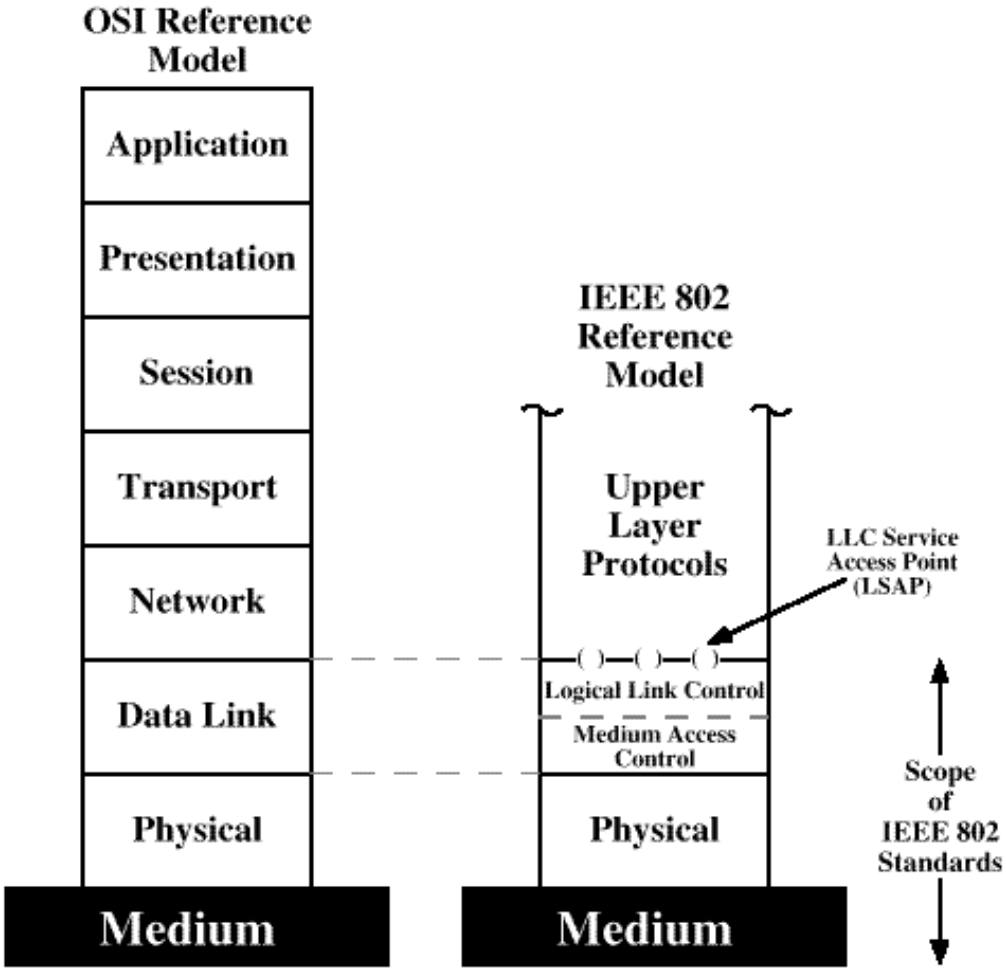
1. LAN ARCHITECTURE

- LAN Protocol Architecture
  - LAN protocol architectures are specified by IEEE 802 reference model
  - In IEEE 802 reference model, there are two separate layers corresponding to data link layer of OSI model
    - MAC (Medium Access Control) layer
    - LLC (Logical Link Control) layer



IEEE 802 protocol layers compared to OSI model

- LLC Layer
  - Provide an interface to higher layers
  - Flow and error control
- MAC Layer
  - Interface to physical layer
  - Govern access to LAN transmission system
  - Sending/receiving frames
  - Frame synchronization
  - Error detection
- Physical Layer
  - Specification of the transmission medium and the topology
  - Encoding/decoding of signals
  - Preamble generation/removal (for synchronization)
  - Bit transmission/reception

