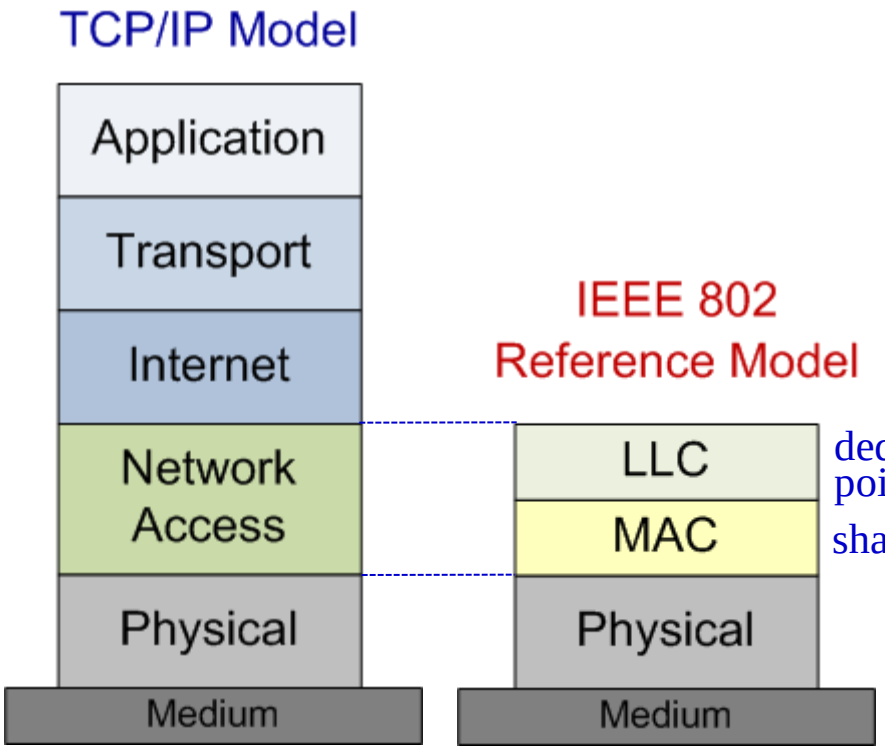
Chapter 11

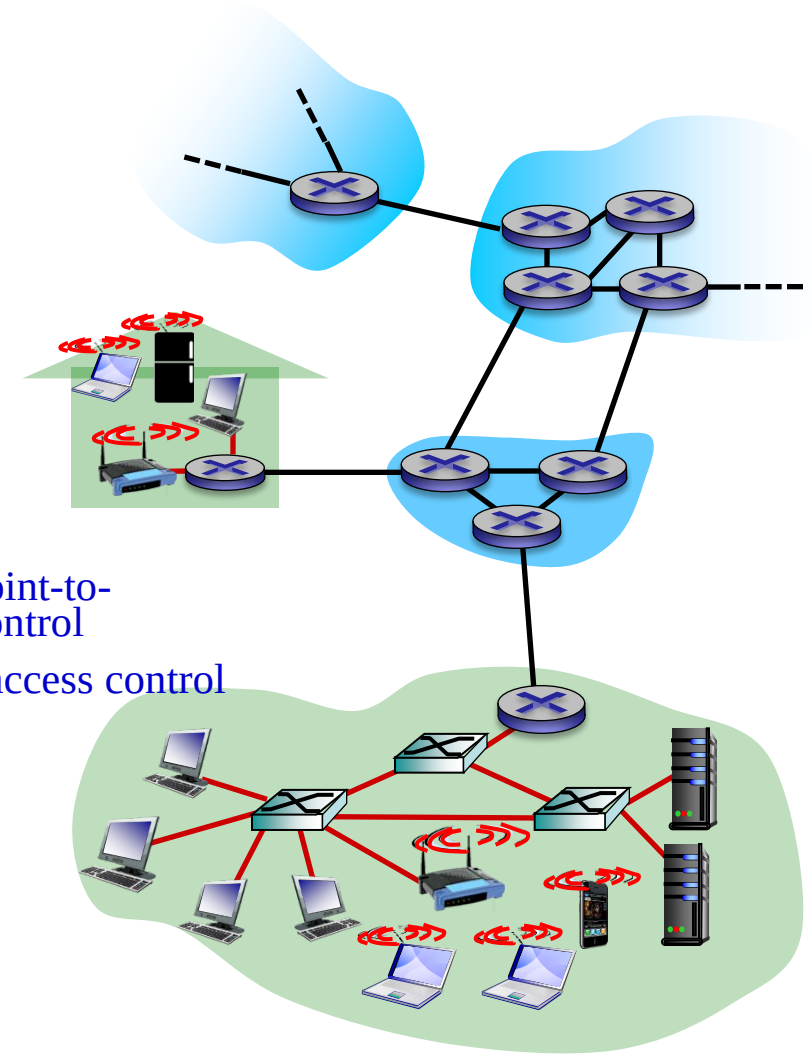
LAN Overview

LAN (local area networks)

- LAN features
  - Local area: ~ 10 km (wireless: 100 m)
  - Single organization
  - High speed, Low error rate
  - Shared medium
- IEEE 802 reference model
  - LAN standards
  - bottom 2 layers of ISO reference model
    - LLC (logical link control) sublayer
    - MAC (medium access control) sublayer
    - PHY (physical) layer

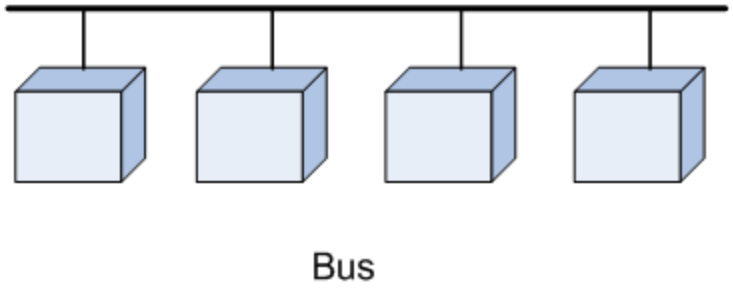
IEEE 802 Protocol Layer



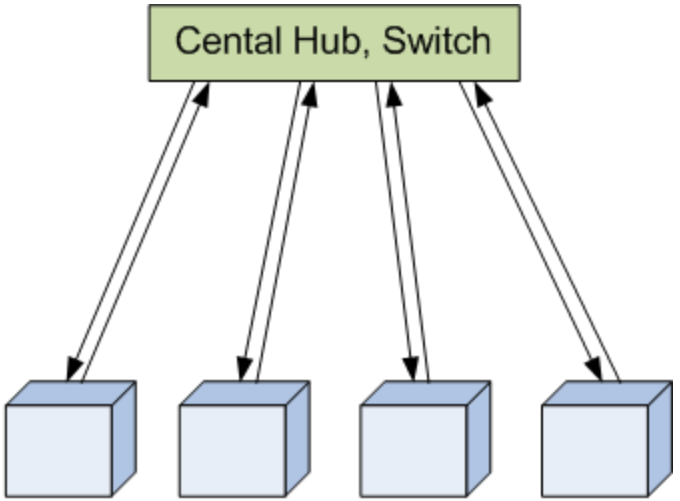


Wired LAN Topology

- The way in which the stations are interconnected.
- The medium is shared to all stations (shared medium)
- Bus, Star



