ET4254 – Communications and Networking 1

Topic 10:- Local Area Network Overview

Aims:-

- LAN topologies and media
- LAN protocol architecture
- bridges, hubs, layer 2 & 3 switches

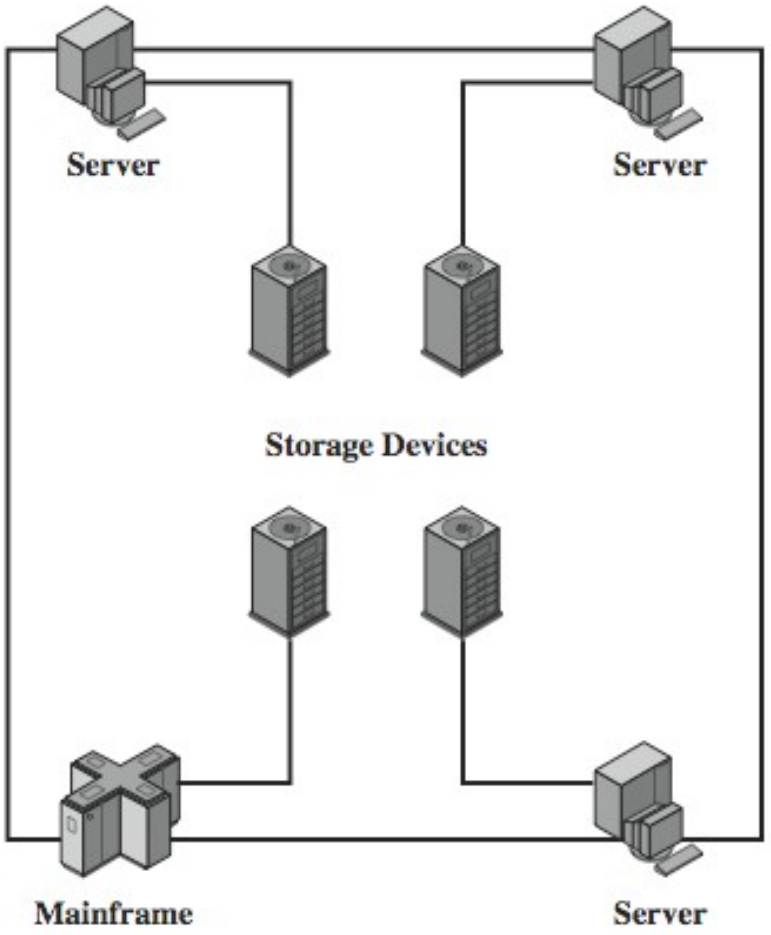
LAN Applications (1)

- personal computer LANs
  - low cost
  - limited data rate
- back end networks
  - interconnecting large systems (mainframes and large storage devices)
    - *high data rate*
    - *high speed interface*
    - *distributed access*
    - *limited distance*
    - *limited number of devices*

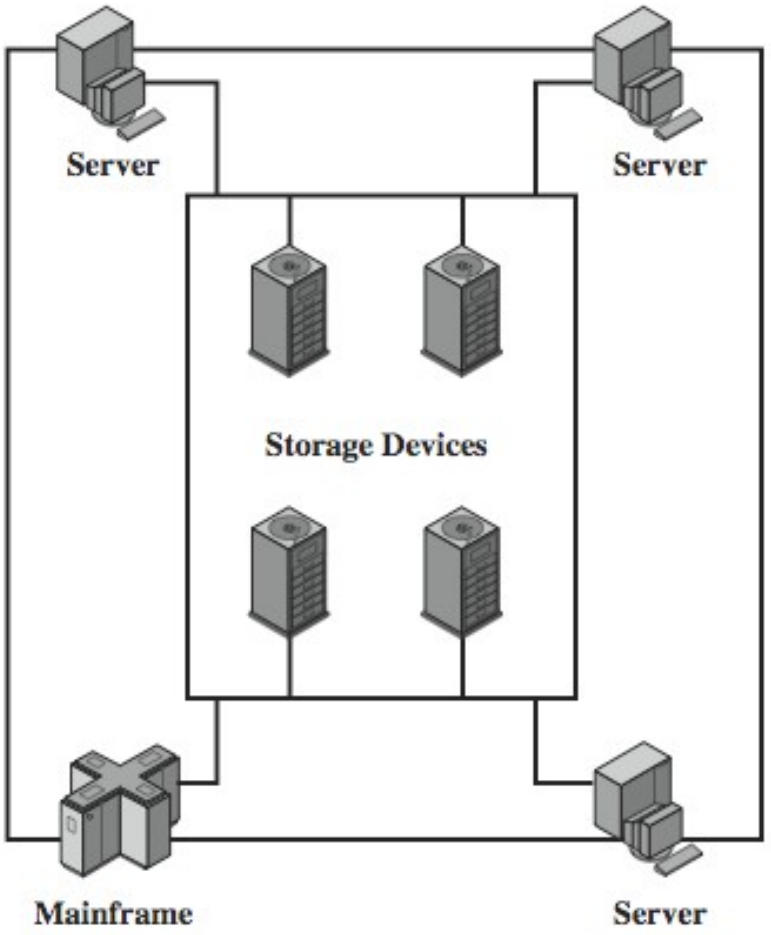
LAN Applications (2)

- storage area networks (SANs)
  - separate network handling storage needs
  - detaches storage tasks from specific servers
  - shared storage facility
    - *eg. hard disks, tape libraries, CD arrays*
  - accessed using a high-speed network
    - *eg. Fibre Channel*
  - improved client-server storage access
  - direct storage to storage communication for backup

Storage Area Networks



(a) Server-based storage



(b) Storage area network

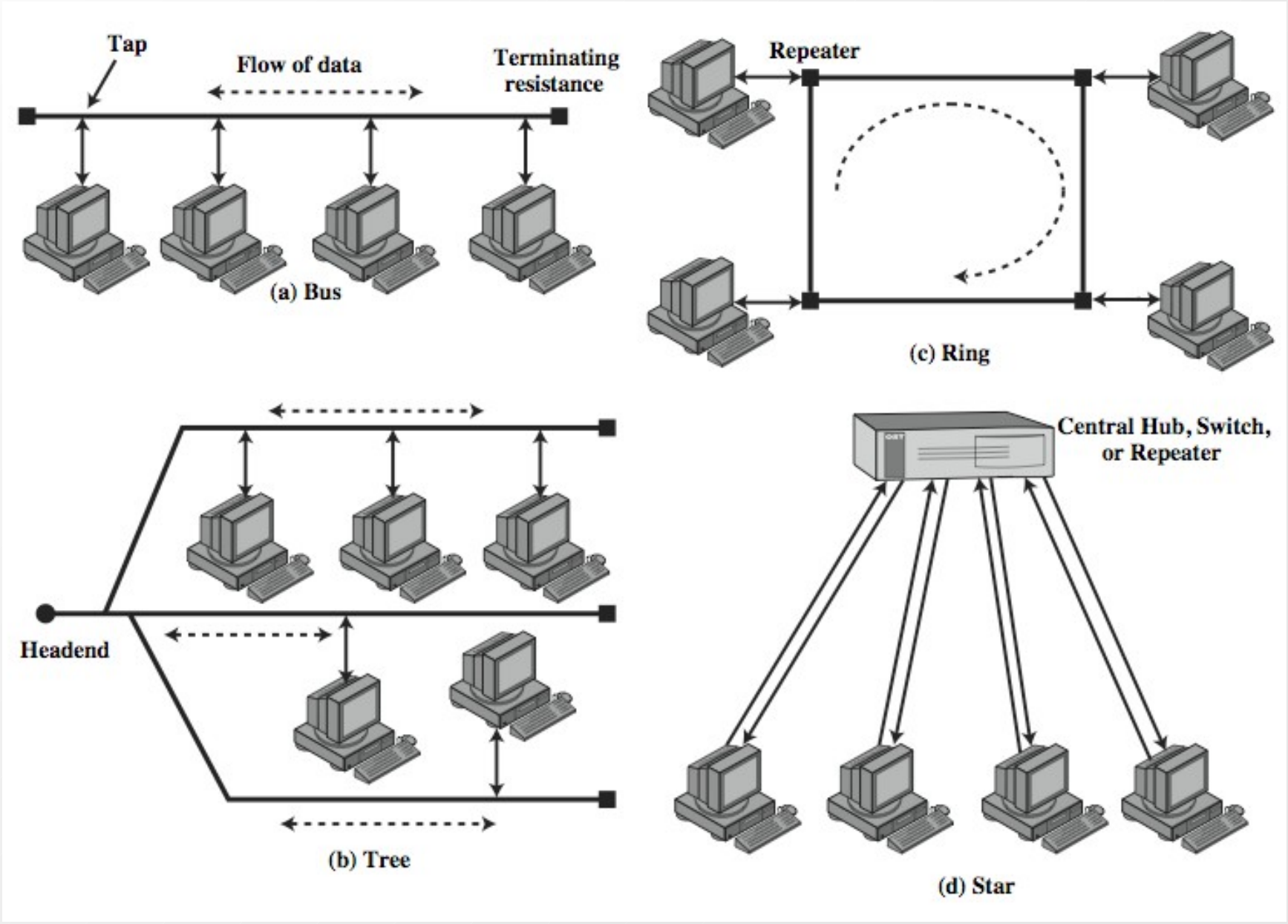
LAN Applications (3)