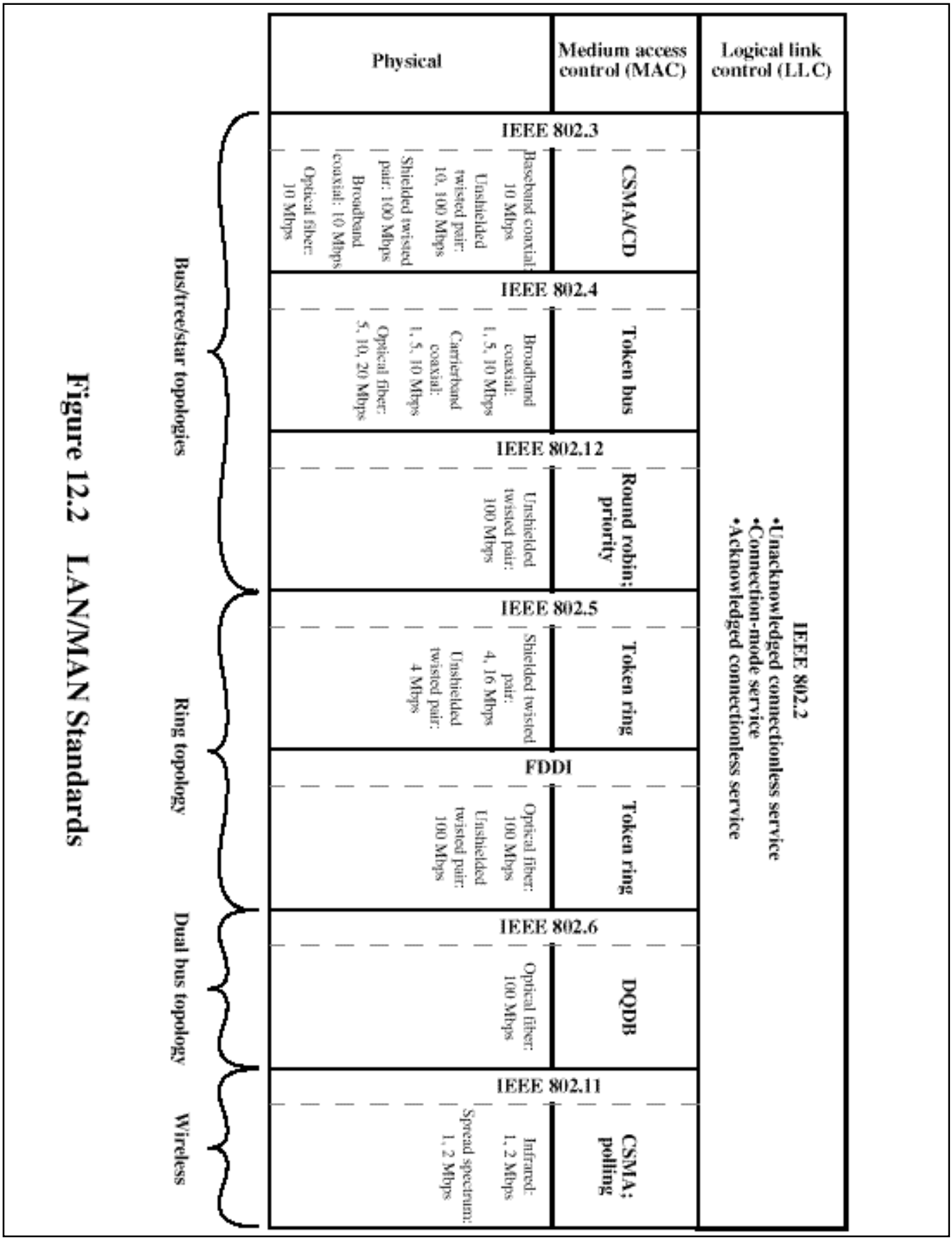


Figure 12.2 LAN/MAN Standards

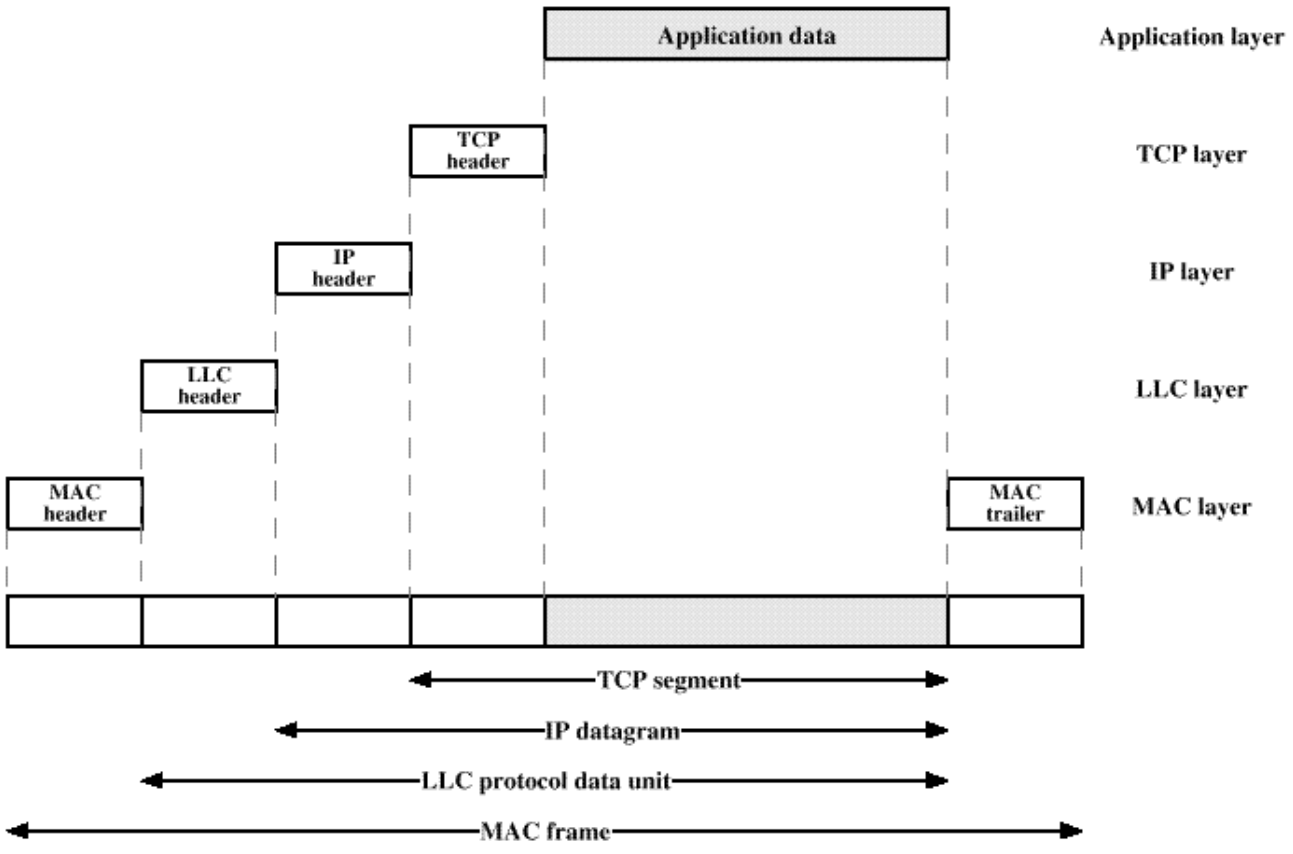


Figure 12.3 LAN Protocols in Context

- LAN Topologies
  - Bus, Tree, ring, and star

- Bus and Tree Topologies
  - Multipoint medium is used
  - Stations connected to common bus with passive “taps”
  - Need addressing, and medium access control

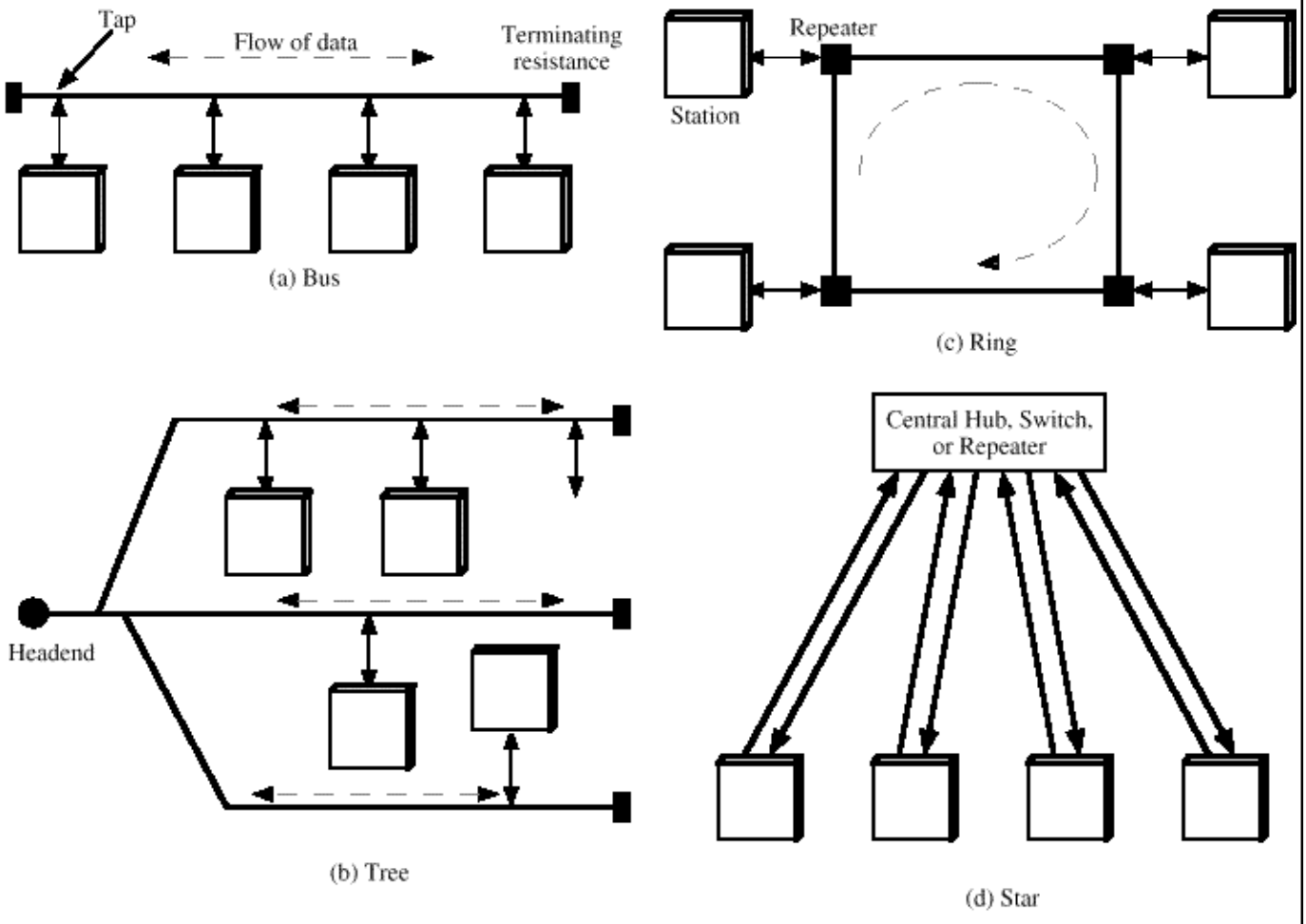


Figure 12.4 LAN/MAN Topologies

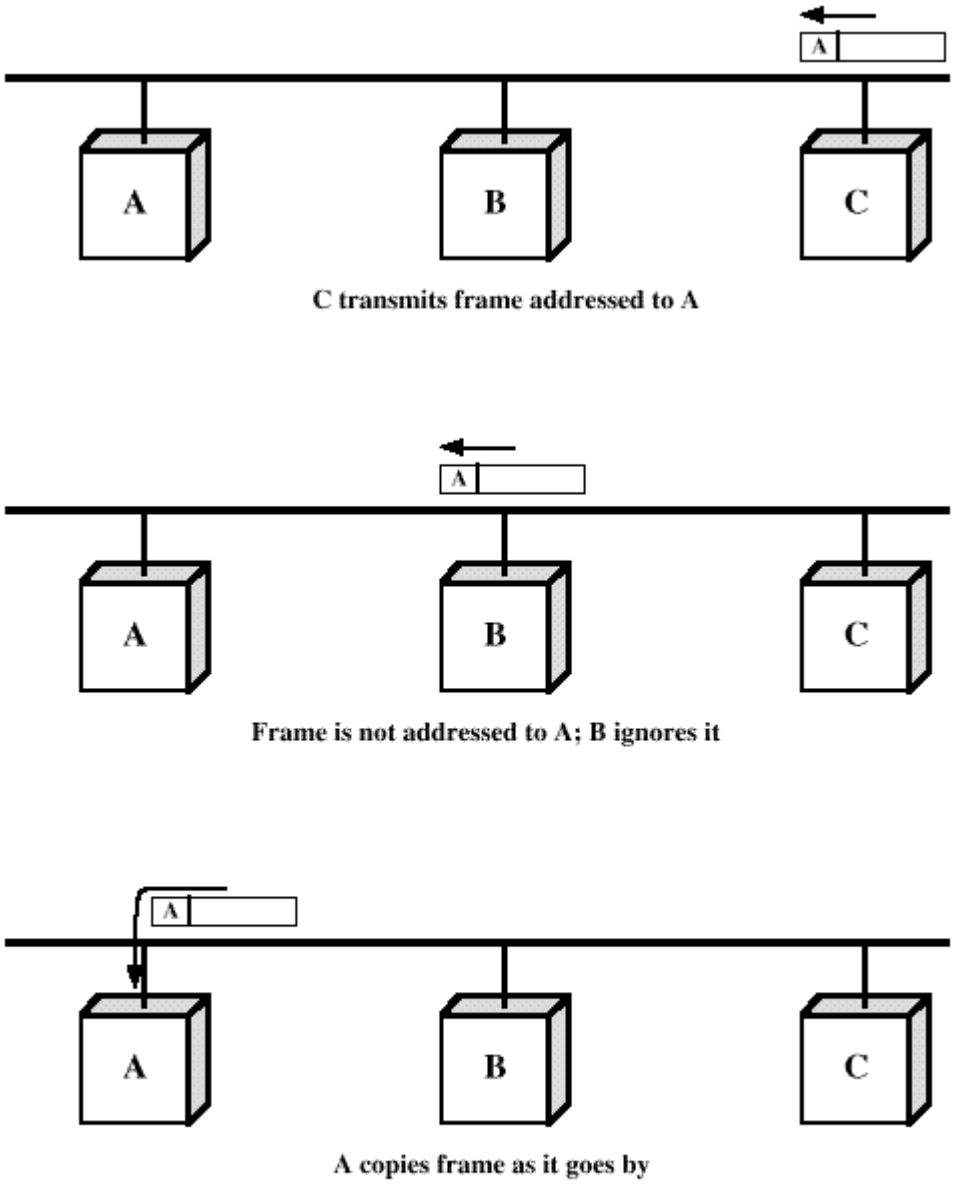


Figure 12.5 Frame Transmission on a Bus LAN

- Ring Topology
  - The network consists of a set of “repeaters” joined by point-to-point links in a closed loop.
  - Medium access control is needed