Bus



Star

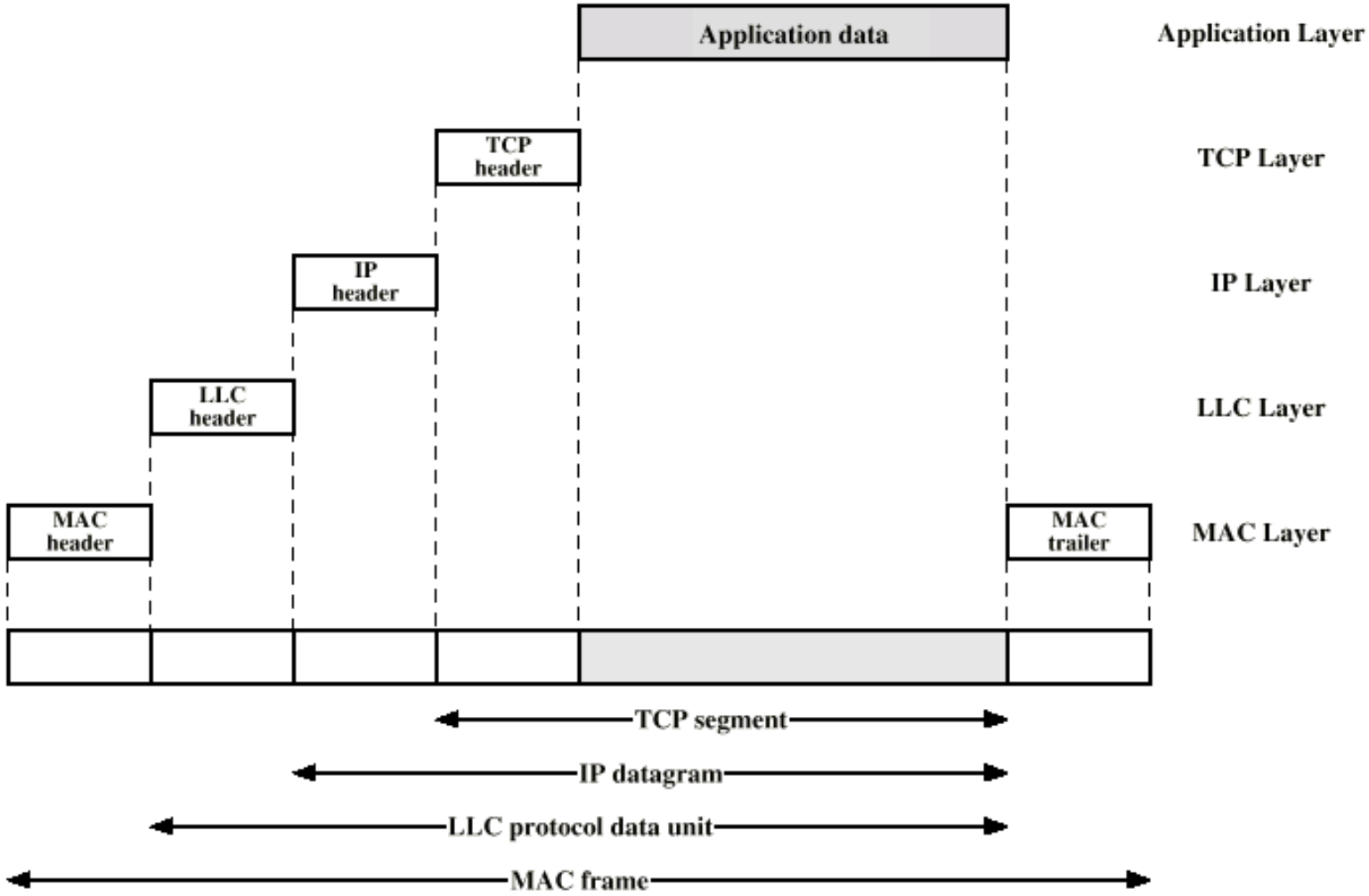
Functions of Each Layer (1)

- PHY (Physical)
  - bit transmission/reception
  - encoding/decoding of signals
  - preamble generation/removal for bit synchronization
  - includes specification of medium and topology
- MAC (Medium Access Control)
  - control access to shared transmission medium
  - on transmission, assemble data into a frame with address and error detection fields
  - on reception, perform address recognition and merely detect errors and discard any erroneous frame

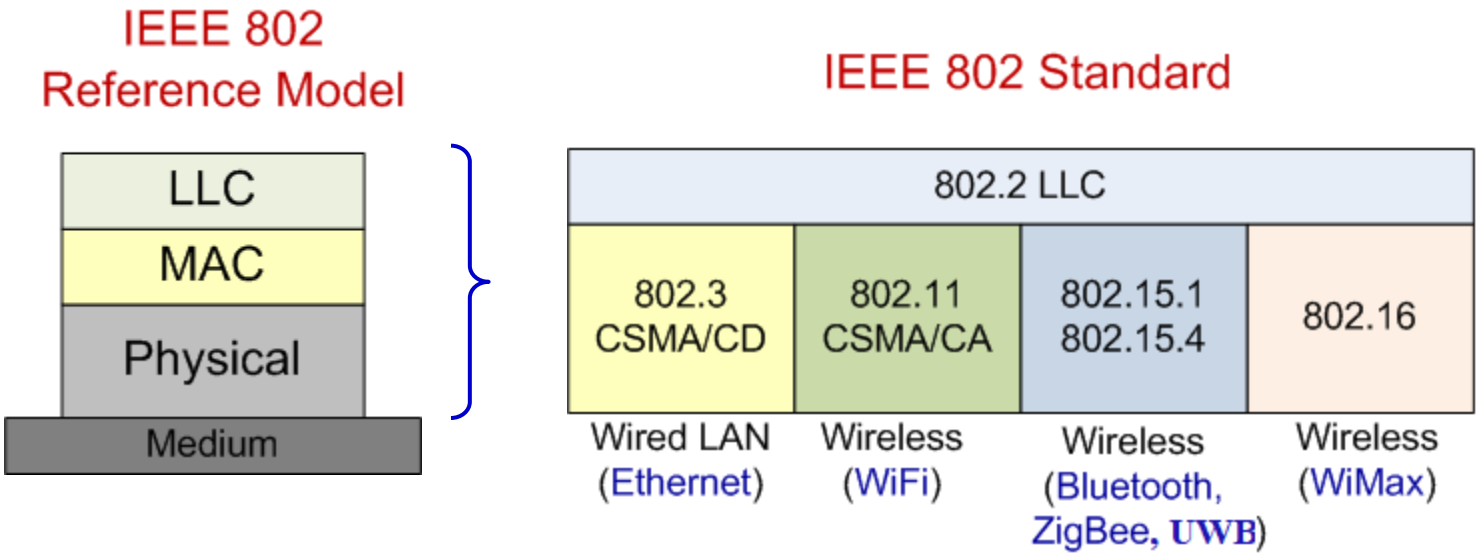
Functions of Each Layer (2)

- LLC (Logical Link Control)
  - Provide an interface to higher layers
  - Data link control layer of OSI model (dedicated point-to-point link)
  - LLC Services
    - Unacknowledged connectionless (type-1)
      - no flow control and no error control
      - in higher layer, reliability issue is expected to be dealt with
    - Connection-mode (type-2)
      - Logical connection is set up
      - Flow control and error control (error recovery by retransmission)
      - is similar with Asynchronous Balanced Mode of HDLC
    - Acknowledged connectionless (type-3)
      - No prior logical connection setup
      - Datagrams are acknowledged