- high speed office networks
  - desktop image processing
  - high capacity local storage
- backbone LANs
  - interconnect low speed local LANs
  - reliability
  - capacity
  - cost

LAN Architecture

- topologies
- transmission medium
- layout
- medium access control

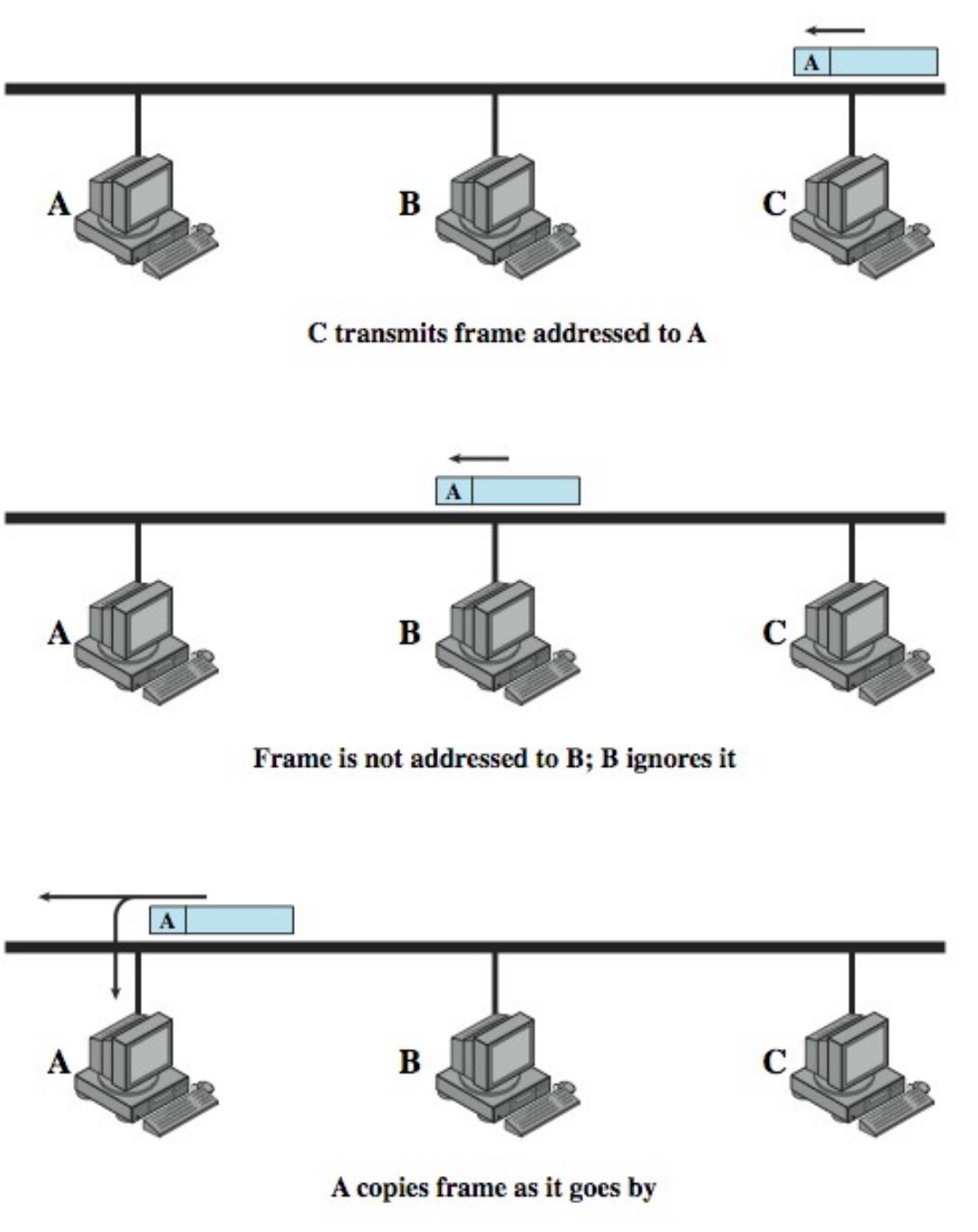
LAN Topologies



Bus and Tree

- used with multipoint medium
- transmission propagates throughout medium
- heard by all stations
- full duplex connection between station and tap
  - allows for transmission and reception
- need to regulate transmission
  - to avoid collisions and hogging
- terminator absorbs frames at end of medium
- tree a generalization of bus
- headend connected to branching cables