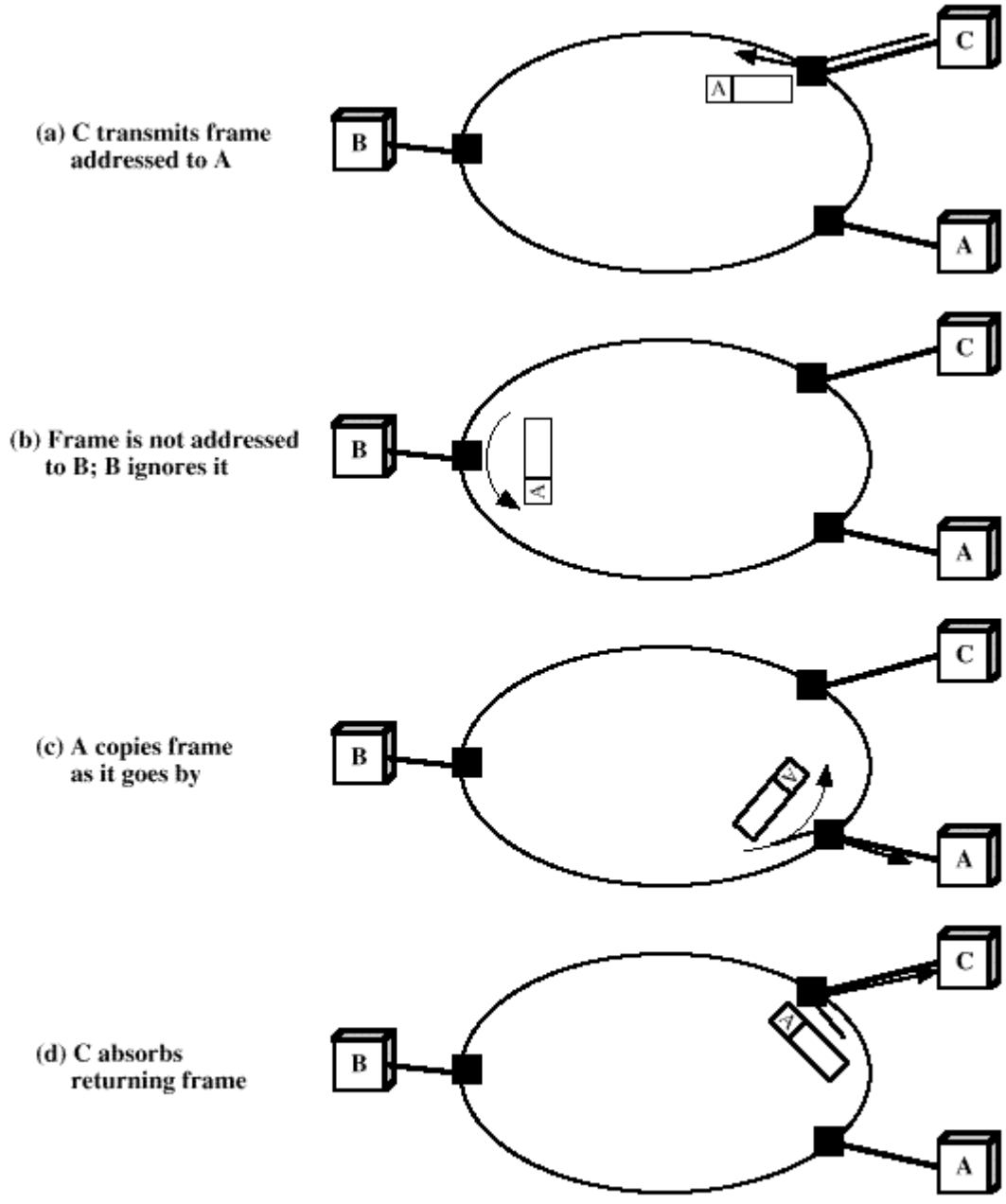


Figure 12.6 Frame Transmission on a Ring LAN

- Star Topology
  - Each station is directly connected to a common central node
  - Two alternatives
    - The central node operate as a broadcaster
    - The central node operate as a frame switch

- Medium Access Control
  - Some means of controlling access to the shared transmission medium is needed to provide for an orderly and efficient use of the network's transmission capacity ⇒ MAC protocol
  - Major issues are: WHERE and HOW
    - WHERE: either Centralized or Distributed
    - HOW: Synchronous or Asynchronous
      - Synchronous: FDM, synchronous TDM ⇒ not well used
      - Asynchronous: Round Robin, Reservation, Contention
  - Centralized vs. distributed access control
    - Advantages of centralized control
      - Easier to provide centralized control with priorities, etc.
      - Individual station logic is simple
      - Avoids problem of group coordination
    - Disadvantages
      - Less reliable
      - May become bottleneck and reduce efficiency
      - Overheads may be higher if propagation delay is high

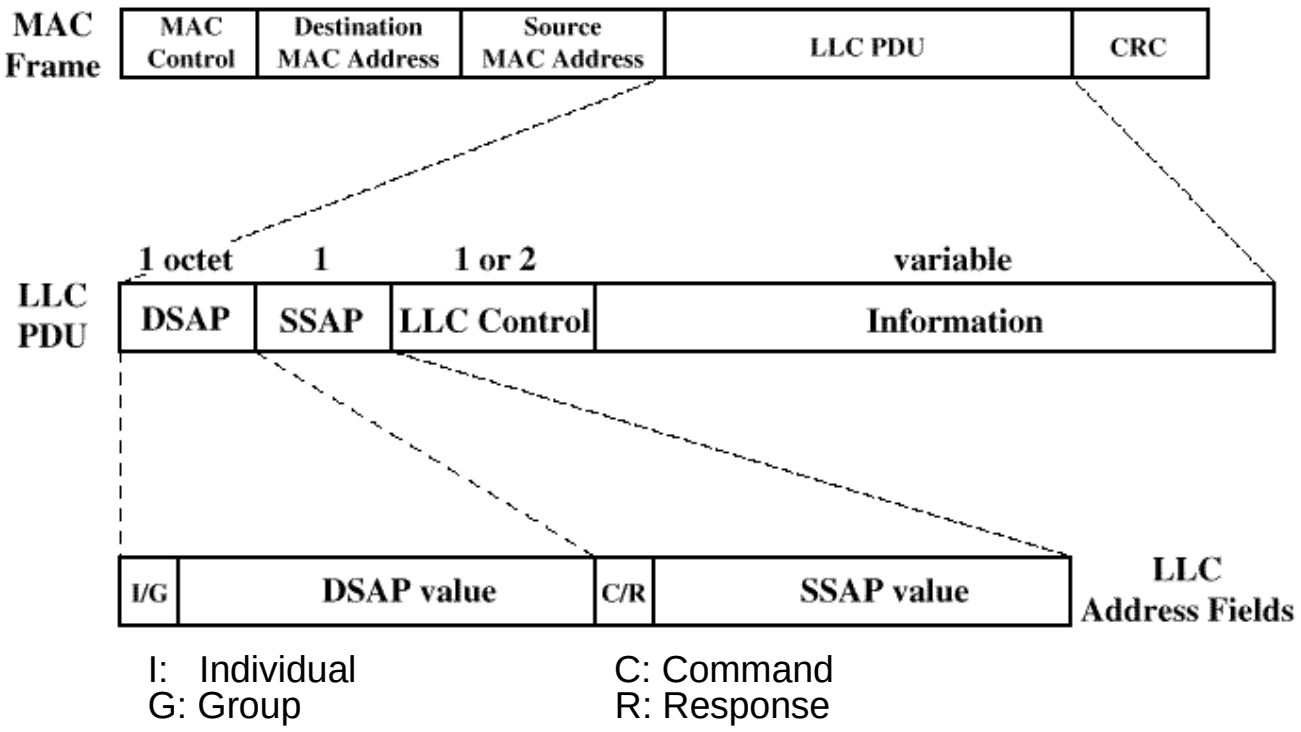
- Access Control Mechanisms
  - Round-Robin
    - Each station, in turn, is given opportunity to transmit. Either a central controller polls a station to permit to go, or stations can coordinate among themselves. “Token” is passed. Simple but overhead may be high when traffic
  - Reservation
    - Station wishing to transmit makes “reservations” for time slots in advance. Central or distributed.
  - Contention (Random Access)
    - No control on who tries; If “collision” occurs, retransmission after random timeout is attempted.