Protocol Data Unit



IEEE 802 Standards



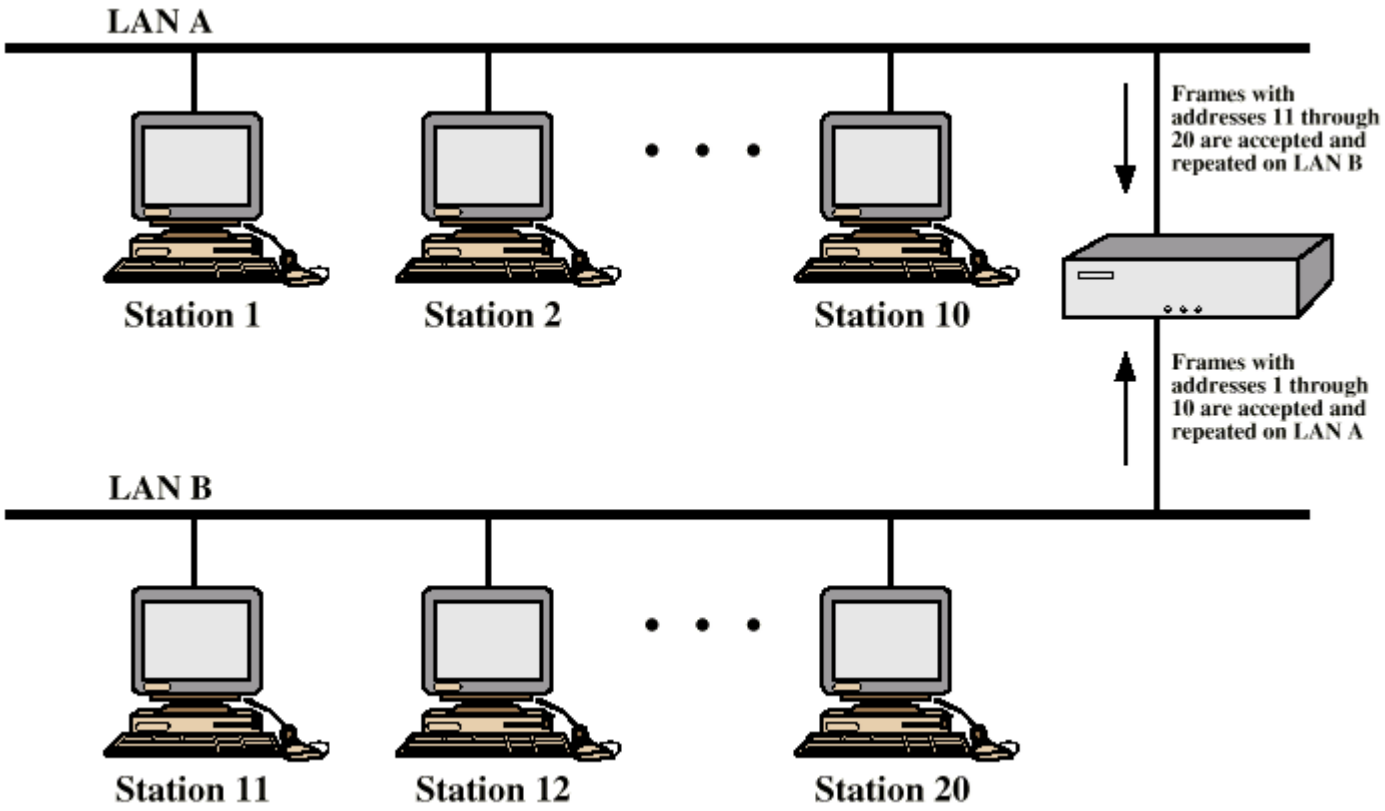
Bridge

Expansion beyond single LAN

- Interconnection to other LANs/WANs
- Bridge or router is used
- Bridge is simpler
  - Connects LANs
  - Minimal processing
- Router is more general
  - Interconnect LAN and WAN

Functions of a Bridge

- Read all frames transmitted on one LAN and accept those addressed to any station on the other LAN
- Using MAC protocol for second LAN, retransmit each frame



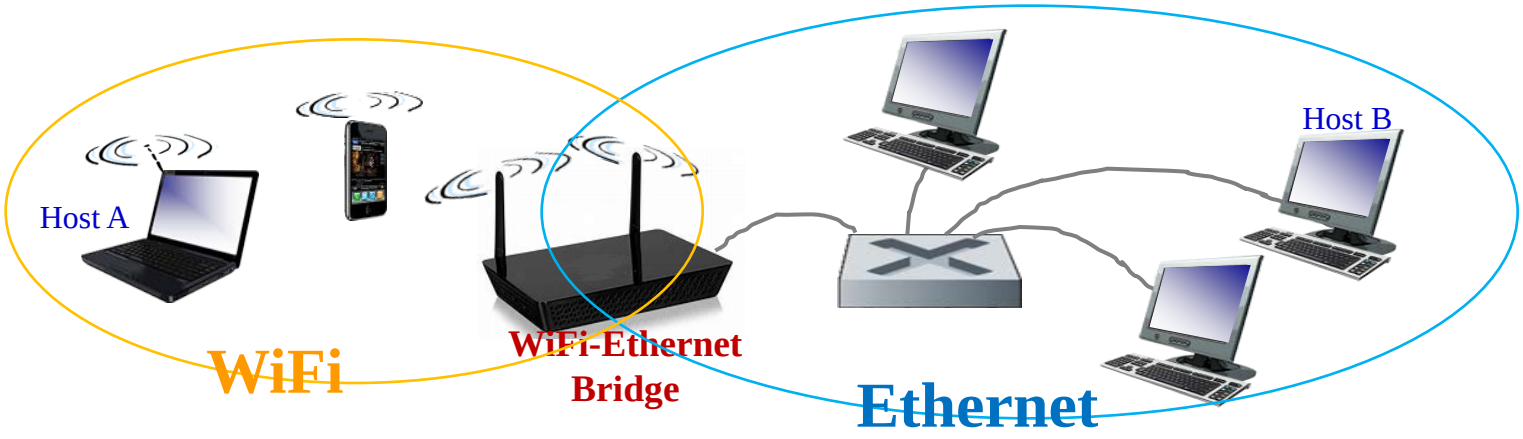
Bridge Design Aspects

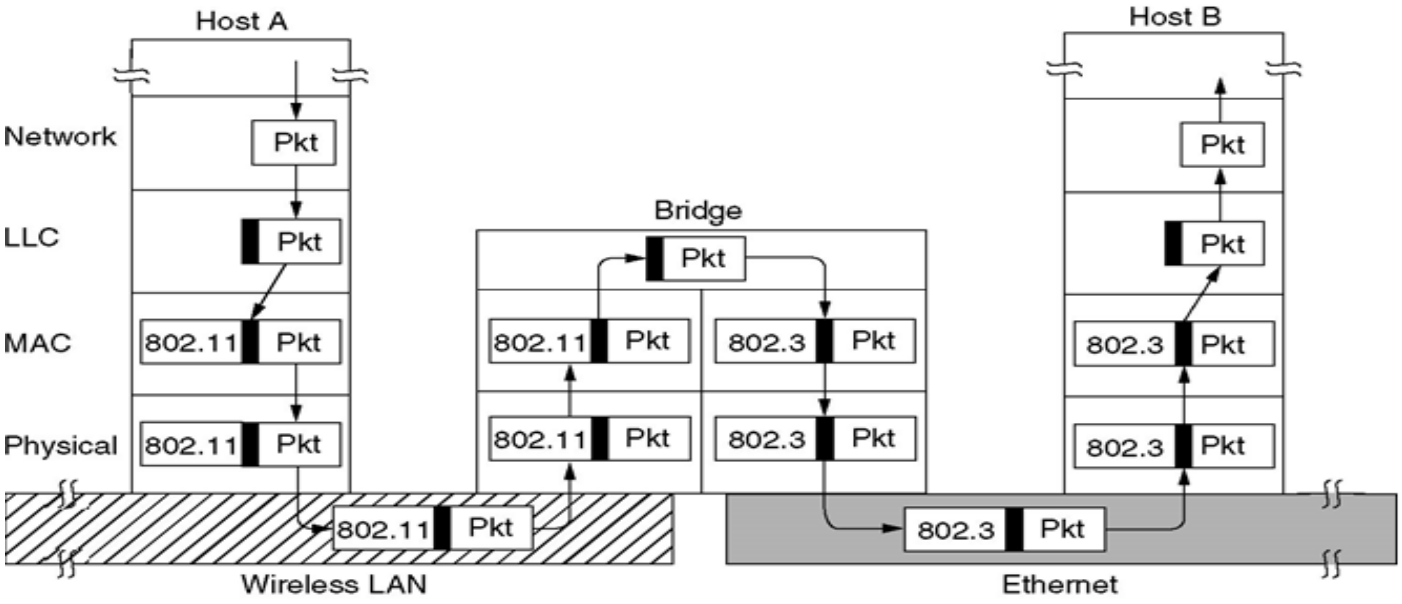
- When connecting LANs with identical protocols
  - No modification to content or format of frame
  - No encapsulation
  - Exact bitwise copy of frame
- Amount of Buffer to meet peak traffic demand
- Contains routing and address intelligence
  - Must know which frames to pass
  - May be more than one bridge to cross
- Bridging is transparent to stations
  - Appears to all stations on multiple LANs as if they are on one single LAN