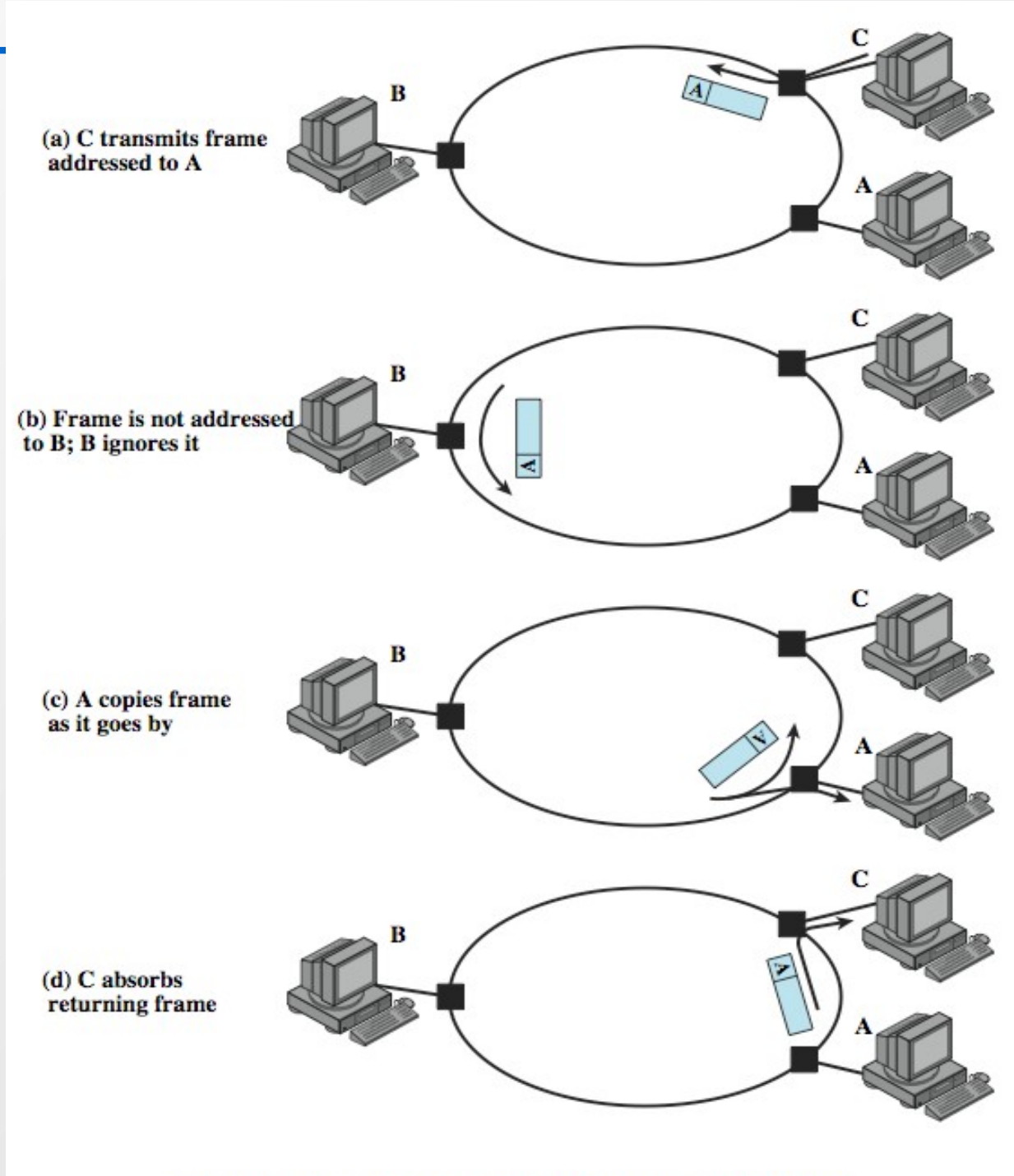
Frame Transmission on Bus LAN



Ring Topology

- a closed loop of repeaters joined by point to point links
- receive data on one link & retransmit on another
  - links unidirectional
  - stations attach to repeaters
- data in frames
  - circulate past all stations
  - destination recognizes address and copies frame
  - frame circulates back to source where it is removed
- media access control determines when a station can insert frame

Frame Transmission Ring LAN



Star Topology

- each station connects to central node
  - usually via two point to point links
- either central node can broadcast
  - physical star, logical bus
  - only one station can transmit at a time
- or central node can act as frame switch

Choice of Topology

- reliability
- expandability
- performance
- needs considering in context of:
  - medium
  - wiring layout
  - access control

Bus LAN Transmission Media (1)

- twisted pair
  - early LANs used voice grade cable
  - didn’t scale for fast LANs
  - not used in bus LANs now
- baseband coaxial cable
  - uses digital signalling
  - original Ethernet

Bus LAN Transmission Media (2)

- broadband coaxial cable
  - as in cable TV systems
  - analog signals at radio frequencies
  - expensive, hard to install and maintain
  - no longer used in LANs
- optical fiber
  - expensive taps
  - better alternatives available
  - not used in bus LANs
- less convenient compared to star topology twisted pair
- coaxial baseband still used but not often in new installations

Ring and Star Usage

- ring
  - very high speed links over long distances
  - single link or repeater failure disables network
- star
  - uses natural layout of wiring in building
  - best for short distances
  - high data rates for small number of devices

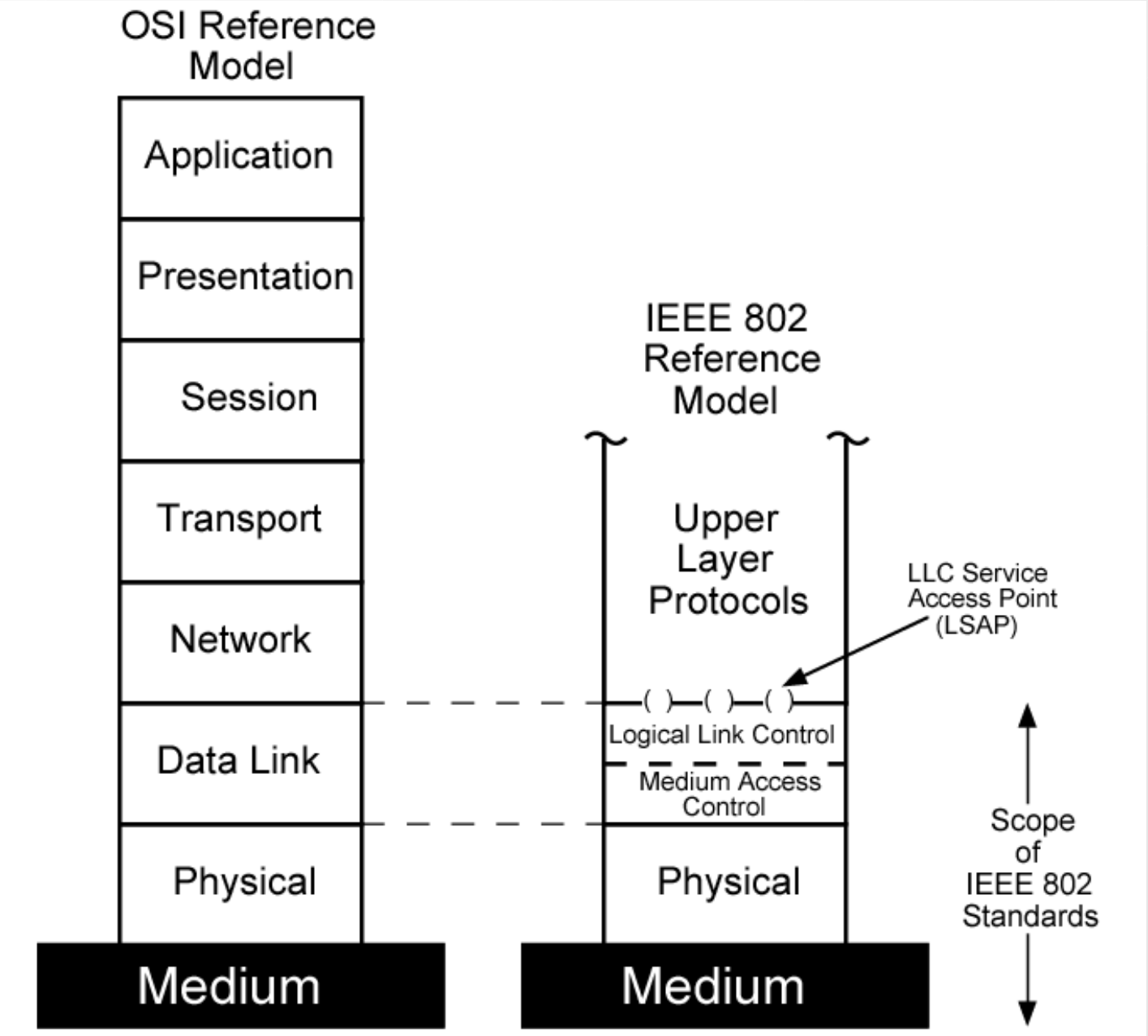
Choice of Medium

- constrained by LAN topology
- capacity
- reliability
- types of data supported
- environmental scope

Media Available

- Voice grade unshielded twisted pair (UTP)
  - Cat 3 phone, cheap, low data rates
- Shielded twisted pair / baseband coaxial
  - more expensive, higher data rates
- Broadband cable
  - even more expensive, higher data rate
- High performance UTP
  - Cat 5+, very high data rates, witched star topology
- Optical fibre
  - security, high capacity, small size, high cost