Standardized medium access control techniques

	Bus Topology	Ring Topology	Switched Topology
Round Robin	Token Bus (IEEE 802.4) Polling (IEEE 802.11)	Token Ring (IEEE 802.5; FDDI)	Request/priority (IEEE 802.12)
Reservation	DQDB (IEEE 802.6)		
Contention	CSMA/CD (IEEE 802.3) CSMA (IEEE 802.11)		CSMA/CD (IEEE 802.3)

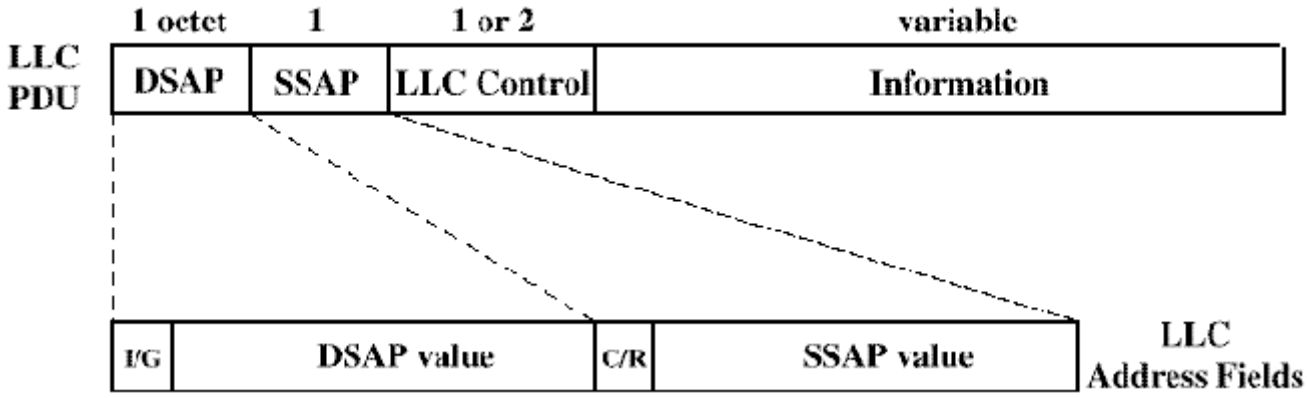
DQDB: Distributed-Queue, Dual Bus
FDDI: Fiber Distributed Data Interface

- MAC Frame Format
  - MAC control
    - Contains any protocol control information needed for the functioning of the MAC protocol. e.g., priority level.
  - Destination/Source MAC address
    - Destination/source physical attachment point on the LAN for this frame
  - LLC PDU
    - LLC data
  - CRC
    - Error detecting code



LLC PDU with generic MAC frame format

- Logical Link Control



- LLC Services/Protocols
  - Unacknowledged connectionless service (Type 1)
    - Datagram style service. No flow and error control mechanisms. Delivery of data is not guaranteed.
    - Unnumbered information PDU is used to transfer user data
  - Connection-mode service (Type 2)
    - A logical connection is setup, and flow and error control are provided.
    - The connection is uniquely identified by the pair of SAPs.
    - Information PDUs include send and receive sequence numbers for for sequencing and flow control. Supervisory PDUs are used for flow and error control.
  - Acknowledgement connectionless service
    - Acknowledged datagrams, but no prior logical connection is setup.
    - Each transmitted PDU is acknowledged. To guard against lost PDUs, 1-bit sequence number is used.

2. BUS/TREE LANS

- Multipoint transmission medium
  - Need medium access control technique
  - Signal balancing is difficult (compared to point-to-point)
- Most popular medium is coaxial cable
- Two transmission techniques used with coaxial cable
  - Baseband transmission
    - Uses digital signaling (e.g., Differential Manchester)
    - Bidirectional signal (e.g., Ethernet)
  - Broadband transmission
    - Analog signaling (e.g., FSK)
    - Unidirectional signal due to difficulty of building bidirectional amps at the same high frequency.

Transmission Techniques for Coaxial Cable Bus/Tree LANs

Baseband	Broadband
Digital signaling	Analog signaling (requires RF modem)
Entire bandwidth consumed by signal—no frequency division multiplexing (FDM)	FDM possible—multiple channels for data, video, audio
Bidirectional	Unidirectional
Bus topology	Bus or tree topology
Distance: up to a few kilometers	Distance: up to tens of kilometers

Baseband and Broadband Transmission Techniques

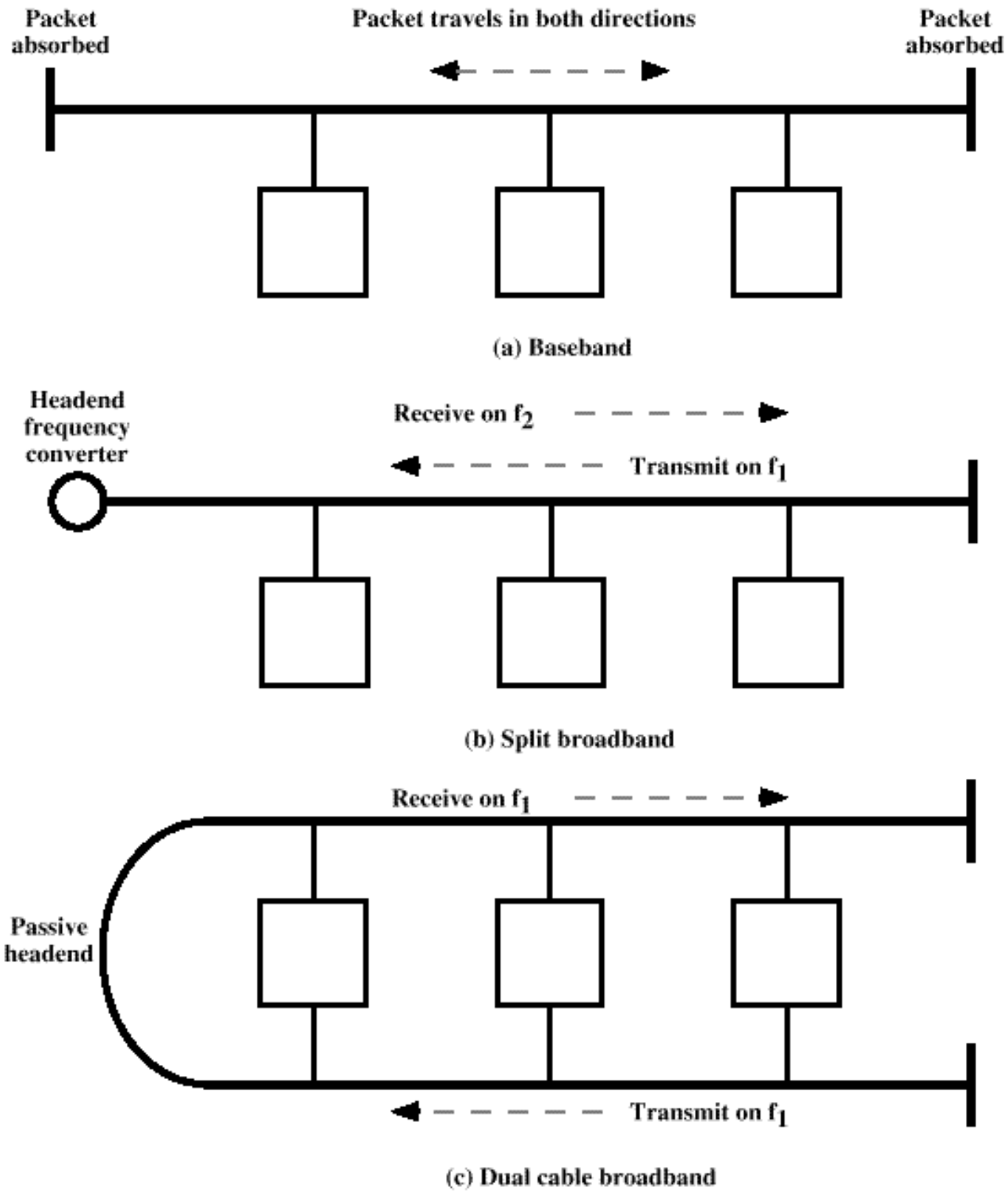


Table 12.4 IEEE 802.3 Specifications for 10-Mbps Baseband Coaxial Cable Bus LANs

	10BASE5	10BASE2
Data rate	10 Mbps	10 Mbps
Maximum Segment Length	500 m	185 m
Network Span	2500 m	1000 m
Nodes per Segment	100	30
Node Spacing	2.5 m	0.5 m
Cable Diameter	0.4 in	0.25 in

