High-Speed LANs Part III: LLC and Bridging

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These slides are available on-line at:

http://www.cse.wustl.edu/~jain/cse473-05/

- Logical Link Control
- Bridges
- Path determination: Spanning tree
- Layer 2 switches
- Layer 3 switches

Logical Link Control

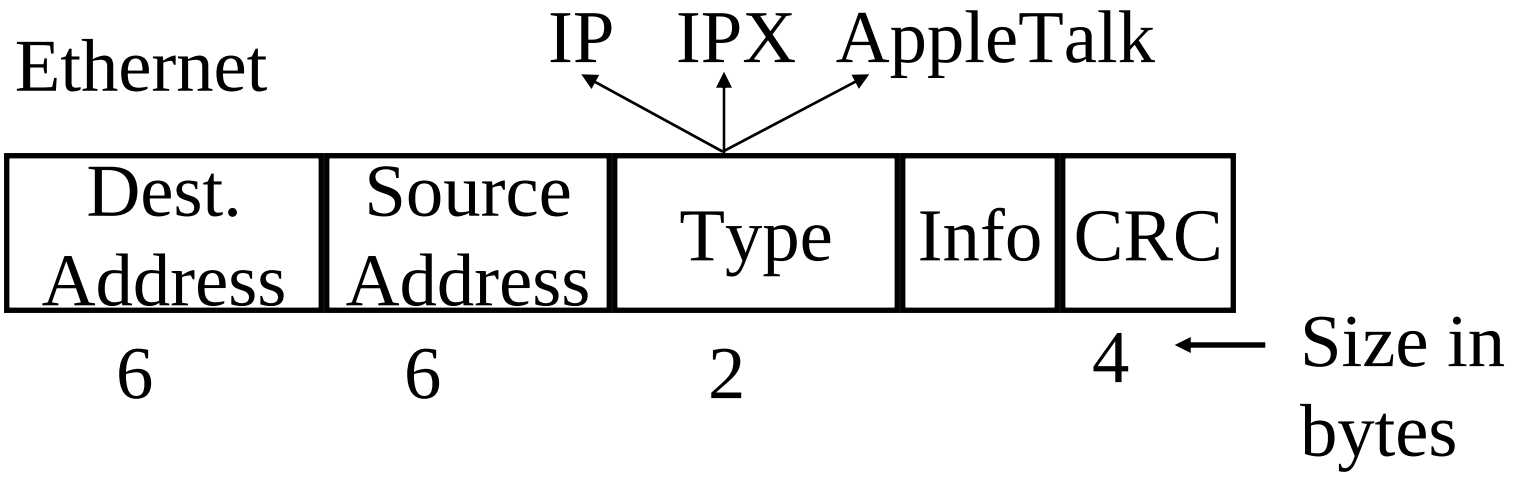
- IEEE 802 Datalink:

	Logical Link Control		
Media Access	802.3 CSMA?CD	802.4 Token Bus	802.5 Token Ring

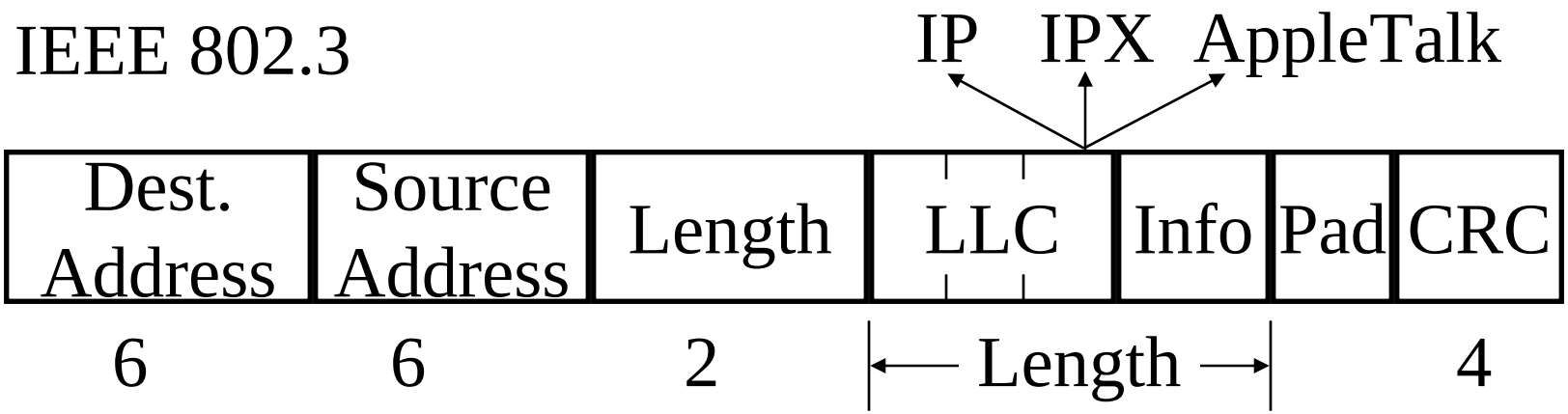
- Logical Link Control Functions:
  - Upper layer Protocol multiplexing
  - Flow control (Windows)
  - Error Control (Retransmissions)
- Several different types of LLC's: Type 1, 2, 3, …
- Based on HDLC