LAN Protocol Architecture



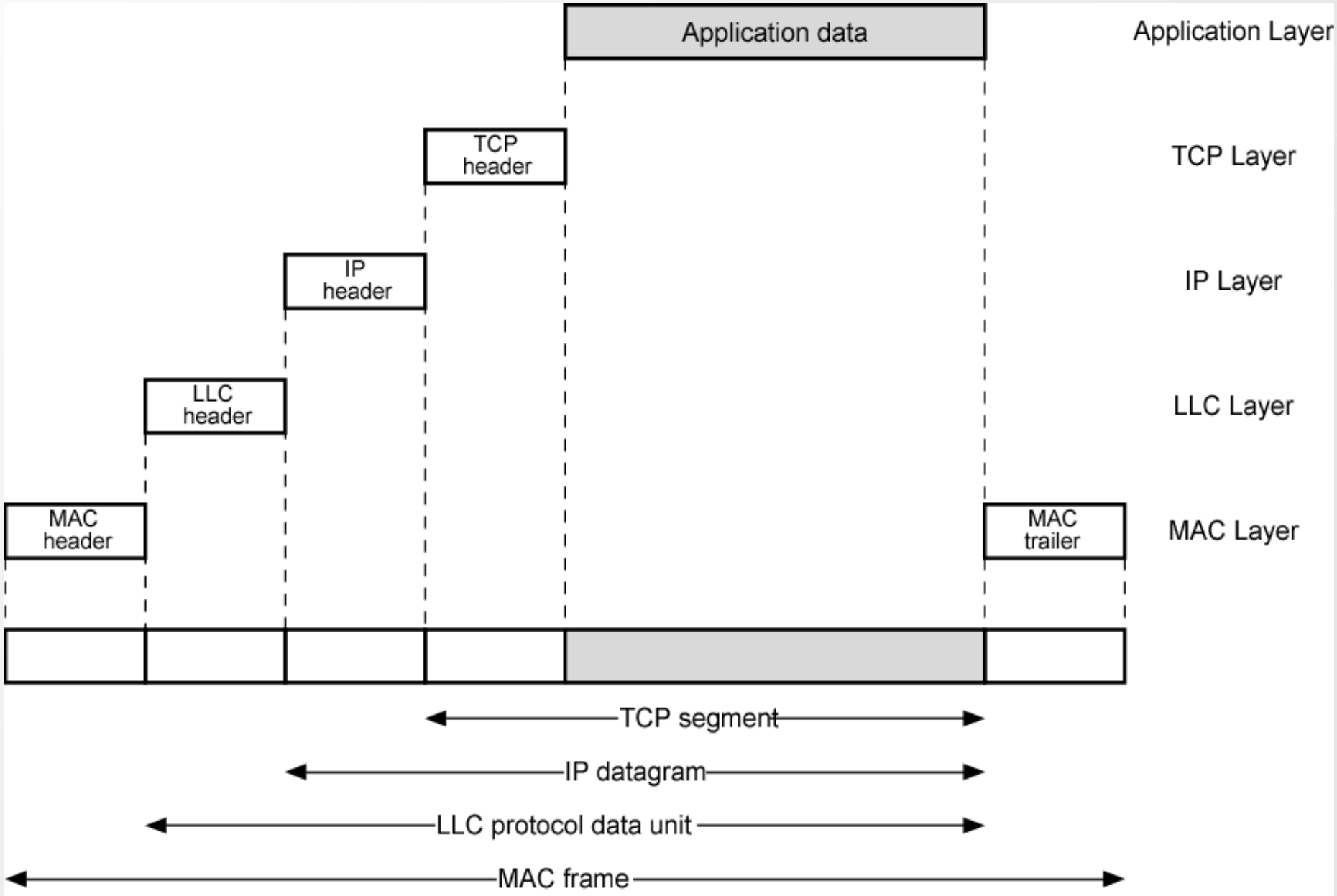
IEEE 802 Layers (1)

- Physical
  - encoding/decoding of signals
  - preamble generation/removal
  - bit transmission/reception
  - transmission medium and topology

IEEE 802 Layers (2)

- Logical Link Control
  - interface to higher levels
  - flow and error control
- Media Access Control
  - on transmit assemble data into frame
  - on receive disassemble frame
  - govern access to transmission medium
  - for same LLC, may have several MAC options

LAN Protocols in Context



Logical Link Control

- transmission of link level PDUs between stations
- must support multiaccess, shared medium
- but MAC layer handles link access details
- addressing involves specifying source and destination LLC users
  - referred to as service access points (SAP)
  - typically higher level protocol

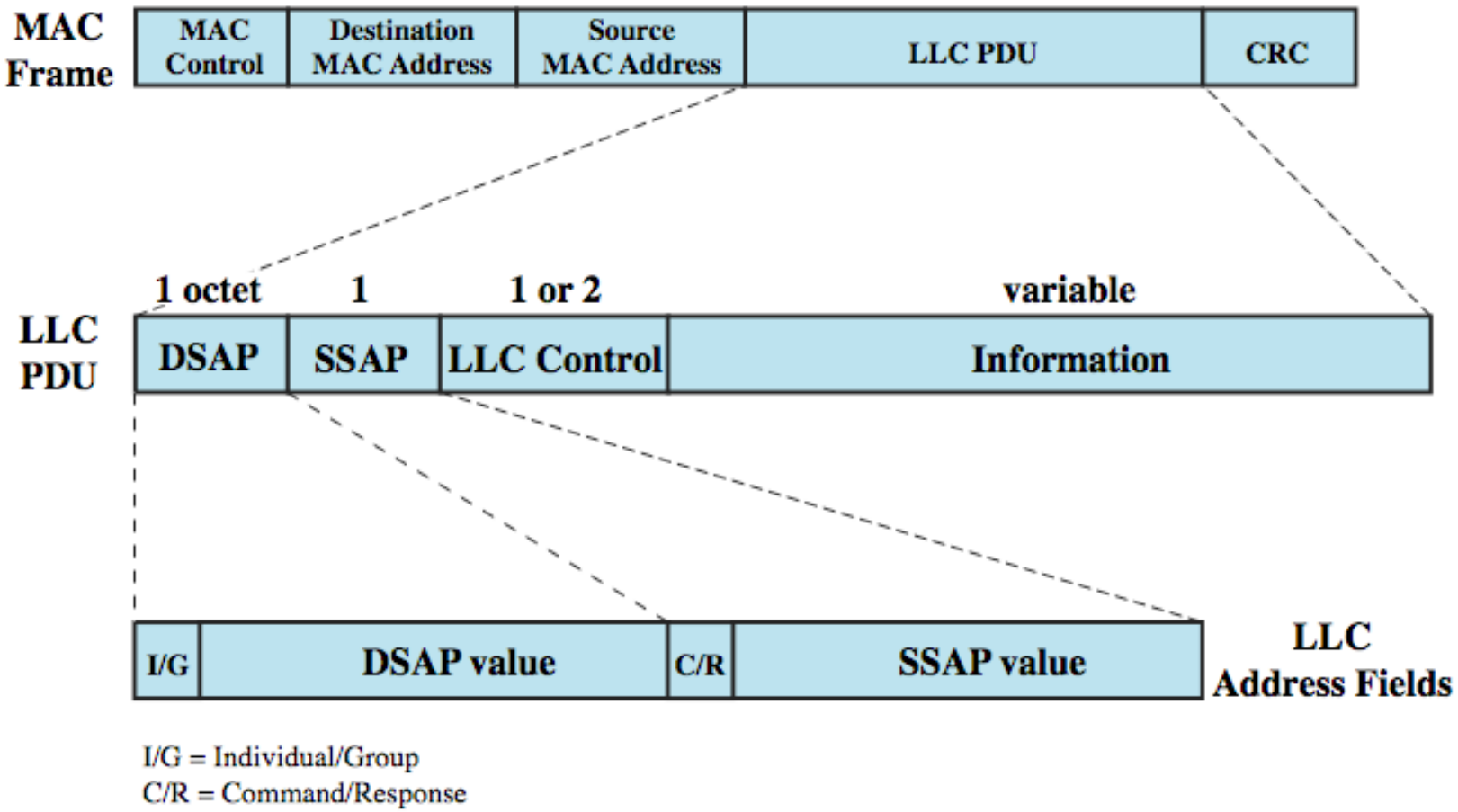
LLC Services

- based on HDLC
- unacknowledged connectionless service
- connection mode service
- acknowledged connectionless service

LLC Protocol

- modeled after HDLC
- asynchronous balanced mode
  - connection mode (type 2) LLC service
- unacknowledged connectionless service
  - using unnumbered information PDUs (type 1)
- acknowledged connectionless service
  - using 2 new unnumbered PDUs (type 3)
- permits multiplexing using LSAPs

MAC Frame Format



Media Access Control

- where
  - central
    - *greater control, single point of failure*
  - distributed
    - *more complex, but more redundant*
- how
  - synchronous
    - *capacity dedicated to connection, not optimal*
  - asynchronous
    - *in response to demand*

Asynchronous Systems

- round robin
  - each station given turn to transmit data
- reservation
  - divide medium into slots
  - good for stream traffic
- contention
  - all stations contend for time
  - good for bursty traffic
  - simple to implement
  - tends to collapse under heavy load