Bridge Protocol Architecture

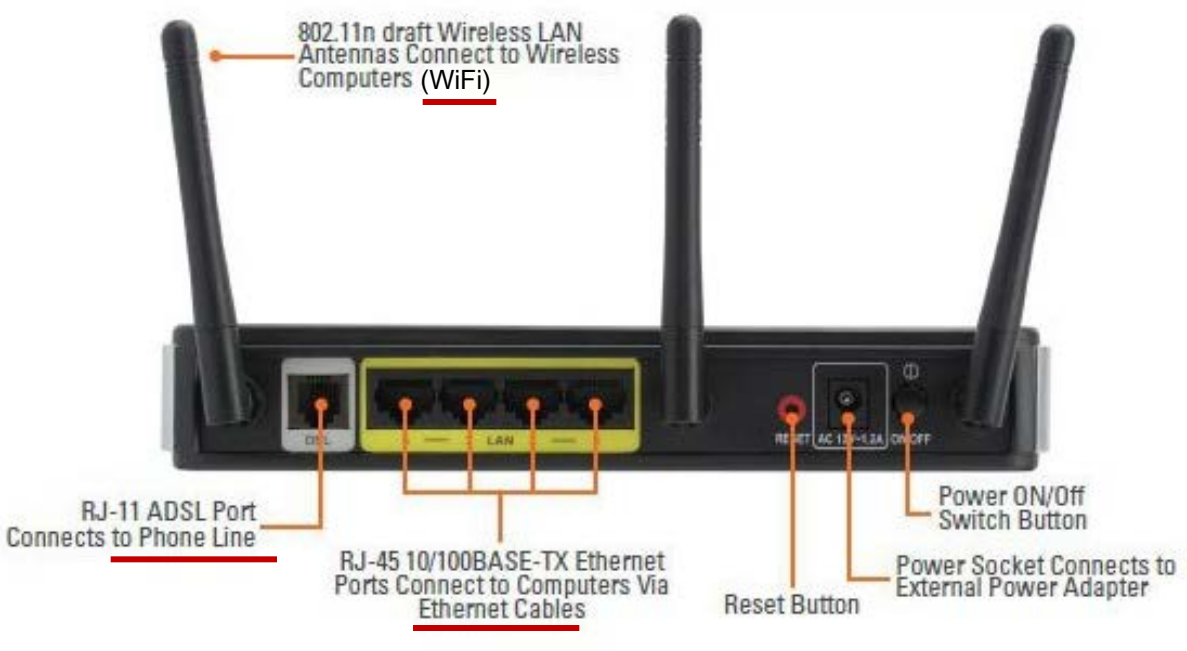
- IEEE 802.1D
- Bridge does not need the LLC layer
  - It is relaying MAC frames
- MAC level Bridge
  - Station address is at this level (MAC address)
  - Destination MAC address (DA): the address of the destination in the entire LAN (multiple LANs interconnected by bridges)
    - DA is the MAC address of a router if the final destination node is on an external network.

Connection of Two LANs by a Bridge



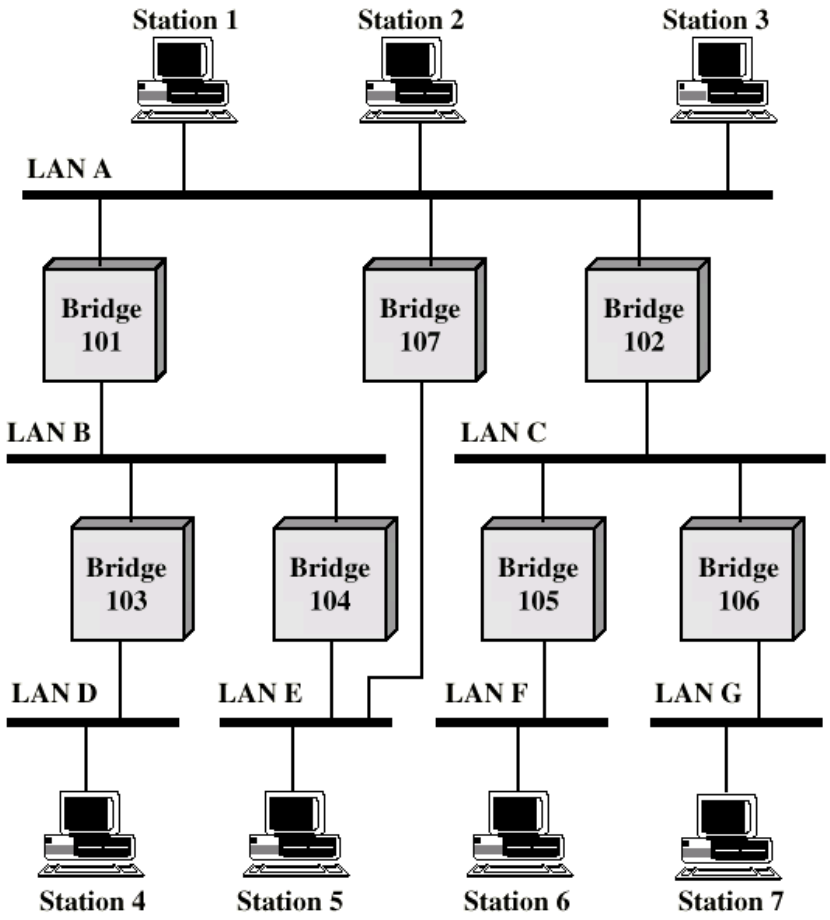


DSL modem + WiFi AP + Ethernet Switch



Routing in Multiple LANs

- Complex large LANs need alternative routes
  - Load balancing
  - Fault tolerance
- Bridge must decide which LAN to forward frame on
- Routing
  - Spanning Tree algorithm: IEEE 802.1D
  - Source Routing



Spanning Tree (1)

- Bridge automatically develops the routing table and automatically updates it in response to changes
- Consists of three mechanism
  - Frame forwarding
  - Address learning
  - Loop resolution: spanning tree

Spanning Tree (2)

- Frame forwarding
  - Forwarding database for each port
    - List the addresses of the stations reached through each port
    - can preloaded or be learned
  - For a frame arriving on port X:
    - If the destination MAC address is listed for port X, discard the frame
    - search forwarding database to see if the destination MAC address is listed for any port except X
    - If the address is not found, forward to all ports except X
    - If the address is listed for port Y, check port Y for blocking or forwarding state
      - Blocking prevents port from receiving or transmitting
    - If not blocked, transmit frame through port Y

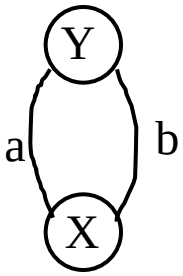
Spanning Tree (3)

- Address Learning
  - When a frame arrives at port X
    - It means that the frame has come from the LAN attached to port X
    - update the forwarding database for port X to include the source address of the frame
  - Timer on each entry in database
    - If timer expires, entry is removed

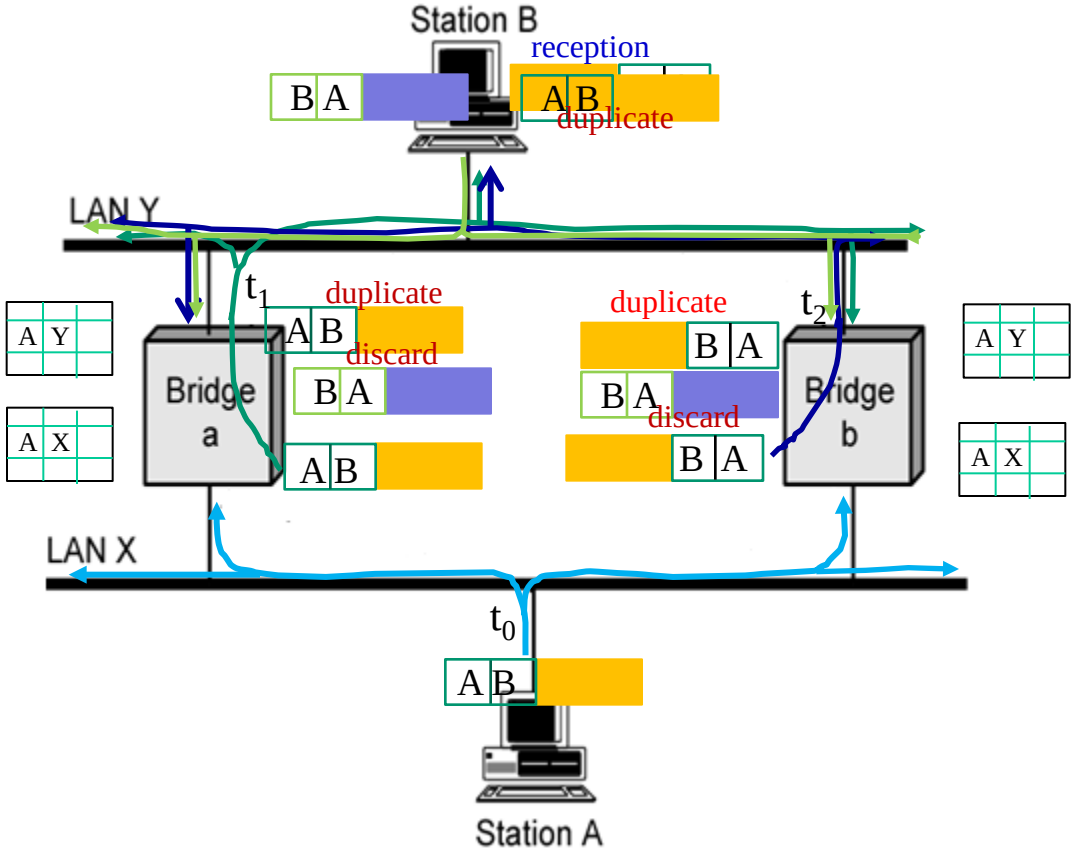
❖ Each time a frame arrives, its source address is checked against forwarding database for arriving port
  - If present, timer is reset
  - If not present, entry is created and timer is set