Protocol Multiplexing

- Ethernet



- IEEE 802.3

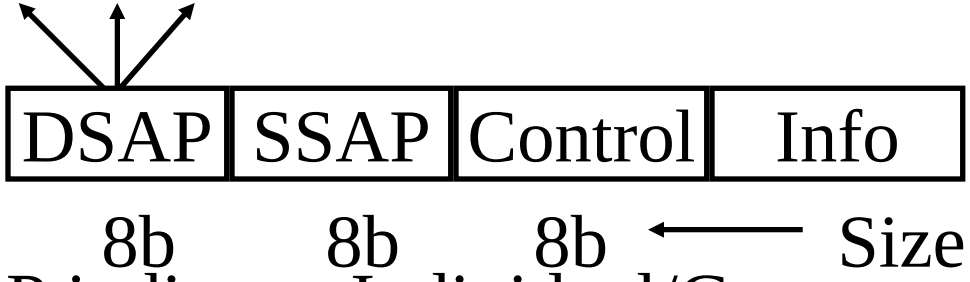


LLC Types

- Type 1: Unacknowledged connectionless (on 802.3)
  No flow or error control.
  Provides protocol multiplexing.
- Type 2: Acknowledged connection oriented (on 802.5)
  Provides flow control, error control. Uses SABME (Set asynchronous balanced mode), UA (unnumbered ack), DM (disconneced mode), DISC (disconnect)
- Type 3: Acknowledged connectionless
  Uses one-bit sequence number
  AC command PDUs acked by AC response PDUs

LLC Header

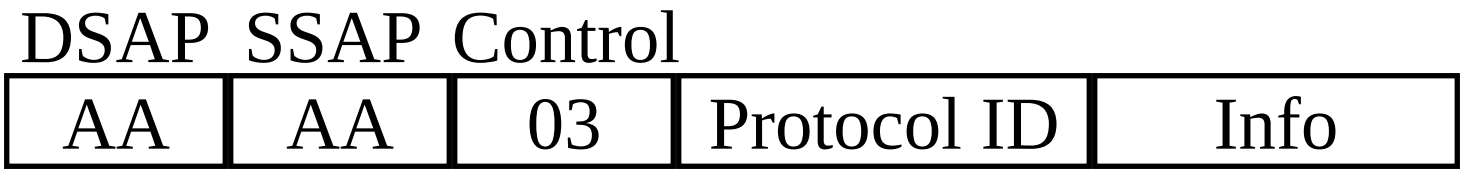
- Multiple network layer protocols can share a datalink
- Each protocol is identified by a "service access point (SAP)"



- First bit of DSAP indicates Individual/Group
- First bit of SSAP indicateds command/response
- Eight-bit SAP ⇒ Only 256 standard values possible
- Even IP couldn't get a standard SAP.
  Use Subnetwork Access Protocol SAP (SNAP SAP)

SNAP SAP

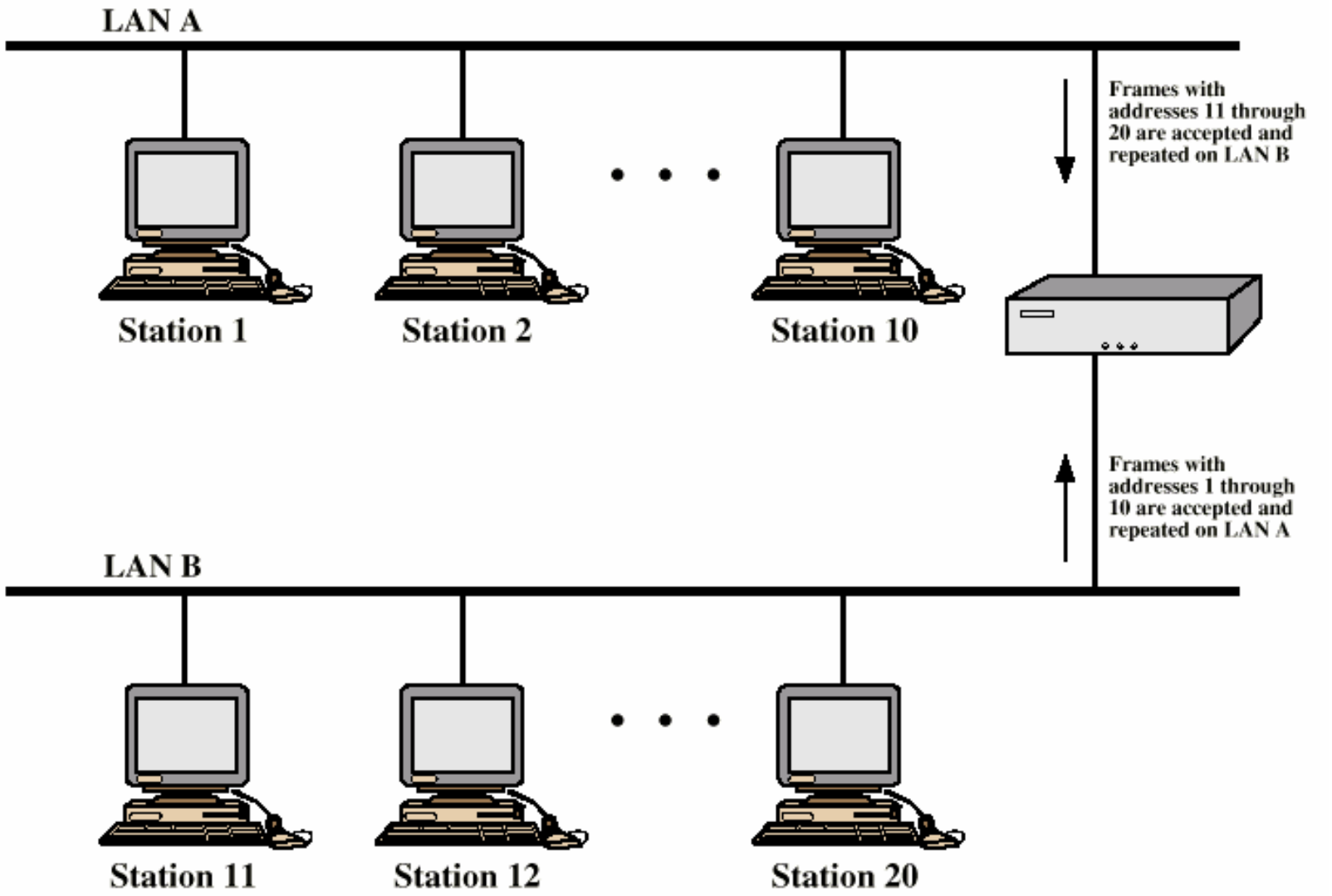
- SubNetwork Access Protocol Service Access Point
- When DSAP=AA, SSAP=AA, Control=UI, protocol ID field is used for multiplexing