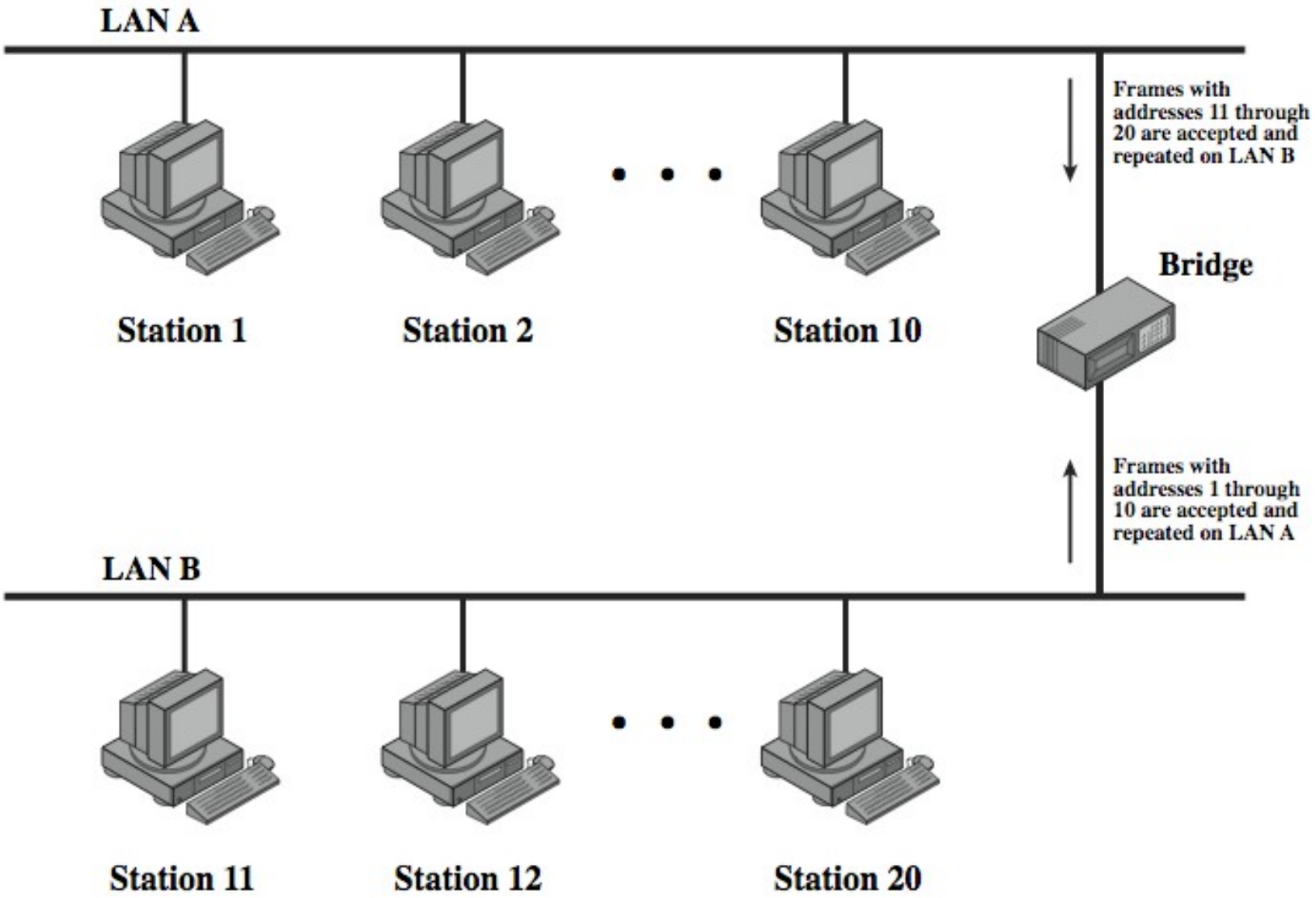
MAC Frame Handling

- MAC layer receives data from LLC layer
- fields
  - MAC control
  - destination MAC address
  - source MAC address
  - LLC
  - CRC
- MAC layer detects errors and discards frames
- LLC optionally retransmits unsuccessful frames

Bridges

- connects similar LANs
- identical physical / link layer protocols
- minimal processing
- can map between MAC formats
- reasons for use
  - reliability
  - performance
  - security
  - geography

Bridge Function



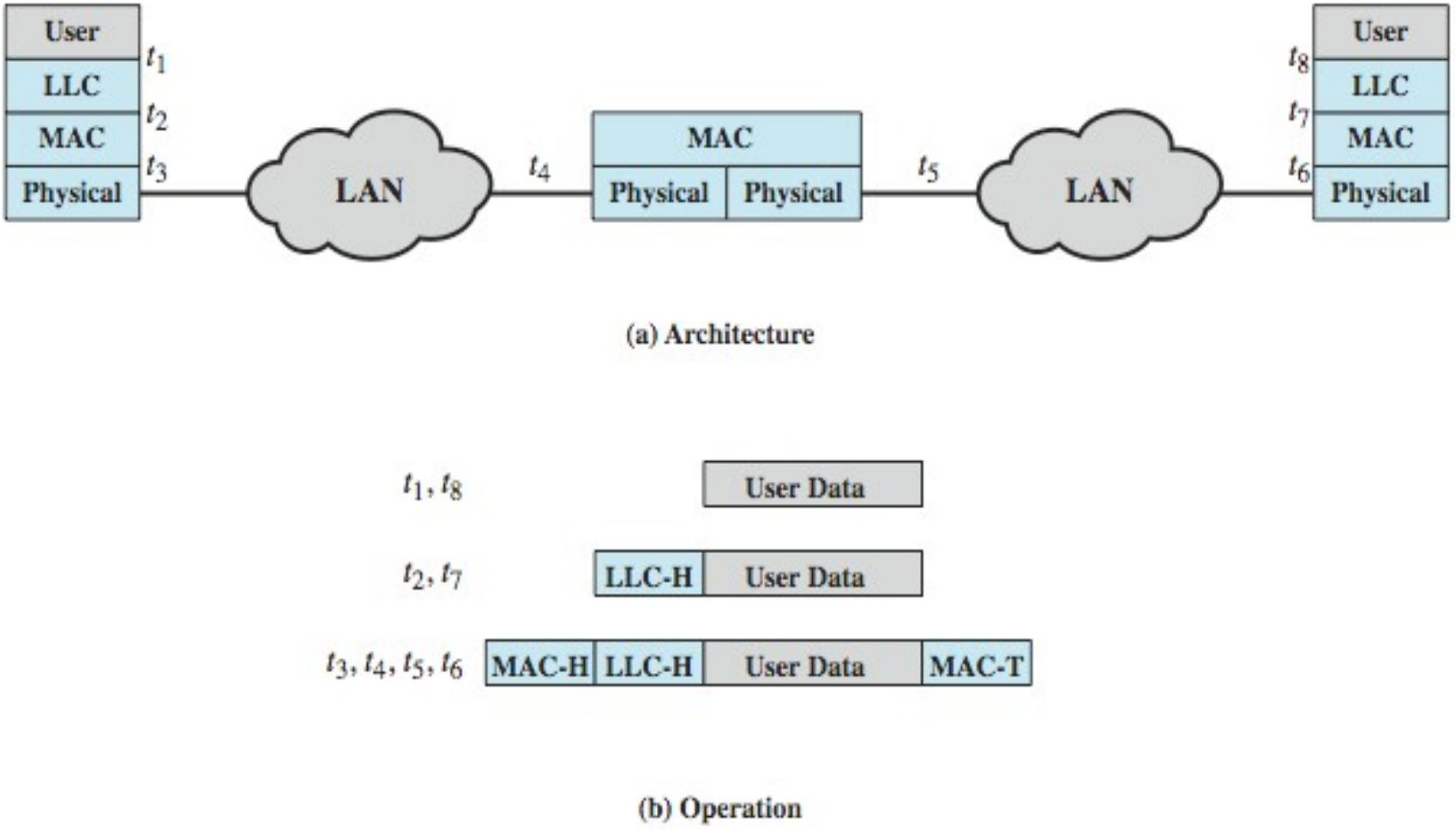
Bridge Design Aspects

- no modification to frame content or format
- no encapsulation
- exact bitwise copy of frame
- minimal buffering to meet peak demand
- contains routing and address intelligence
- may connect more than two LANs
- bridging is transparent to stations