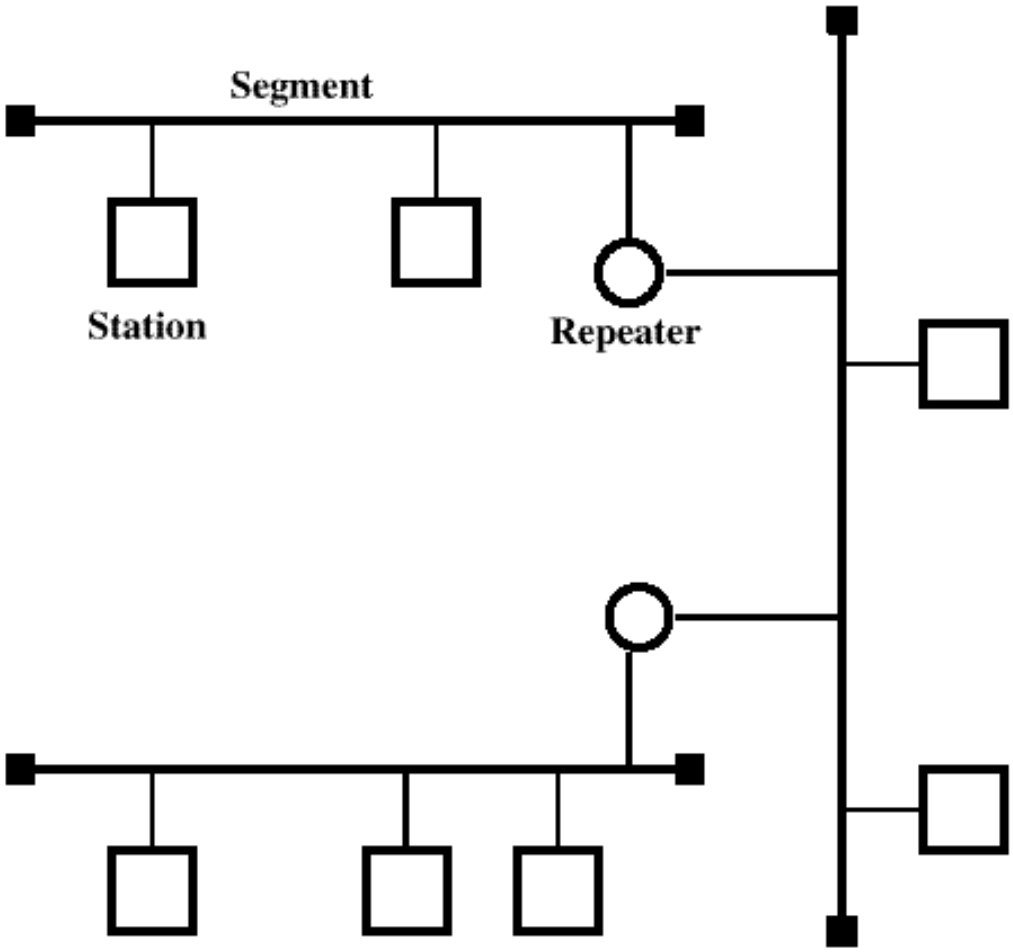


Figure 12.9 Baseband Configuration

- Optical Fiber Bus
  - Either active or passive taps can be used
  - Active tap
    - The bus consists of a chain of point-to-point links, and each node acts as a repeater.
    - The electronic complexity and interface cost are drawbacks.
  - Passive tap
    - The tap extracts a portion of the optical energy from the bus for reception and it injects directly into the medium for transmission.
    - The lossy nature of pure optical taps limits the number of devices and the length of the medium.

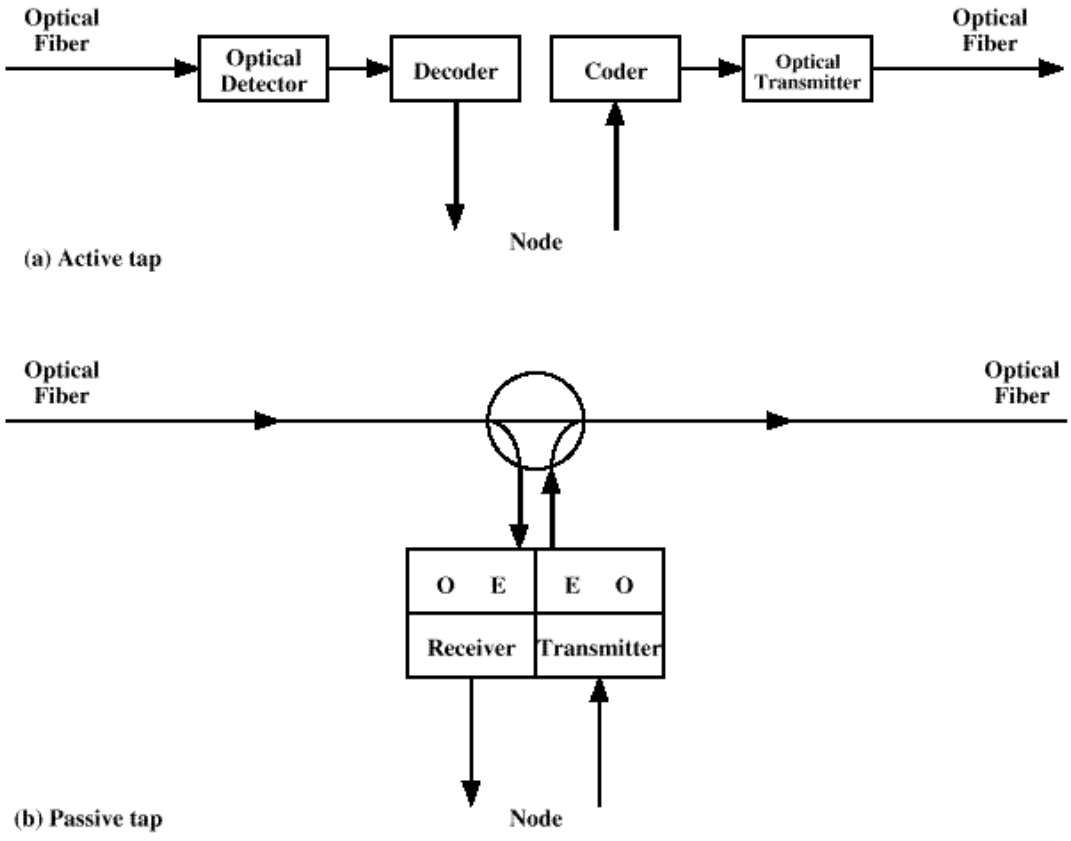


Figure 12.10 Optical fiber bus taps

– Optical fiber bus configurations
  - Single bus (loop bus) configuration
  - Two-bus configuration

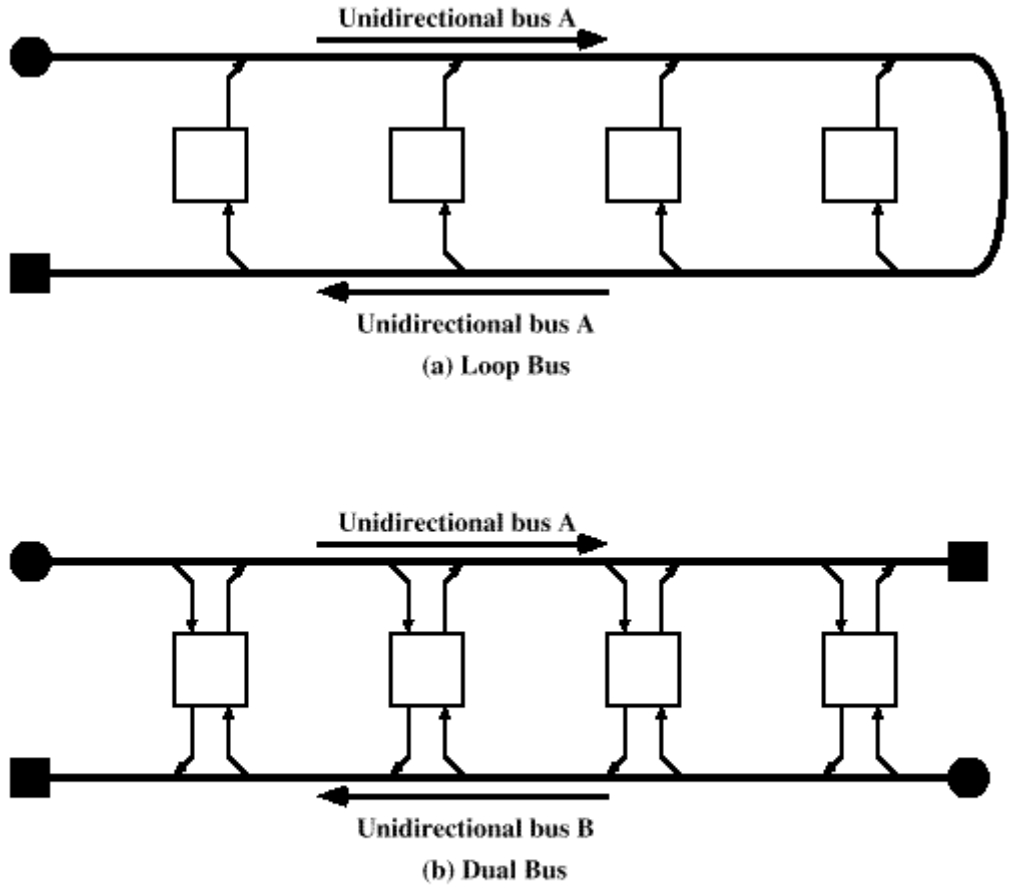
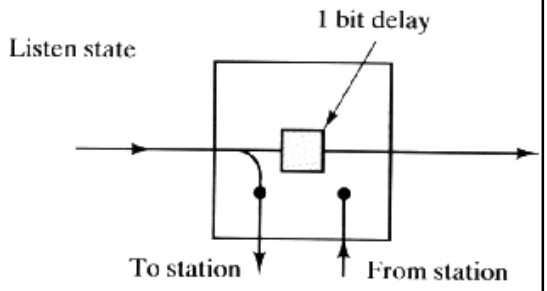
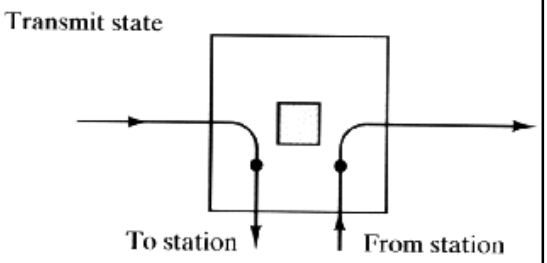