- Protocol ID is 40 bit long. The first 24 bits are Organizationally Unique Identifiers (OUI). OUI of 0 is used. The Ethernet type values are used in the last 16 bits.

  Protocol ID = 00-00-00-xx-xx

Bridges

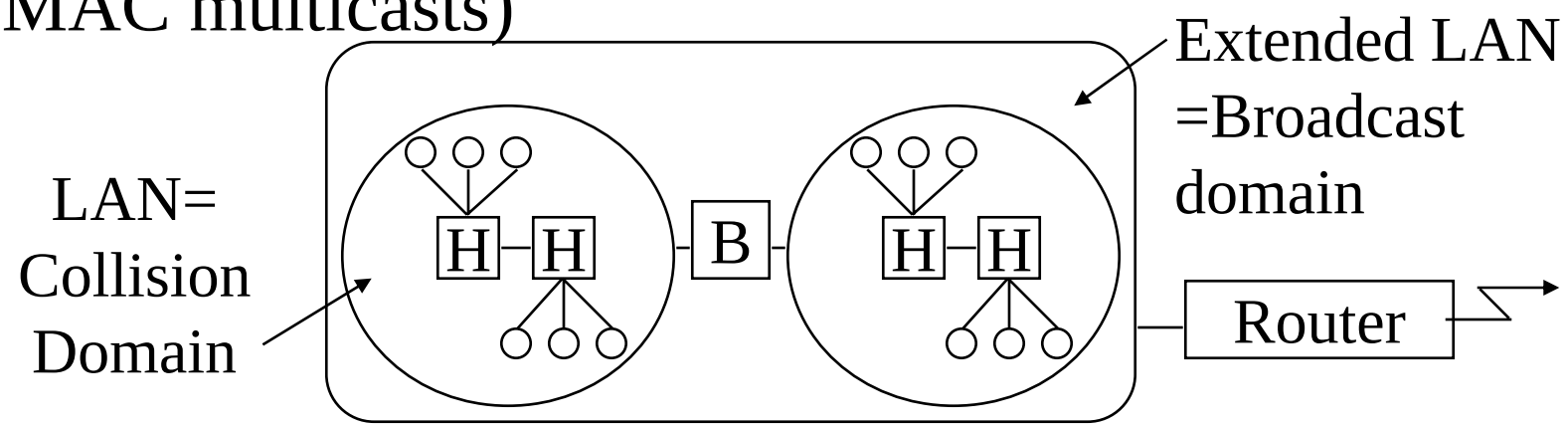

LAN A
Station 1
Station 2
Station 10
Frames with addresses 11 through 20 are accepted and repeated on LAN B
Frames with addresses 1 through 10 are accepted and repeated on LAN A
LAN B
Station 11
Station 12
Station 20

Bridge: Functions

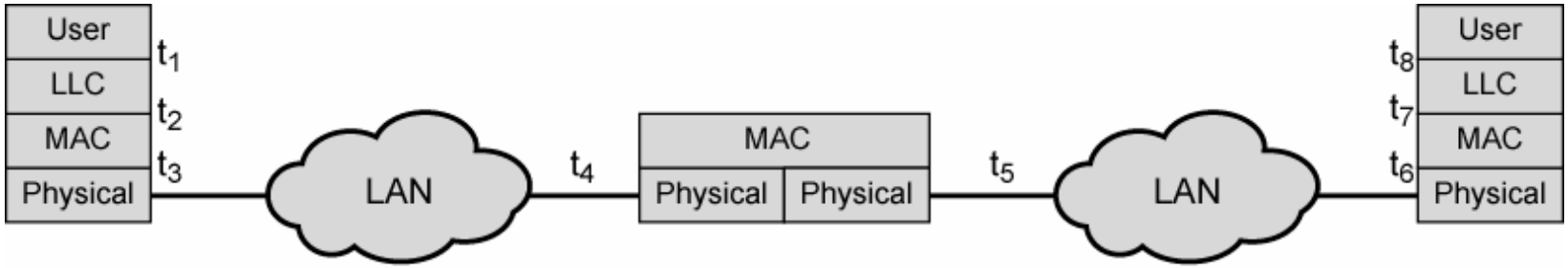
- Monitor all frames on LAN A
- Pickup frames that are for stations on the other side
- Retransmit the frames on the other side
- Knows or learns about stations are on various sides
- Makes no modification to content of the frames. May change headers.
- Provides storage for frames to be forwarded
- Improves reliability (less nodes per LAN)
- Improves performance (more bandwidth per node)
- Security (Keeps different traffic from entering a LAN)
- May provide flow and congestion control