Loop of Bridge

- Address Learning
  - Address learning works well when there are no alternate routes in the network
    - Alternate route means there is a closed loop



  - For any connected graph, there is a spanning tree maintaining connectivity with no closed loops

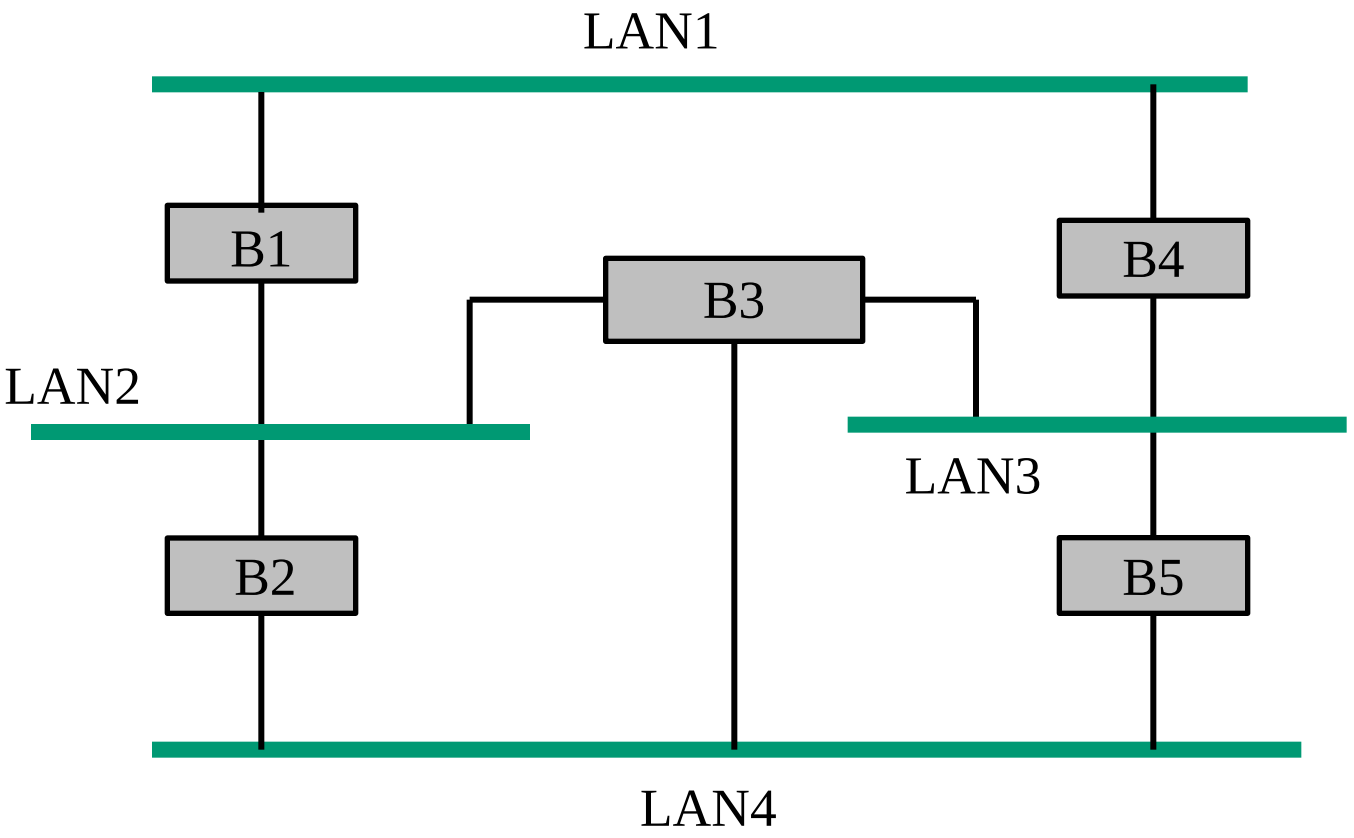


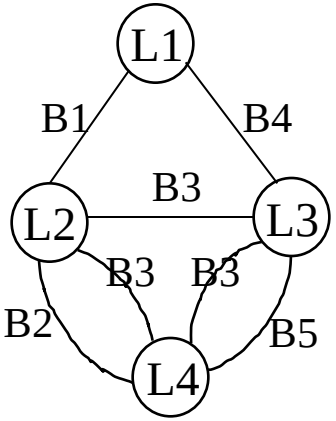
Spanning Tree (4)

- Modeling the LAN system as a graph
  - Each LAN segment: graph node
  - Bridge between LAN segments: graph edge
  - Bridge has a unique id
  - Bridge Port : has a unique ID in the bridge
    - Cost (for example, the capacity of LAN) is assigned
- Minimal cost spanning tree from graph
  - Exchange of information between bridges to find spanning tree
  - Whenever there is a change in topology, the bridges automatically recalculate the spanning tree

Spanning Tree (5)