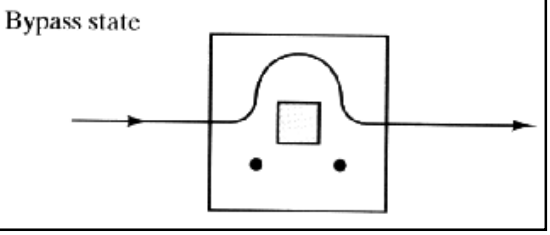
Figure 12.11 Optical Fiber Bus Configurations

3. RING LANs

- Stations connected to active repeaters; repeaters connected in a ring with serial point-to-point lines.
- Twisted pair, coax or fiberoptic cable usable as transmission medium
- Data insertion and data reception are performed by repeaters
- Data removal is performed by the transmitting repeater rather than the addressed repeater, for automatic acknowledgement and multicasting
- Repeater is in one of three states
  - Listen state: Each received bit is retransmitted with a small delay; Scan passing bit stream for particular patterns; Copy each incoming bit and send it to the attached station, while continuing to retransmit each bit; Modify a bit as it passes by.
  - Transmit state: Incoming bit is buffered or discarded; Bit from local host's packet is put out on the ring.
  - Bypass state: Repeater is inactive (due to some fault) and bypassed.

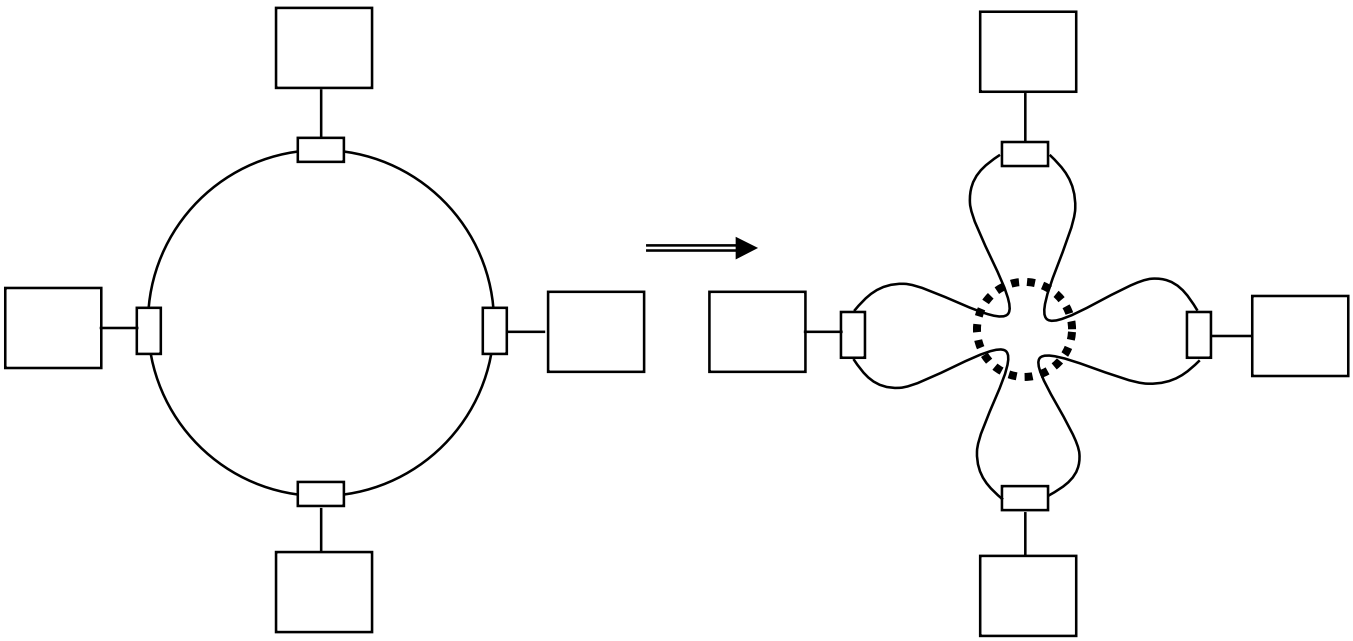






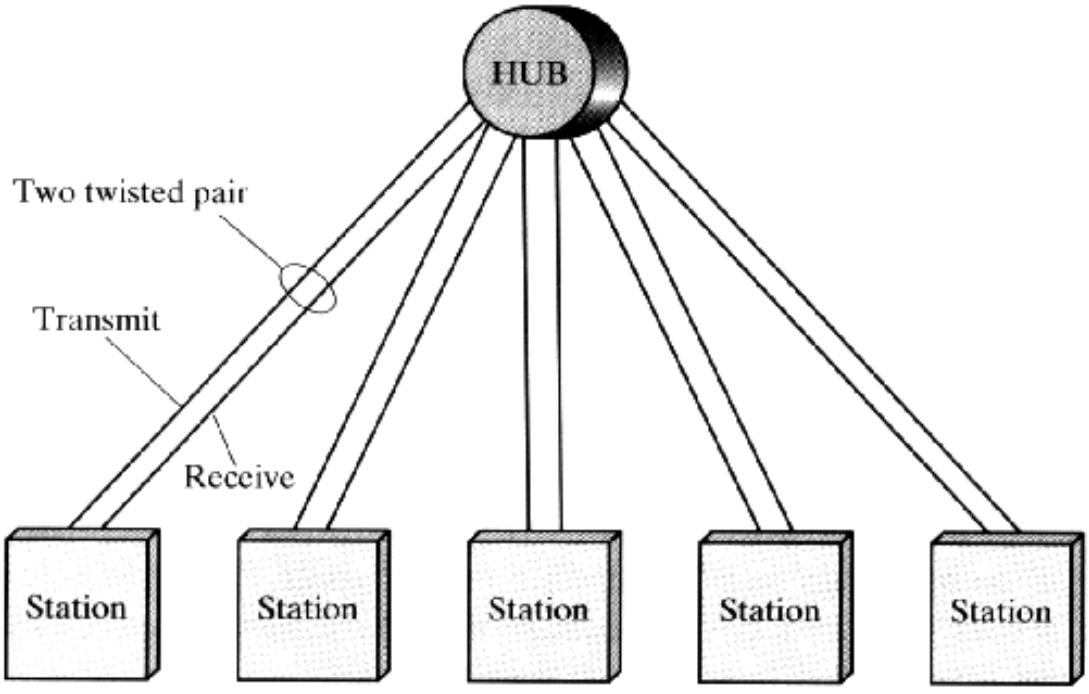
- Potential Ring Problems
  - A break in any link or the failure of a repeater disables the entire network
  - Installation of a new repeater to support new devices requires the identification of two nearby, topologically adjacent repeaters
  - Improvement with the Star-Ring schemes

- Star-Ring Architecture
  - Let all inter-repeater links thread through the single site; the ring wiring concentrator
  - Centralized access to all inter-repeater links makes it easy to locate the fault
  - Easier to add new stations to ring, etc.