Interconnection Devices

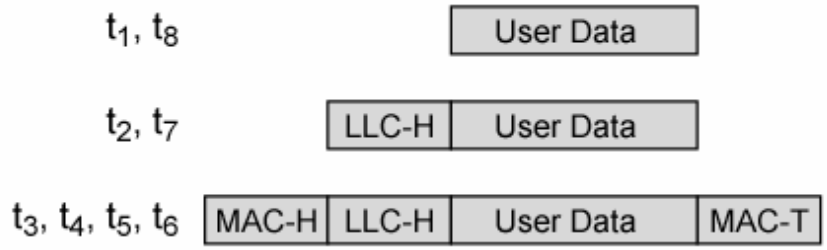
- **Repeater**: PHY device that restores data and collision signals
- **Hub:** Multiport repeater + fault detection, notification and signal broadcast
- **Bridge:** Datalink layer device connecting two or more collision domains (Switch = Multi-port Bridge)
- **Router:** Network layer device (does not propagate MAC multicasts)



Bridge Protocol Architecture

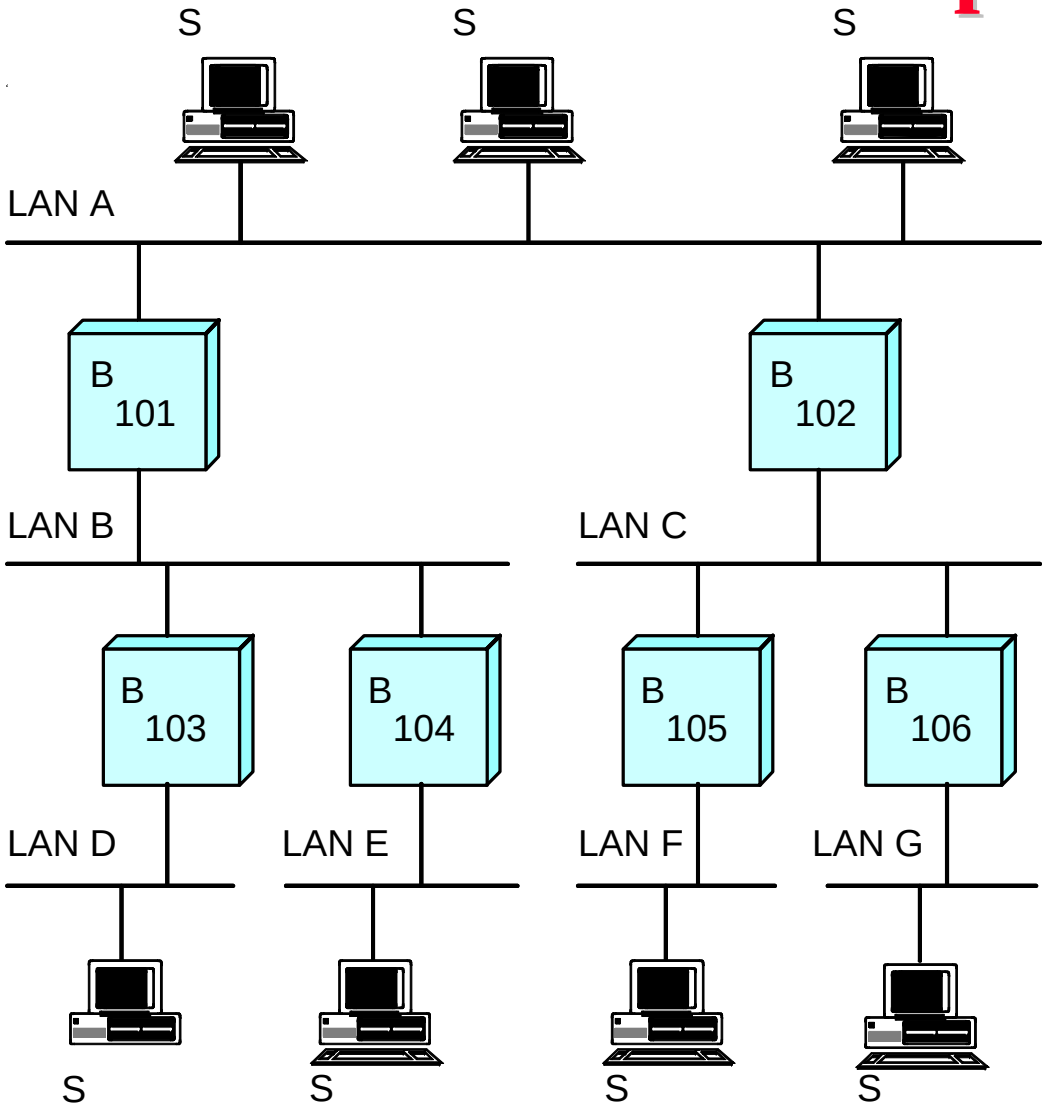


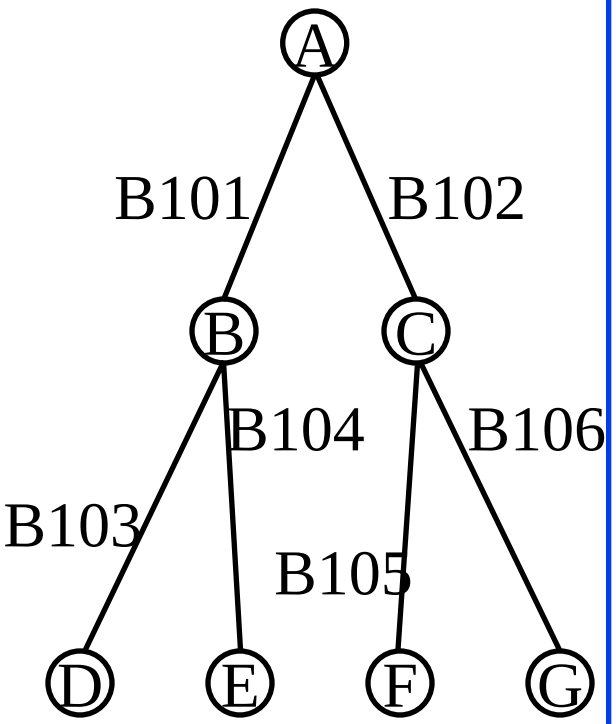
(a) Architecture



(b) Operation

Path Determination: Spanning Tree

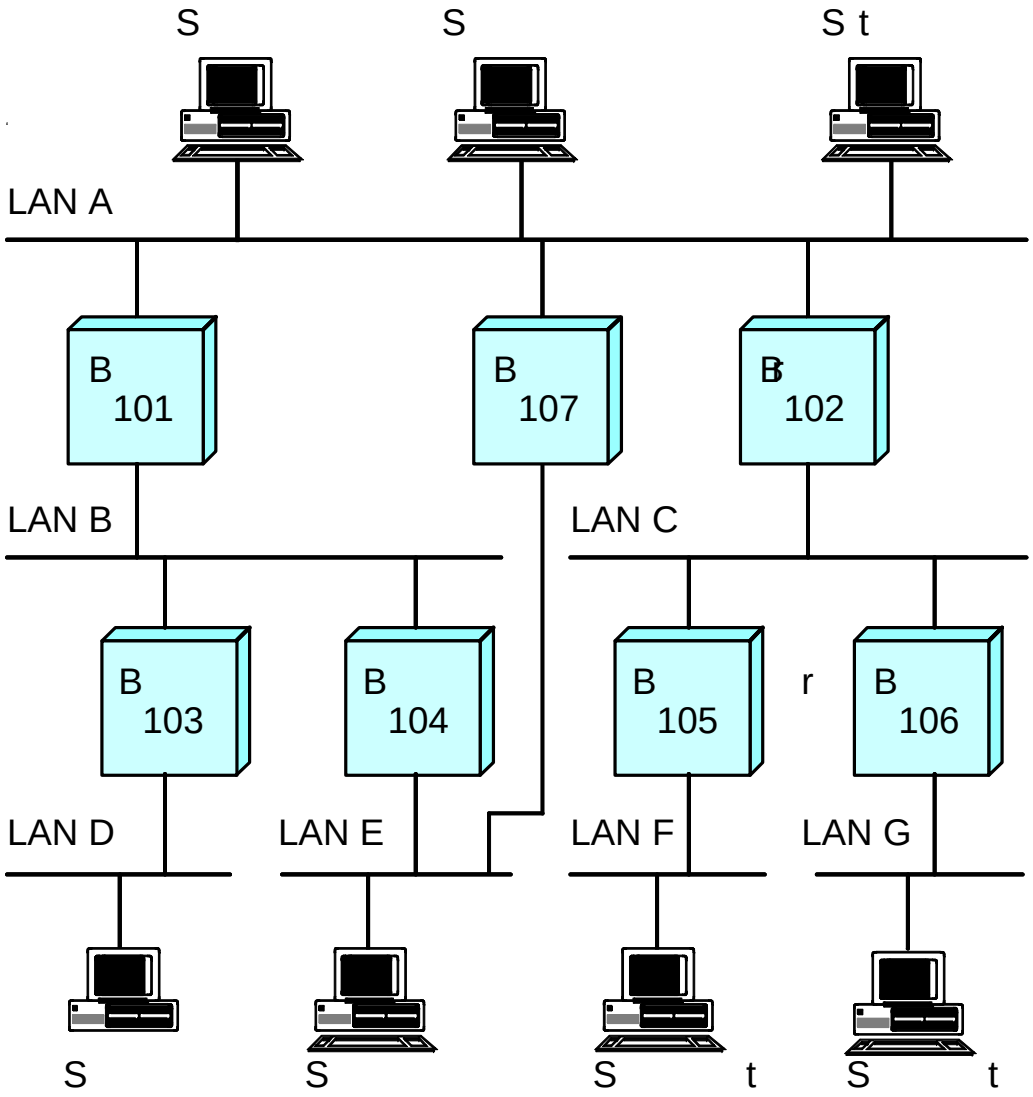


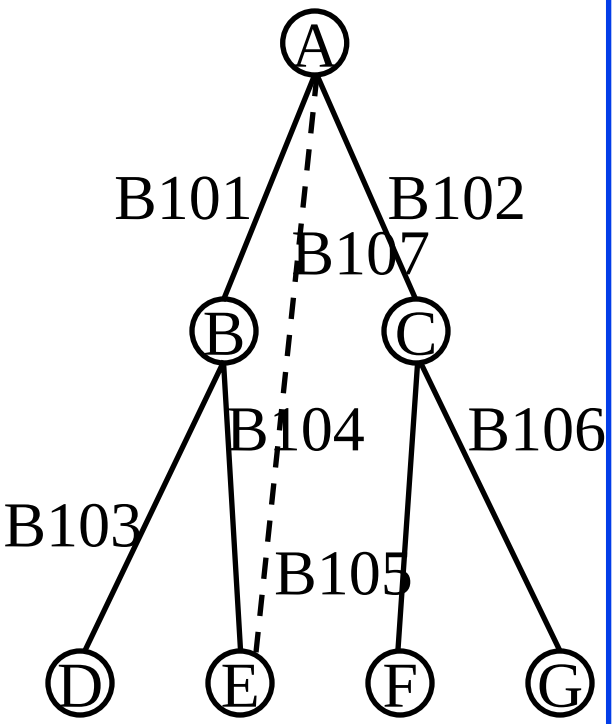


Nodes = LANs

Edges = Bridges

Spanning Tree (Cont)