Example

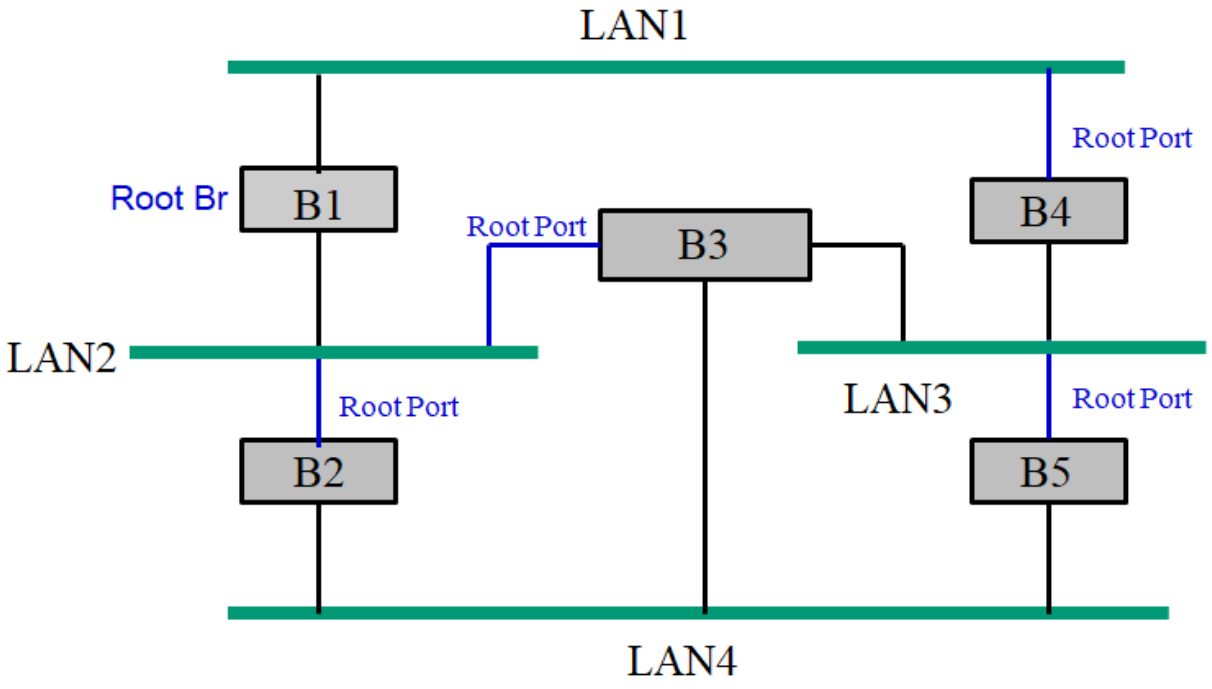




Let us suppose that the cost of all ports are the same

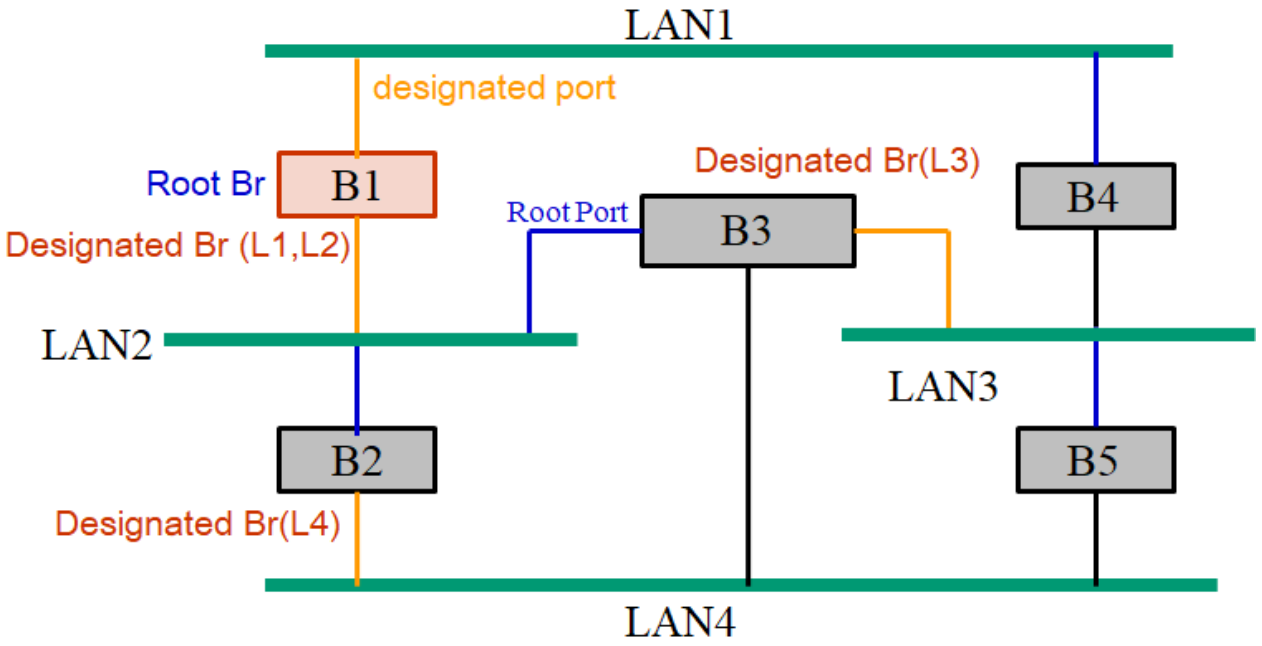
Spanning Tree (6)

1. The bridge with the smallest ID: the *root bridge*
2. On each bridge, select a *root port*
   – Port with the least cost path to the root bridge



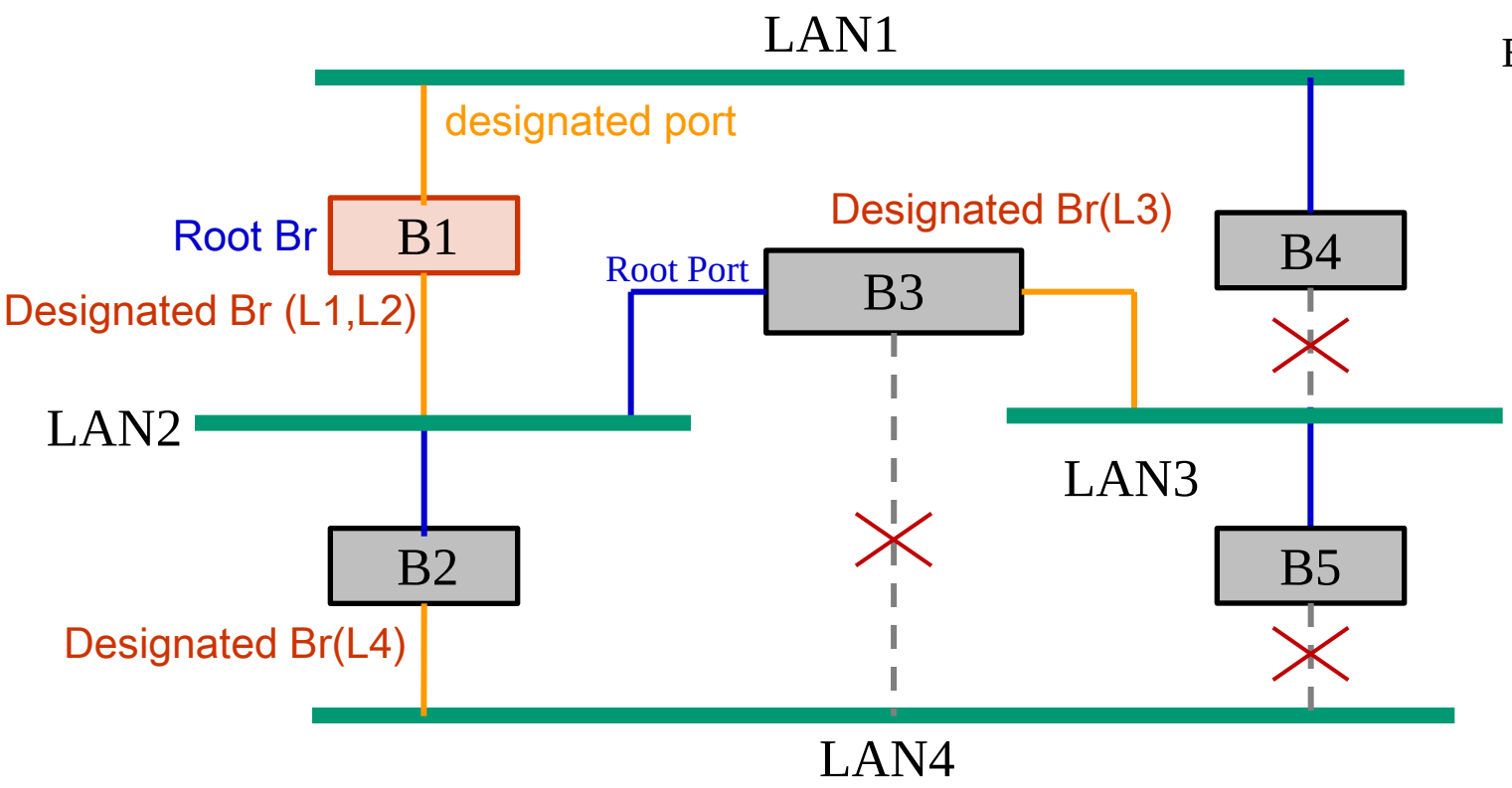
Spanning Tree (7)

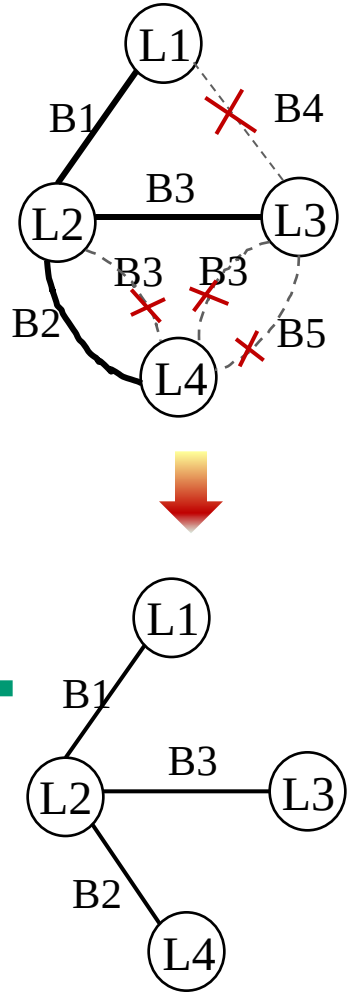
3. On each LAN segment, select a *designated bridge*
   - Bridge with the least cost path to the root bridge
     - If two bridges have same cost, select the bridge with smallest ID
   - Mark the corresponding port as the *designated port*