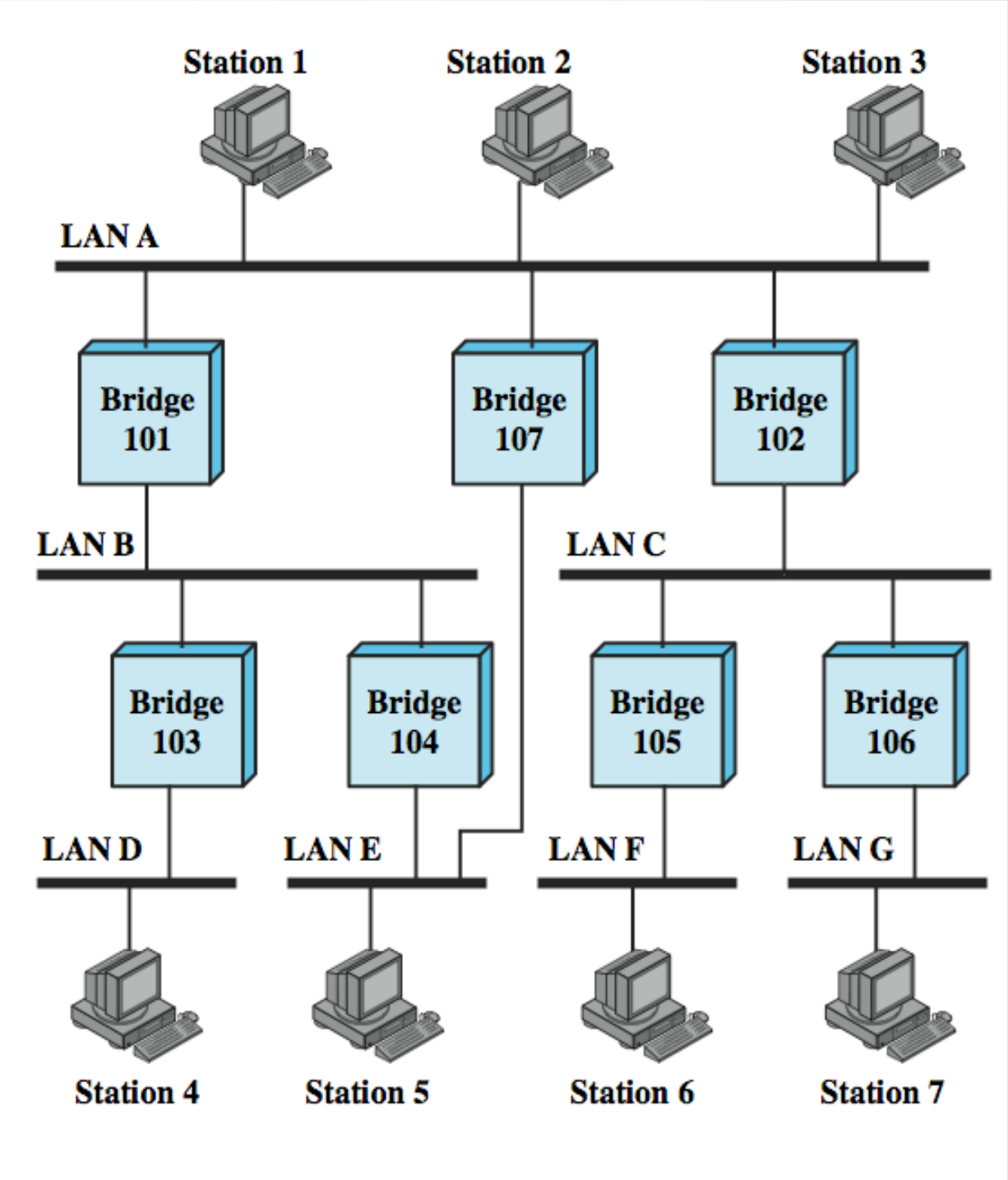
Bridge Protocol Architecture

- IEEE 802.1D
- MAC level
- bridge does not need LLC layer
- can pass frame over external comms system
  - capture frame
  - encapsulate it
  - forward it across link
  - remove encapsulation and forward over LAN link
  - e.g. WAN link

Connection of Two LANs



Bridges and LANs with Alternative Routes



Fixed Routing

- complex large LANs need alternative routes
  - for load balancing and fault tolerance
- bridge must decide whether to forward frame
- bridge must decide LAN to forward frame to
- can use fixed routing for each source-destination pair of LANs
  - done in configuration
  - usually least hop route
  - only changed when topology changes
  - widely used but limited flexibility

Spanning Tree

- bridge automatically develops routing table
- automatically updates routing table in response to changes
- three mechanisms:
  - frame forwarding
  - address learning
  - loop resolution

Frame Forwarding

- maintain forwarding database for each port
  - lists station addresses reached through each port
- for a frame arriving on port X:
  - search forwarding database to see if MAC address is listed for any port except X
  - if address not found, forward to all ports except X
  - if address listed for port Y, check port Y for blocking or forwarding state
  - if not blocked, transmit frame through port Y