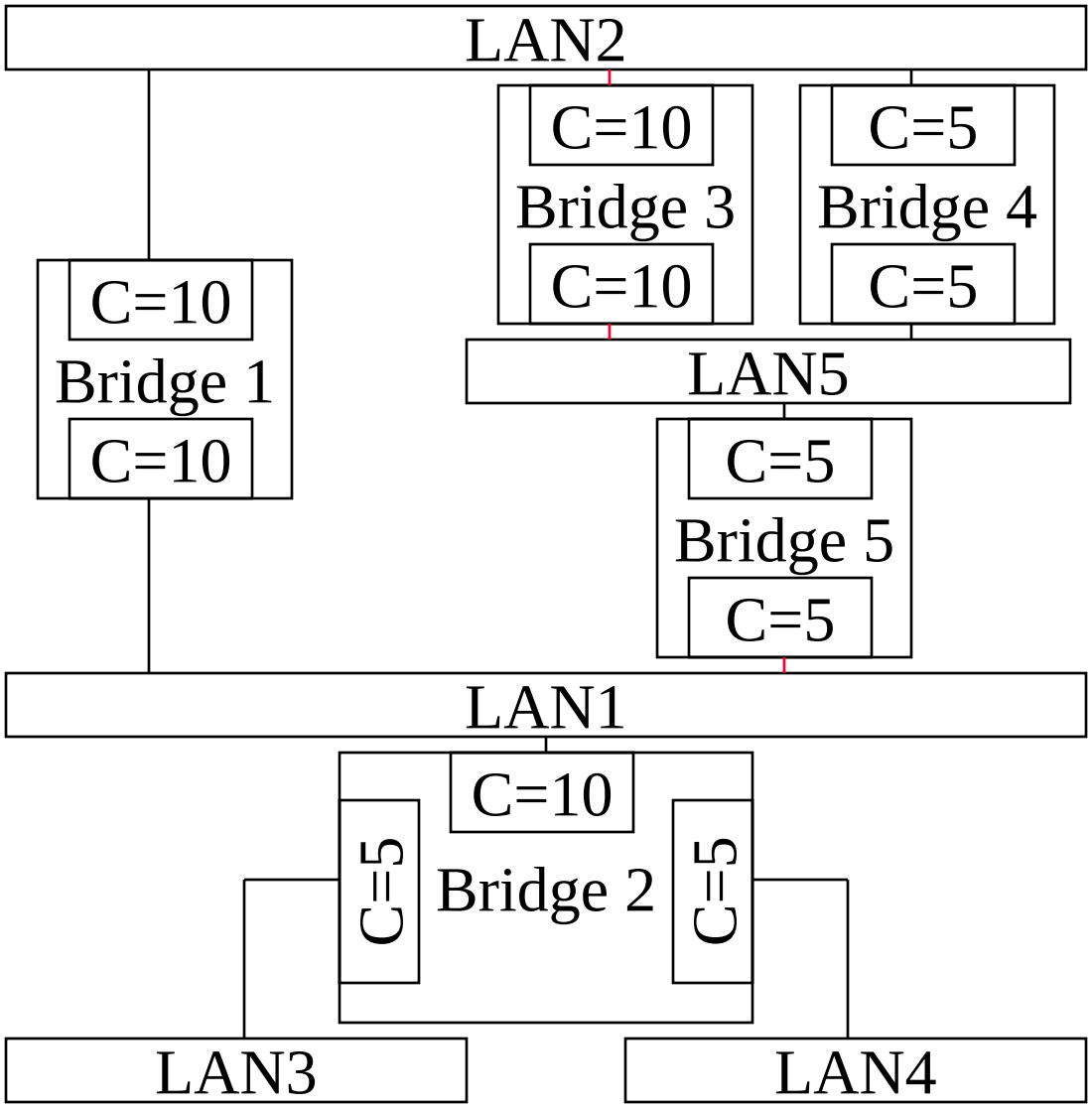
Spanning Tree: Terminology

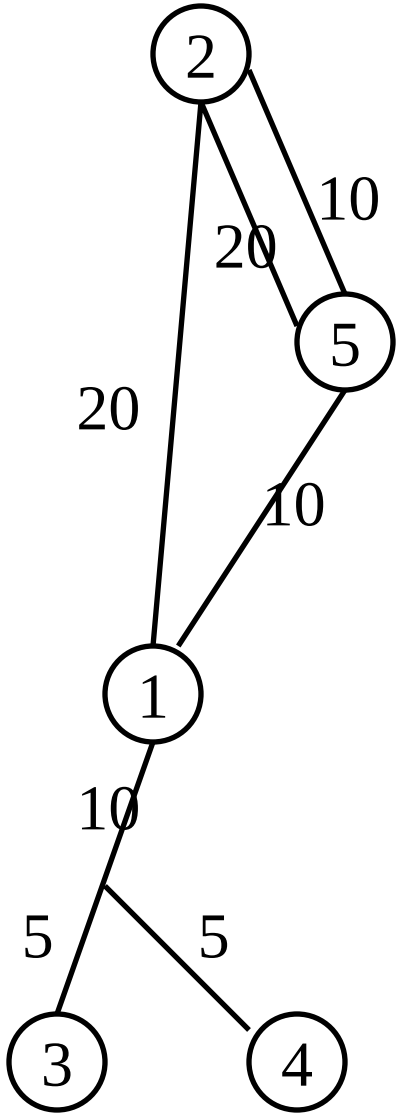
- Bridge Identifier: MAC address plus a priority level
- Port identifier: For each port of a bridge
- Path cost: Cost transmitting through a port
- Root Bridge: The bridge with the lowest identifier
- Root port: Port with minimum cost to the root bridge
- Root path cost: Cost of the path to the root bridge
- Designated bridge: One per LAN. Provides minimum cost path from the LAN to the root bridge.