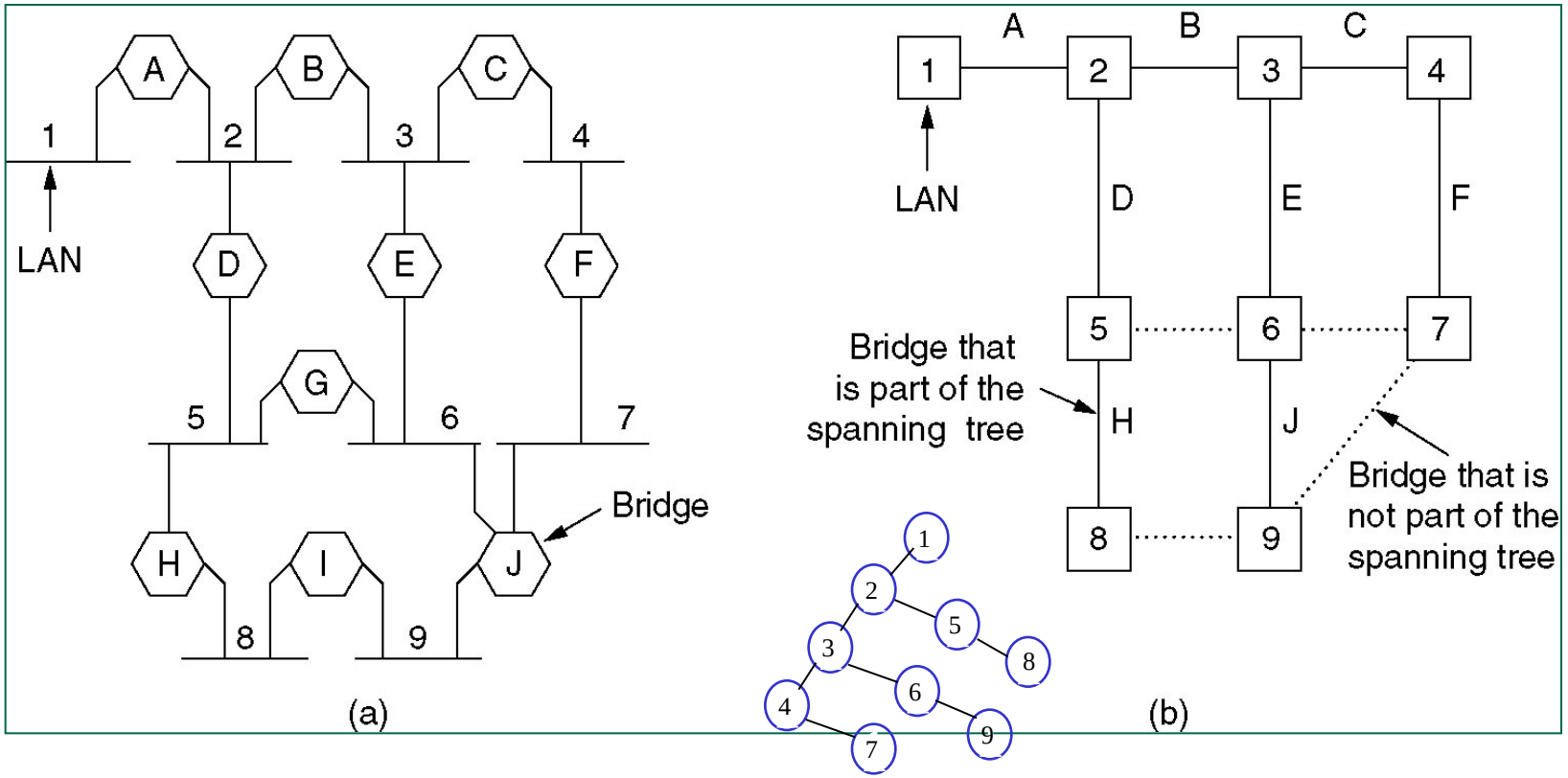
Spanning Tree (8)

4. Forward frames only on marked ports
   - Designated ports and root ports
   - Block on the others





Spanning Tree (9)

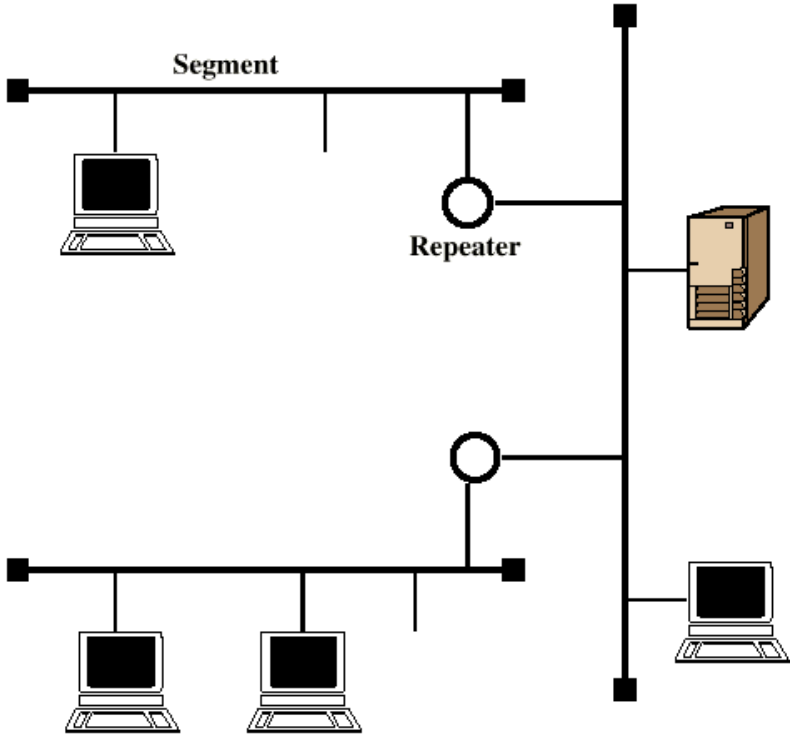


(a) Interconnected LANs

(b) A spanning tree covering the LANs. The dotted lines are not part of the spanning tree.

Repeaters of Bus Topology

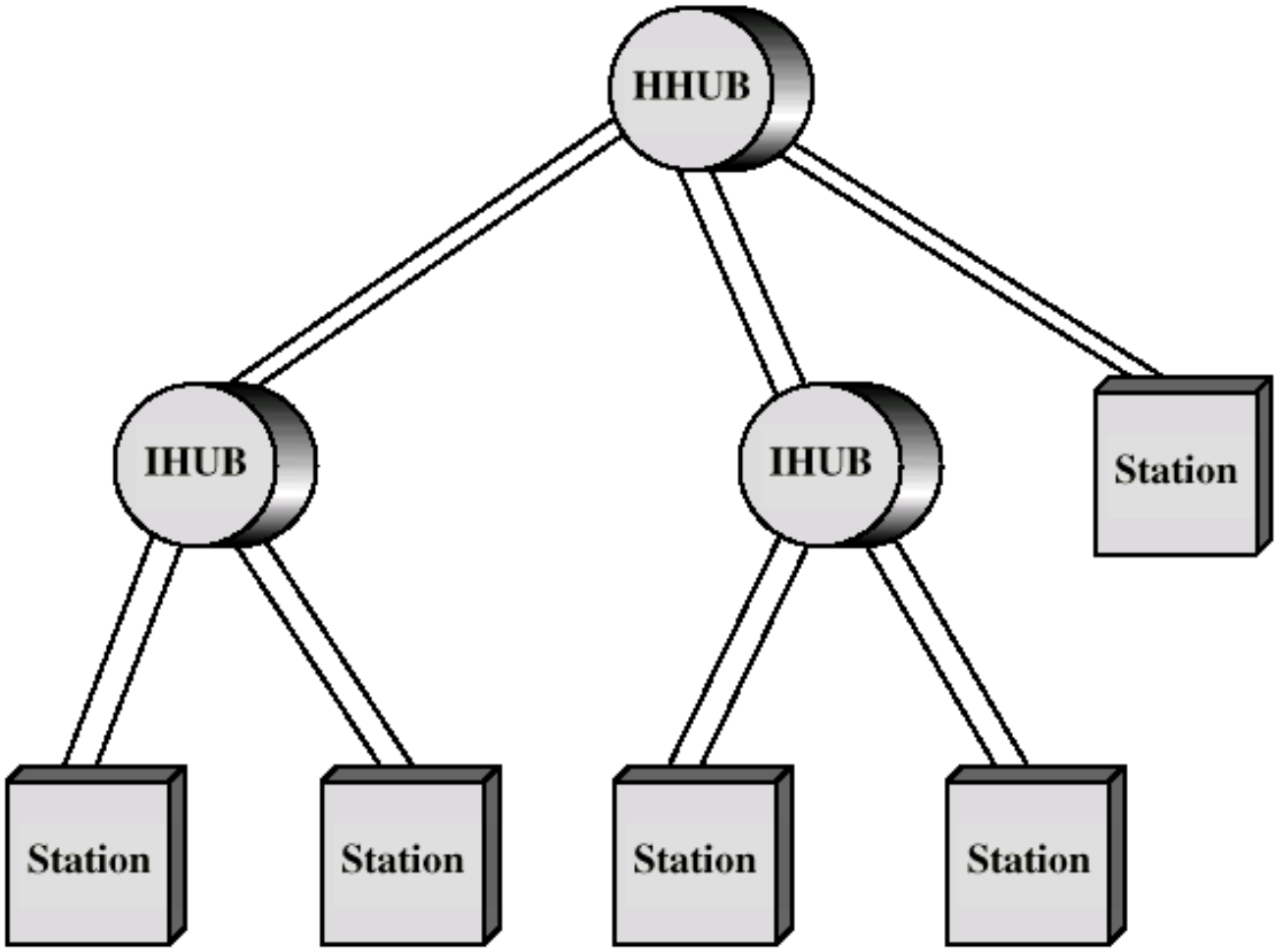
- Joins two segments of cable
- No buffering
- No logical isolation of segments
- If two stations on different segments send at the same time, packets will collide
- Only one path of segments and repeaters between any two stations