4. STAR LANs

- Twisted Pair Star LANs
  - Unshielded twisted pair in a star-wiring arrangement
  - The “hub” acts as a repeater; When a single station transmits, the hub repeats the signal on all outgoing lines; Physically star, but logically bus.
  - Multiple level of hubs can be cascaded in a hierarchical configuration; still logically a bus



Twisted-pair star topology

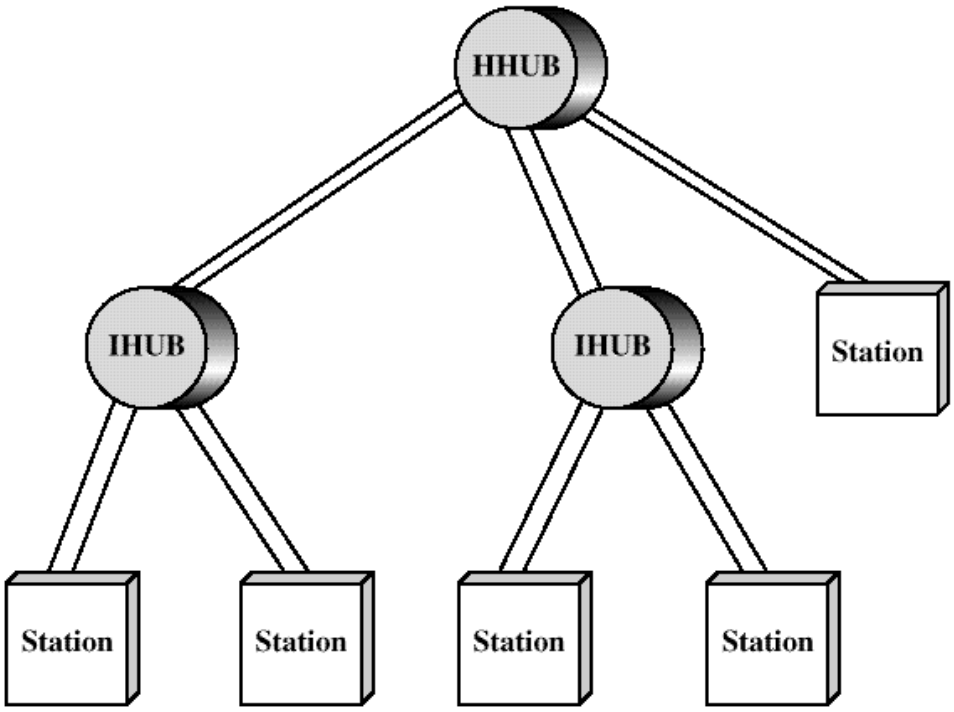
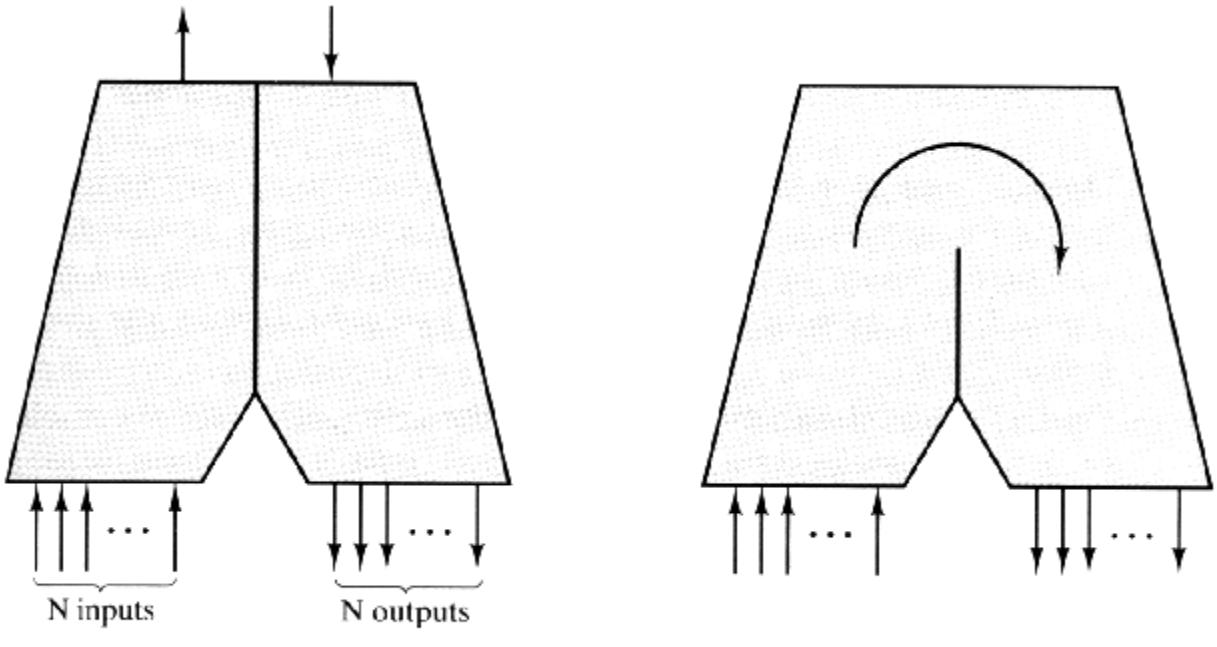


Figure 12.14 Two-Level Twisted-Pair Star Topology



(a) Intermediate hub

(b) Header hub

- Optical Fiber Star
  - Passive star coupler, which connect N input and N output fibers is used for the optical fiber LANs.
  - Light that is input to one of the fibers is equally divided among, and output through, all the N output fibers.
  - Thus, physically a star, but logically a bus.

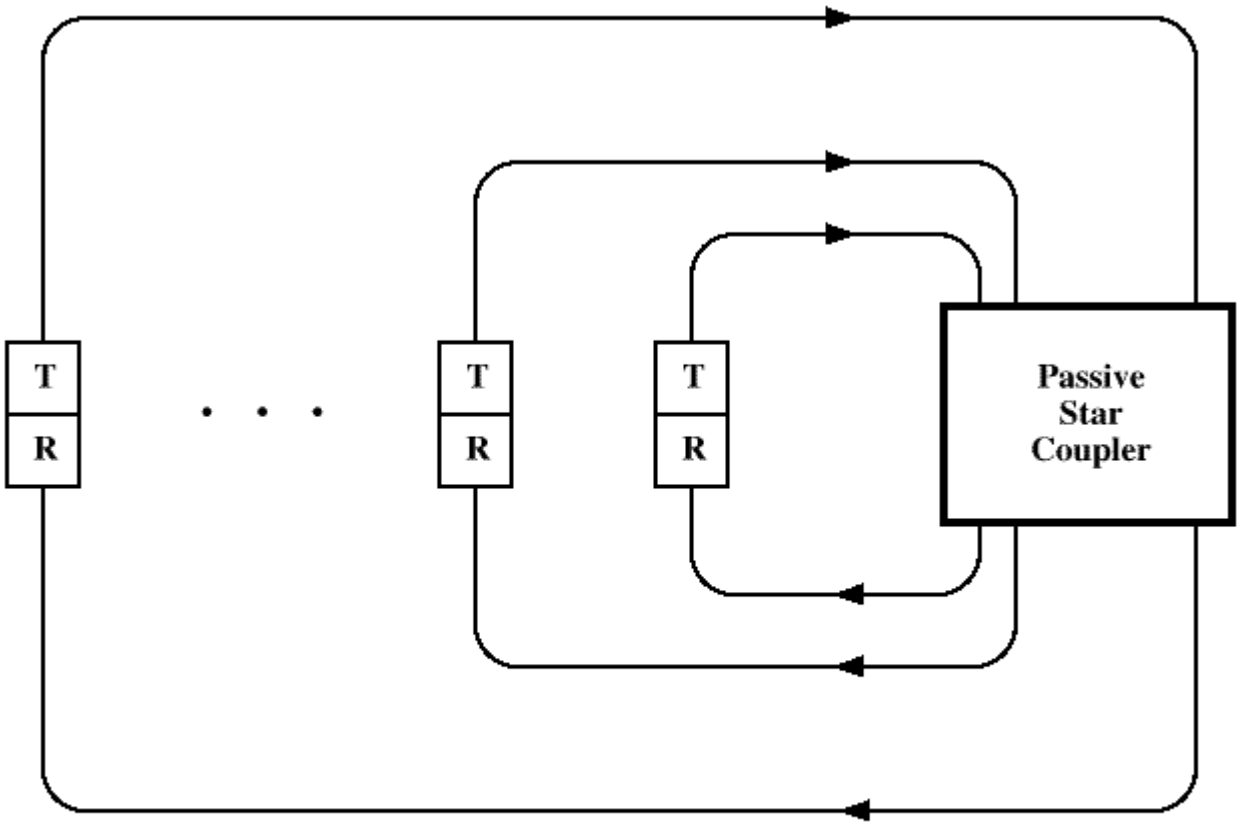


Figure 12.16 Optical Fiber Passive Star Configuration

5. WIRELESS LANs

- Wireless transmission medium is used
- Applications
  - LAN Extension
  - Cross-Building Interconnect
  - Nomadic Access
  - Ad Hoc Networking