- Designated Port: Connects designated bridge to LAN

Spanning Tree Algorithm

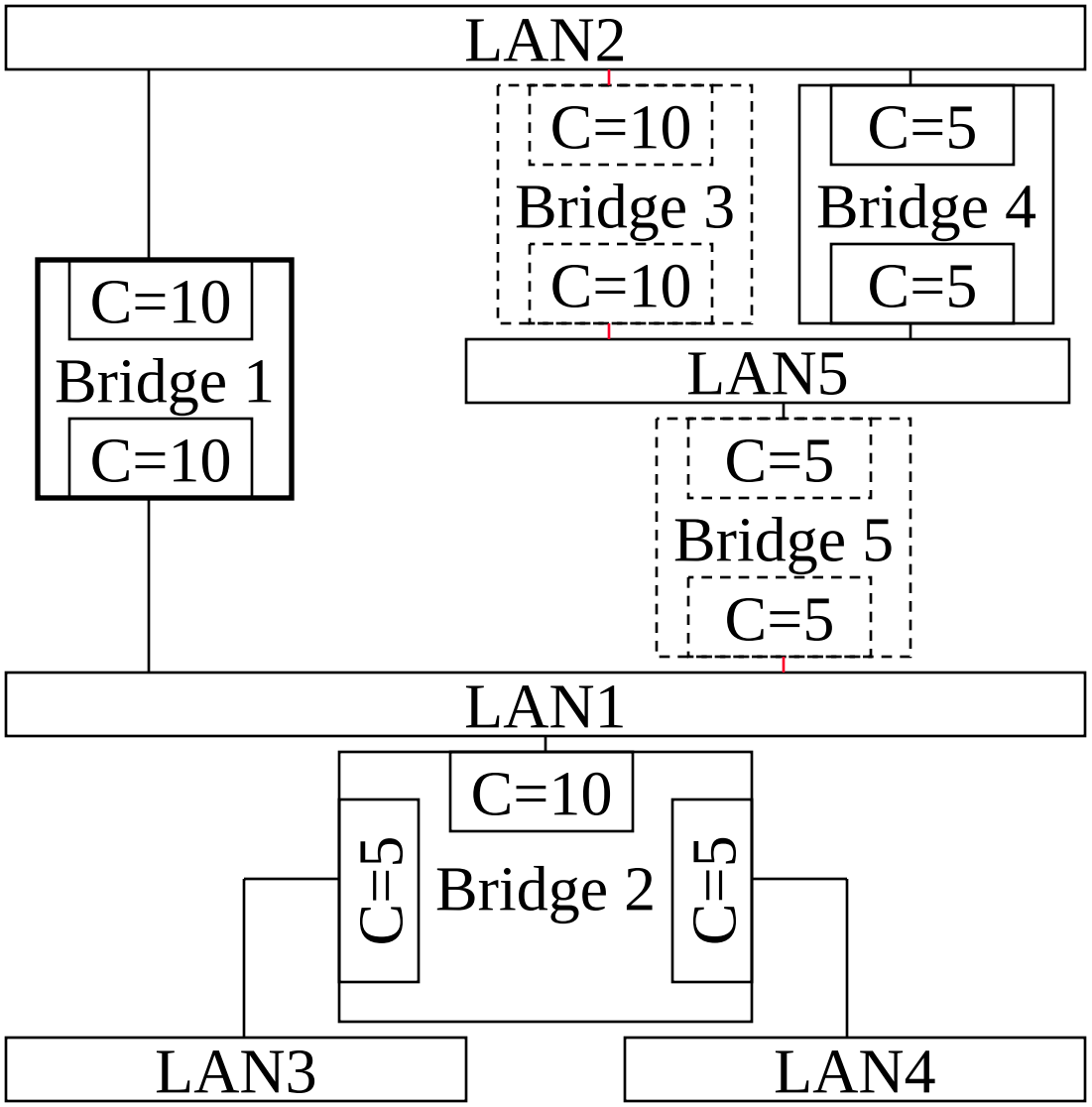
- All bridges multicast to "All bridges"
  - My ID
  - Root ID
  - My cost to root
- The bridges update their info using Dijkstra's algorithm and rebroadcast
- Initially all bridges are roots but eventually converge to one root as they find out the lowest Bridge ID.
- On each LAN, the bridge with minimum cost to the root becomes the Designated bridge
- All ports of all non-designated bridges are blocked.