Star LANs

- Use unshielded twisted pair wire (telephone)
  - Minimal installation cost
    - All locations in building covered by existing installation
- Attach to a central active hub
- Two links
  - Transmit and receive
- Hub repeats incoming signal on all outgoing lines
- Link lengths limited to about 100m
  - Fiber optic - up to 500m
- Logical bus - with collisions

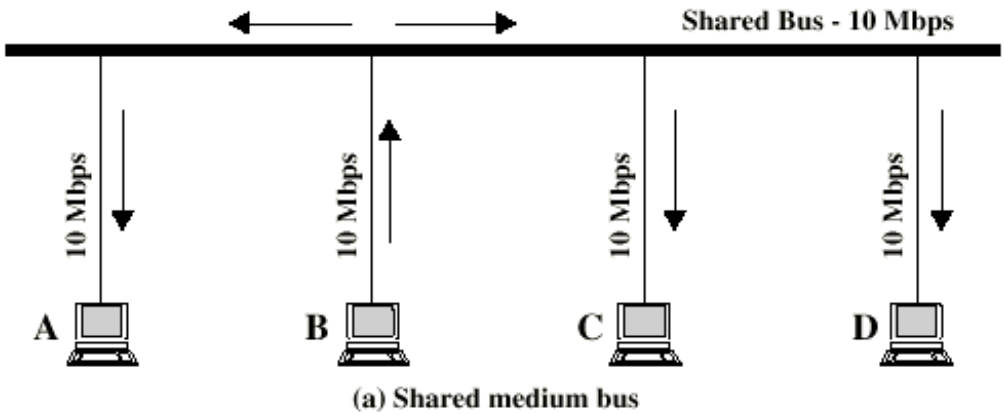
Two Level Star Topology



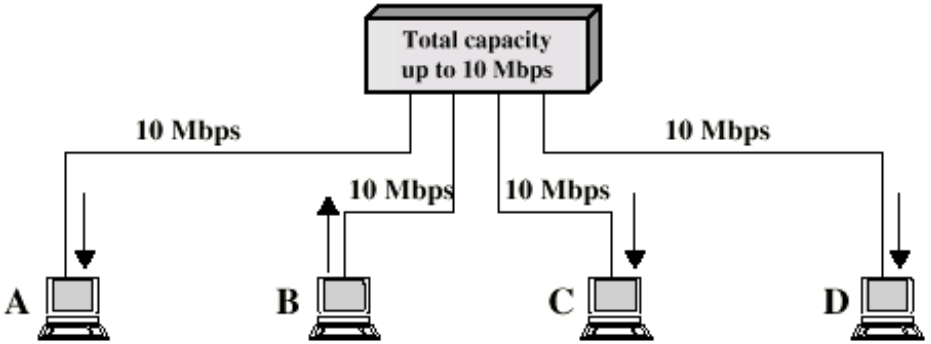
Hubs and Switches

- Shared medium hub
  - Central hub
  - Hub retransmits incoming signal to all outgoing lines
  - Only one station can transmit at a time
  - With a 10Mbps LAN, total capacity is 10Mbps
- Switched LAN hub (Layer 2 Switch)
  - Hub acts as switch
  - Incoming frame switches to appropriate outgoing line
  - Unused lines can also be used to switch other traffic
  - With two pairs of lines in use, overall capacity is now 20Mbps

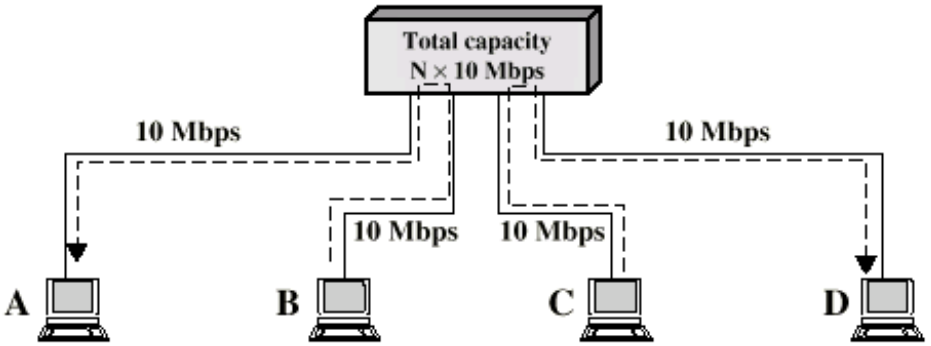
Hubs & Switches



(a) Shared medium bus



(b) Shared medium hub



(c) Switching hub

Wired LAN Configuration

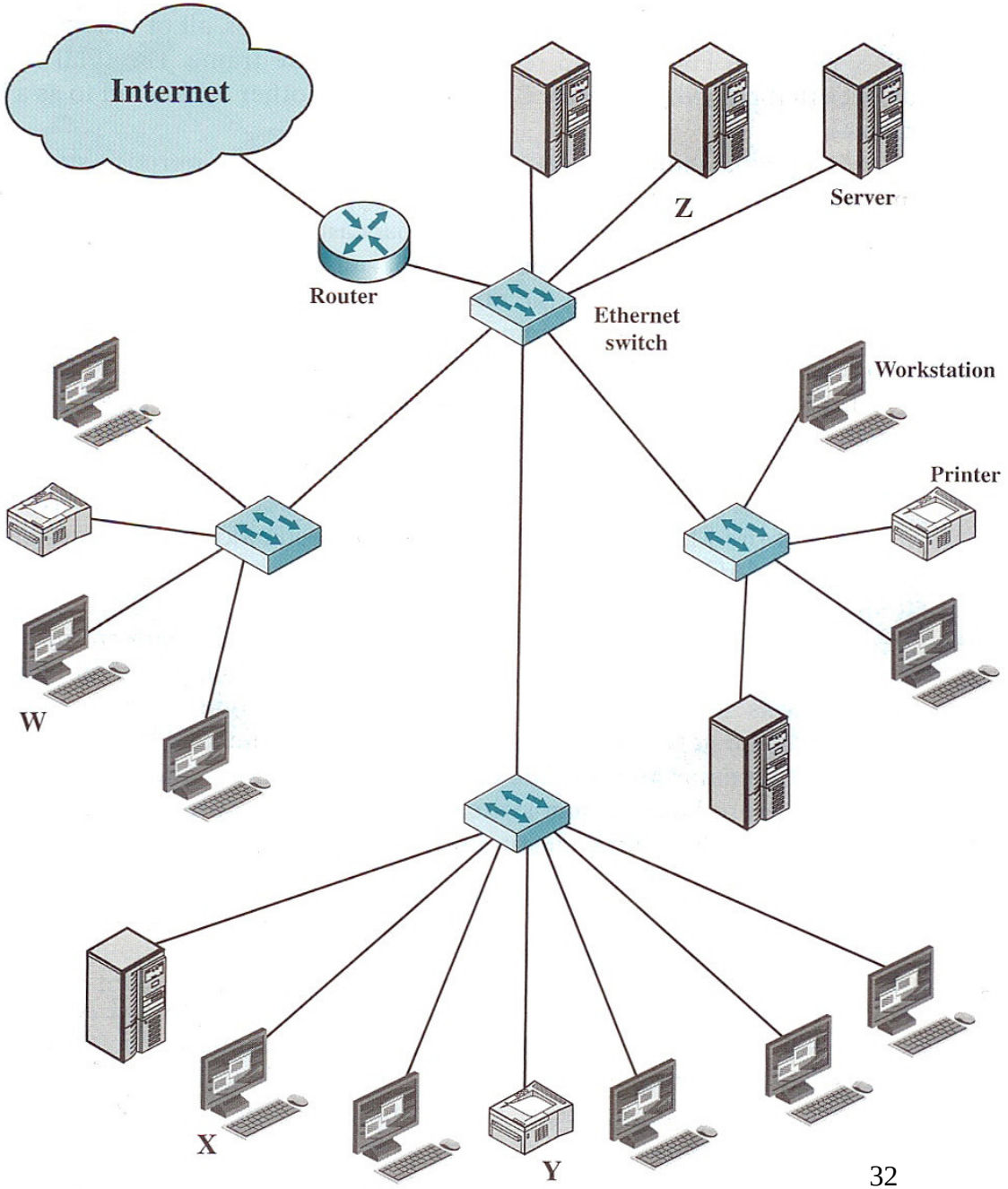


Figure 15.13 A LAN Configuration