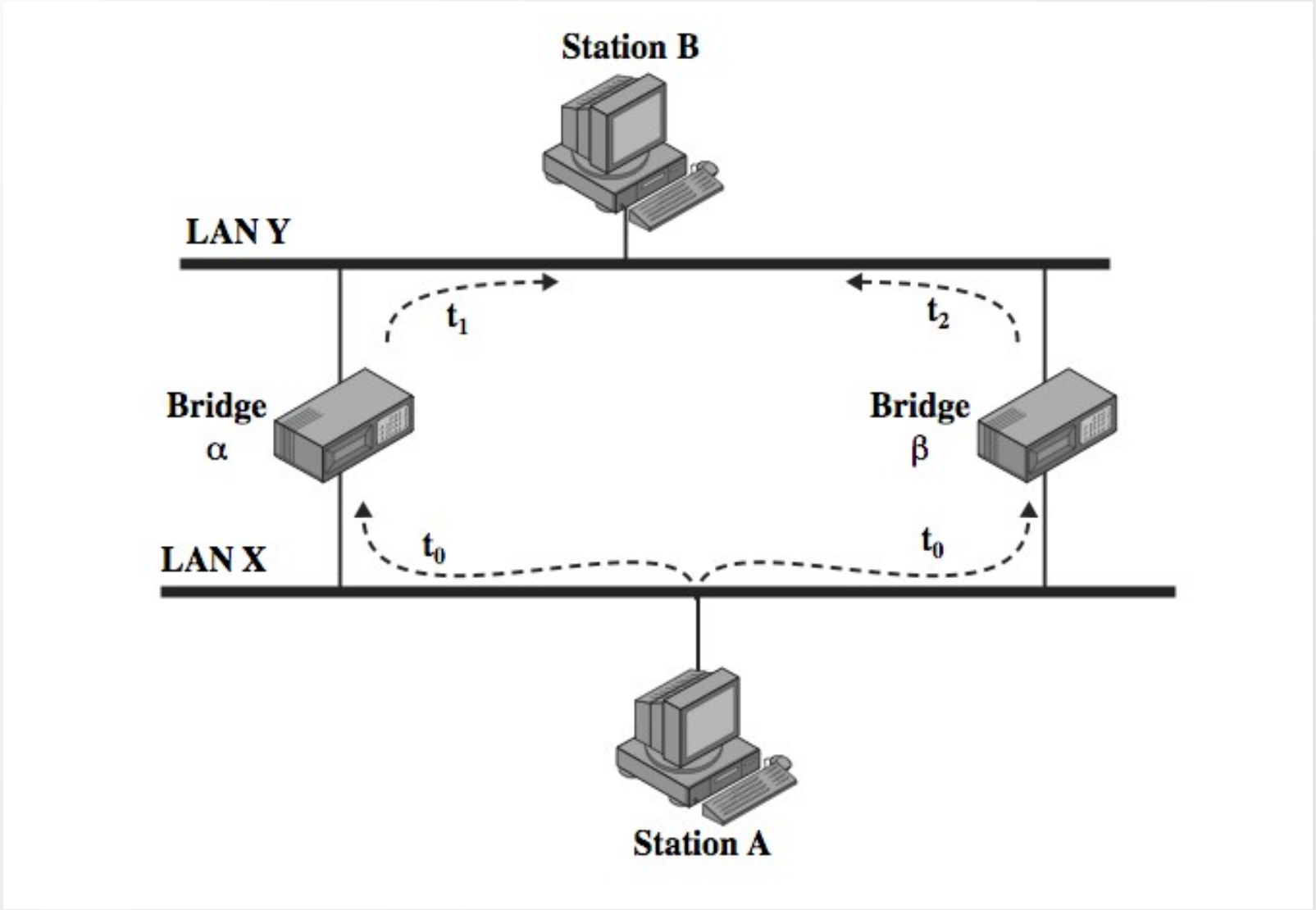
Address Learning

- can preload forwarding database
- when frame arrives at port X, it has come form the LAN attached to port X
- use source address to update forwarding database for port X to include that address
- have a timer on each entry in database
- if timer expires, entry is removed
- each time frame arrives, source address checked against forwarding database
  - if present timer is reset and direction recorded
  - if not present entry is created and timer set

Spanning Tree Algorithm

- address learning works for tree layout
- in general graph have loops
- for any connected graph there is a spanning tree maintaining connectivity with no closed loops
- IEEE 802.1 Spanning Tree Algorithm finds this
  - each bridge assigned unique identifier
  - exchange info between bridges to find spanning tree
  - automatically updated whenever topology changes

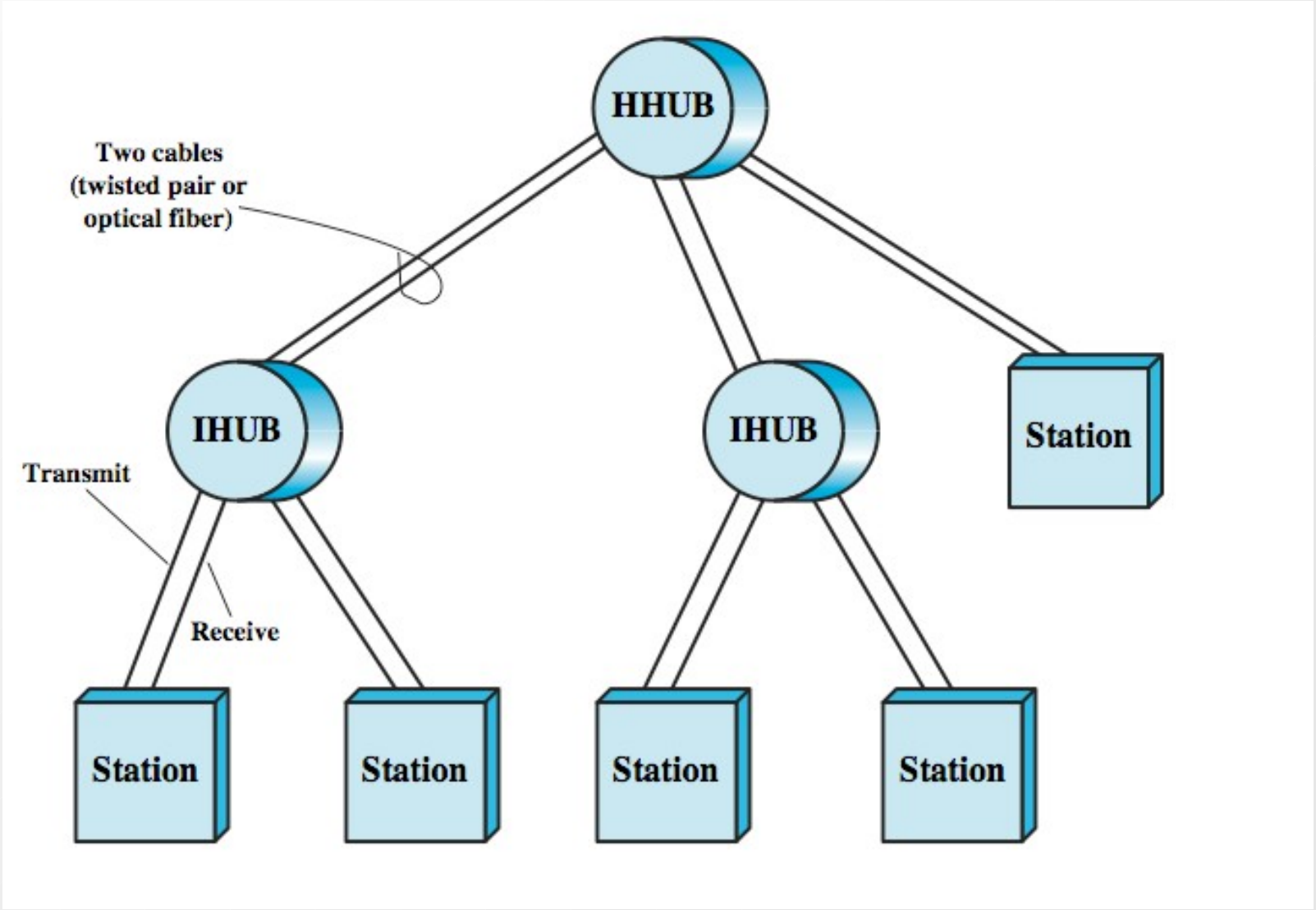
Loop of Bridges



Interconnecting LANs - Hubs

- active central element of star layout
- each station connected to hub by two UTP lines
- hub acts as a repeater
- limited to about 100 m by UTP properties
- optical fiber may be used out to 500m
- physically star, logically bus
- transmission from a station seen by all others
- if two stations transmit at the same time have a collision