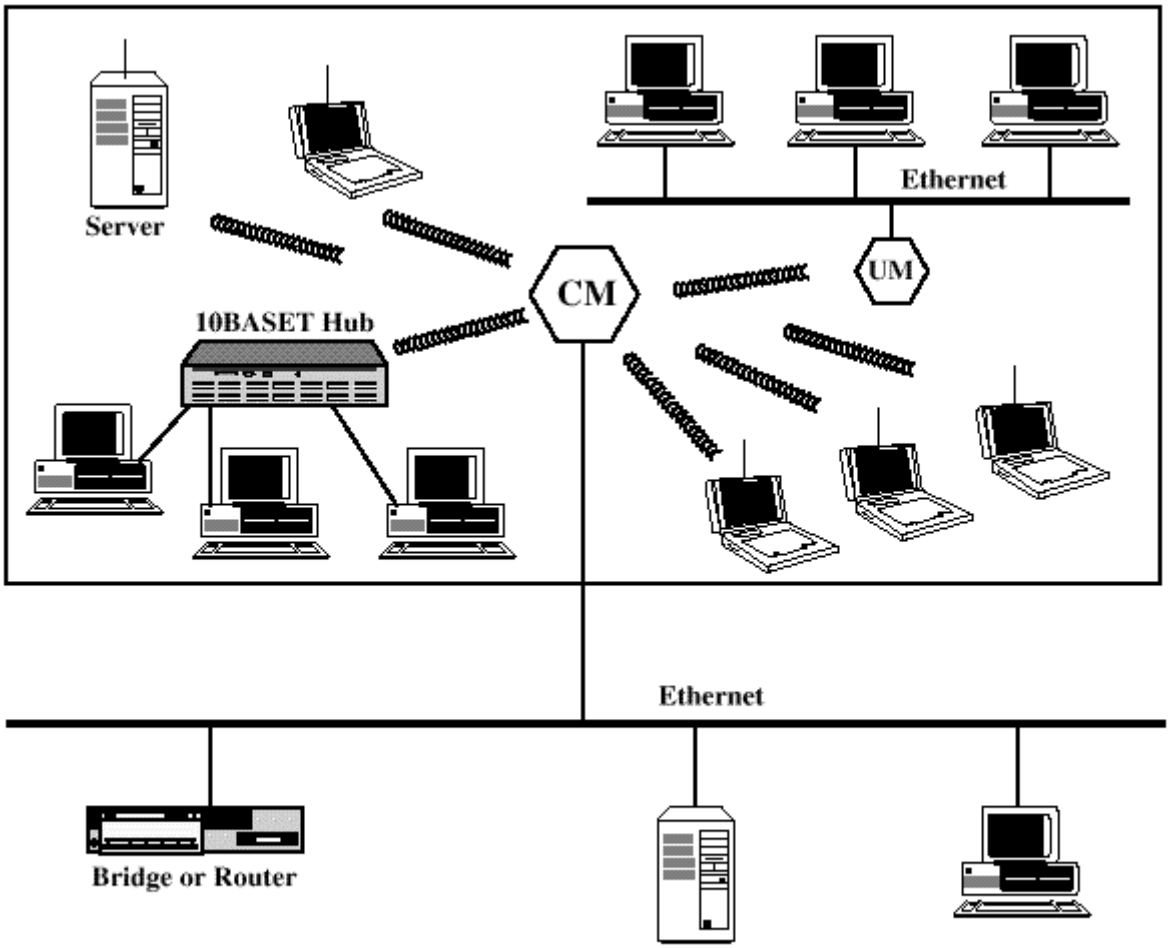


Figure 12.17 Example Single-Cell Wireless LAN Configuration

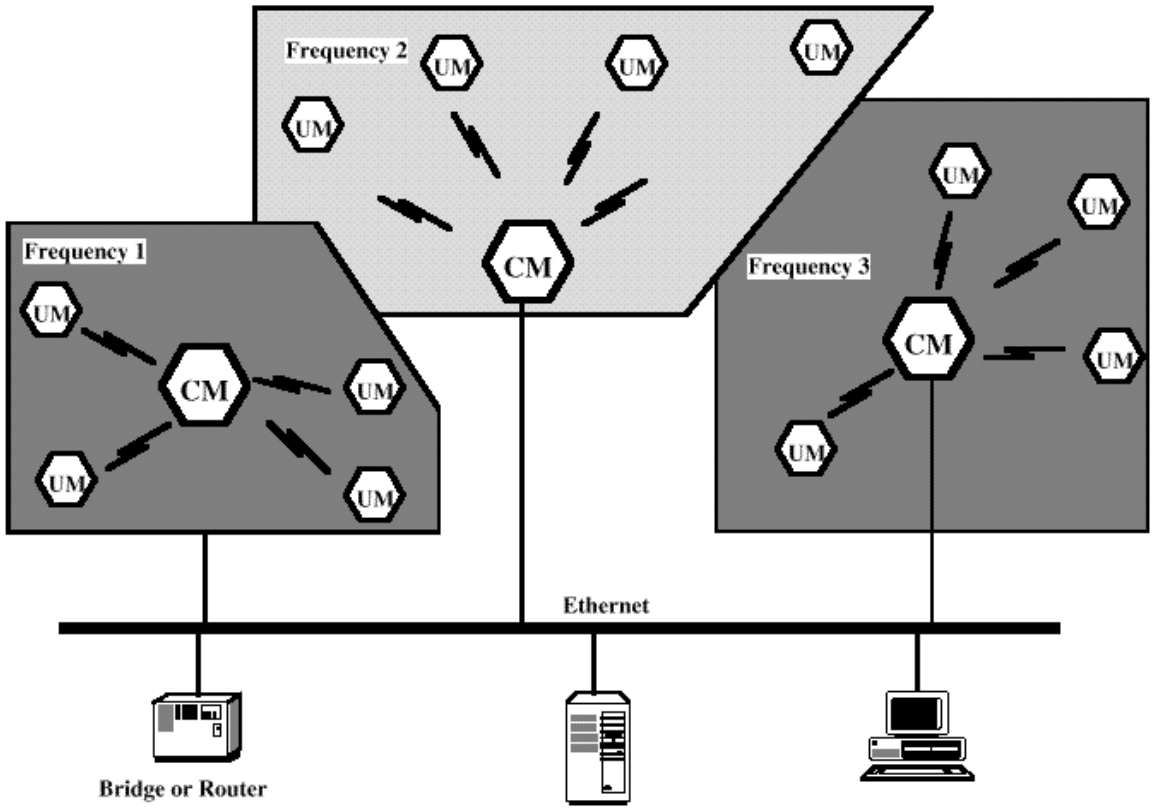
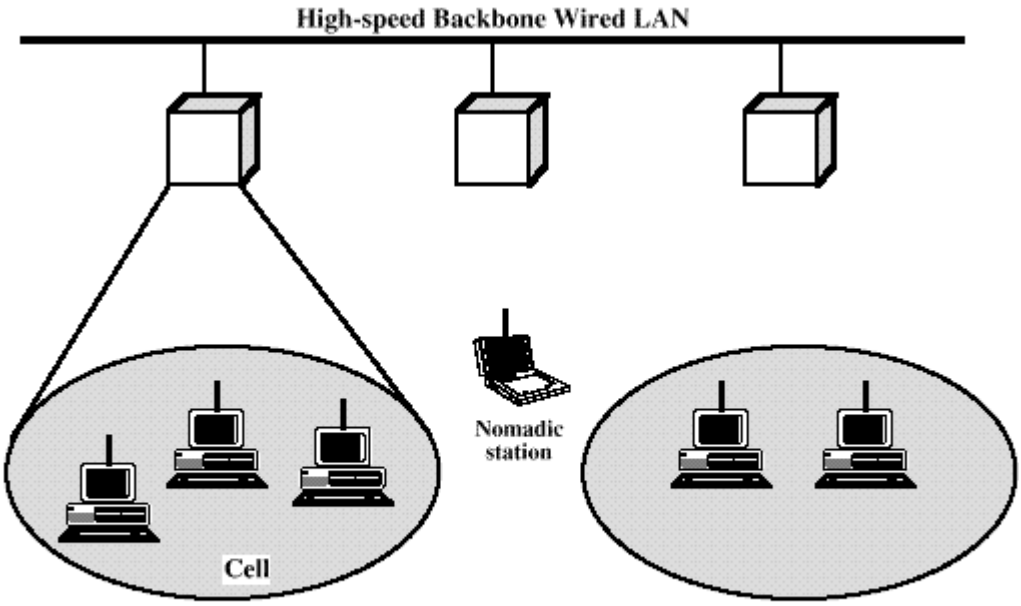
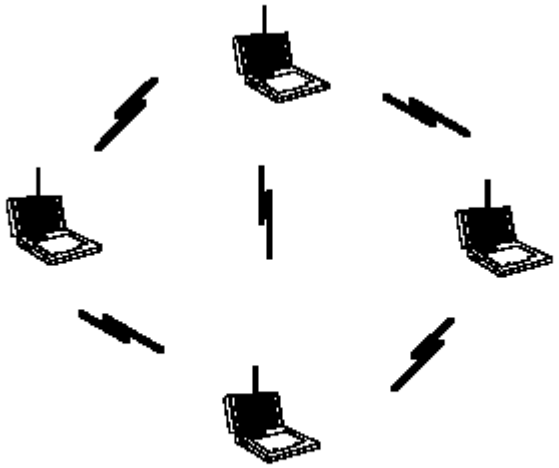


Figure 12.18 Example Multiple-Cell Wireless LAN Configuration

- Wireless LAN Requirements
  - Throughput
  - Number of nodes
  - Service area
  - Battery power consumption
  - Transmission robustness and security
  - Collocated network operation
  - License-free operation
  - Handoff/roaming
  - Dynamic configuration



(a) Infrastructure Wireless LAN



(b) Ad hoc LAN

Figure 12.19 Wireless LAN Configurations