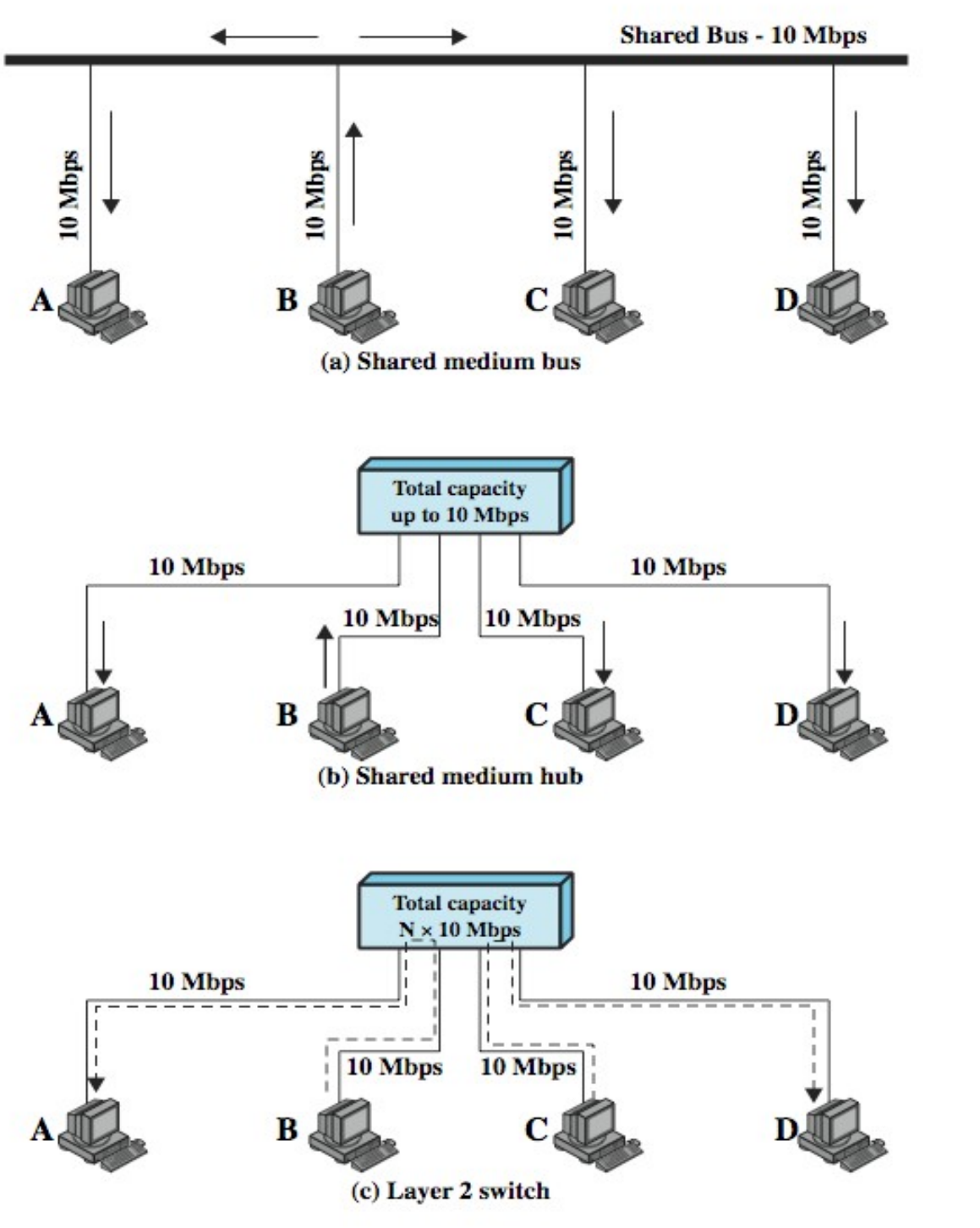
Two Level Hub Topology



Buses, Hubs and Switches

- bus configuration
  - all stations share capacity of bus (e.g. 10Mbps)
  - only one station transmitting at a time
- hub uses star wiring to attach stations
  - transmission from any station received by hub and retransmitted on all outgoing lines
  - only one station can transmit at a time
  - total capacity of LAN is 10 Mbps
- can improve performance using a layer 2 switch
  - can switch multiple frames between separate ports
  - multiplying capacity of LAN

Shared Medium Bus and Hub



Layer 2 Switch Benefits

- no change to attached devices to convert bus LAN or hub LAN to switched LAN
  - e.g. Ethernet LANs use Ethernet MAC protocol
- have dedicated capacity equal to original LAN
  - assuming switch has sufficient capacity to keep up with all devices
- scales easily
  - additional devices attached to switch by increasing capacity of layer 2

Types of Layer 2 Switch

- store-and-forward switch
  - accepts frame on input line, buffers briefly, routes to destination port
  - see delay between sender and receiver
  - better integrity
- cut-through switch
  - use destination address at beginning of frame
  - switch begins repeating frame onto output line as soon as destination address recognized
  - highest possible throughput
  - risk of propagating bad frames

Layer 2 Switch vs Bridge

- Layer 2 switch can be viewed as full-duplex hub
- incorporates logic to function as multiport bridge
- differences between switches & bridges:
  - bridge frame handling done in software
  - switch performs frame forwarding in hardware
  - bridge analyzes and forwards one frame at a time
  - switch can handle multiple frames at a time
  - bridge uses store-and-forward operation
  - switch can have cut-through operation
- hence bridge have suffered commercially

Layer 2 Switch Problems

- broadcast overload
  - users share common MAC broadcast address
  - broadcast frames are delivered to all devices connected by layer 2 switches and/or bridges
  - broadcast frames can create big overhead
  - broadcast storm from malfunctioning devices
- lack of multiple links
  - limits performance & reliability

Router Problems

- typically use subnetworks connected by routers
  - limits broadcasts to single subnet
  - supports multiple paths between subnet
- routers do all IP-level processing in software
  - high-speed LANs and high-performance layer 2 switches pump millions of packets per second
  - software-based router only able to handle well under a million packets per second

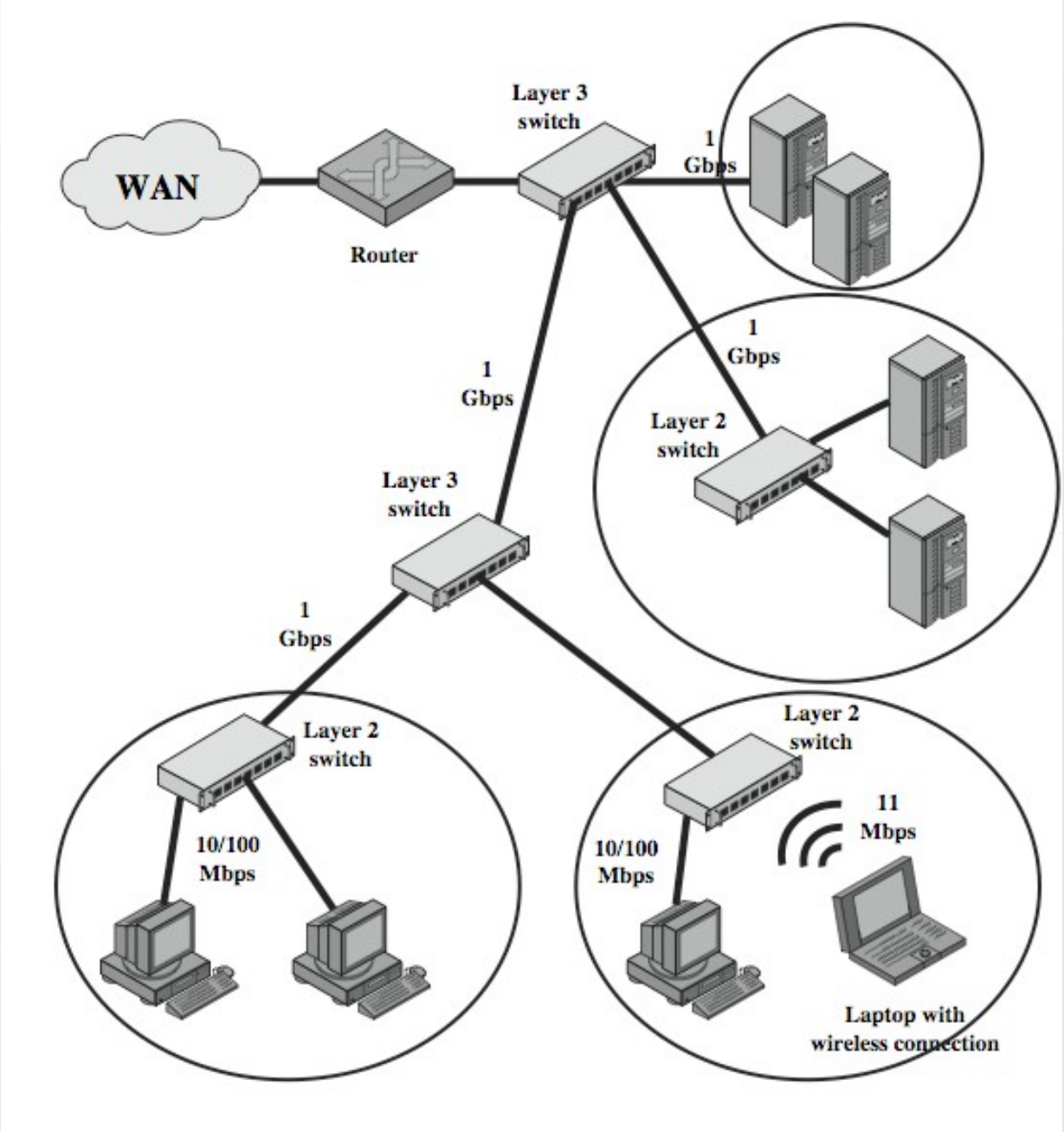
Layer 3 Switches

- Solution: layer 3 switches
  - implement packet-forwarding logic of router in hardware
- two categories
  - packet by packet
  - flow based

Packet by Packet or Flow Based

- packet by packet
  - operates like a traditional router
  - order of magnitude increase in performance compared to software-based router
- flow-based switch
  - enhances performance by identifying flows of IP packets with same source and destination
  - by observing ongoing traffic or using a special flow label in packet header (IPv6)
  - a predefined route is used for identified flows

Typical Large LAN Organization Diagram



Summary

- LAN topologies and media
- LAN protocol architecture
- bridges, hubs, layer 2 & 3 switches