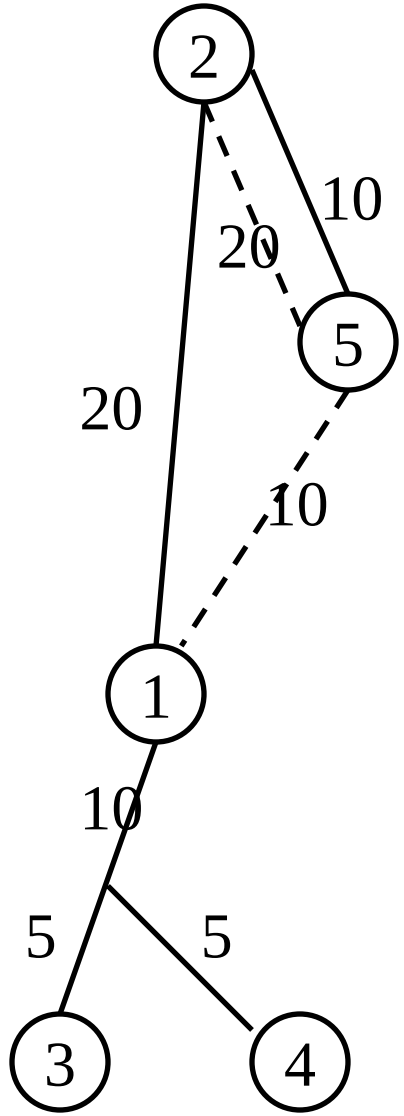
Spanning Tree Example





Spanning Tree Example



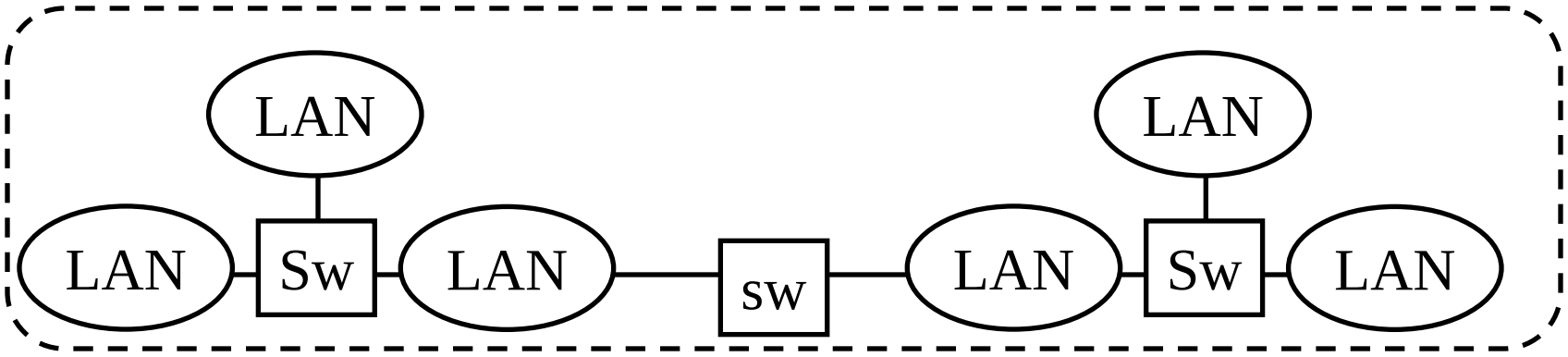


Layer 2 Switches

- Switches = Multi-port bridges with packet forwarding in hardware
- Store-and-forward switch
  - Accepts complete frame on input line
  - Buffers it briefly,
  - Then routes it to appropriate output line
  - Delay between sender and receiver
- Cut-through switch
  - Switch begins repeating frame onto output line as soon as it recognizes destination address
  - Highest possible throughput
  - Risk of propagating bad frames
    - Switch unable to check CRC prior to retransmission

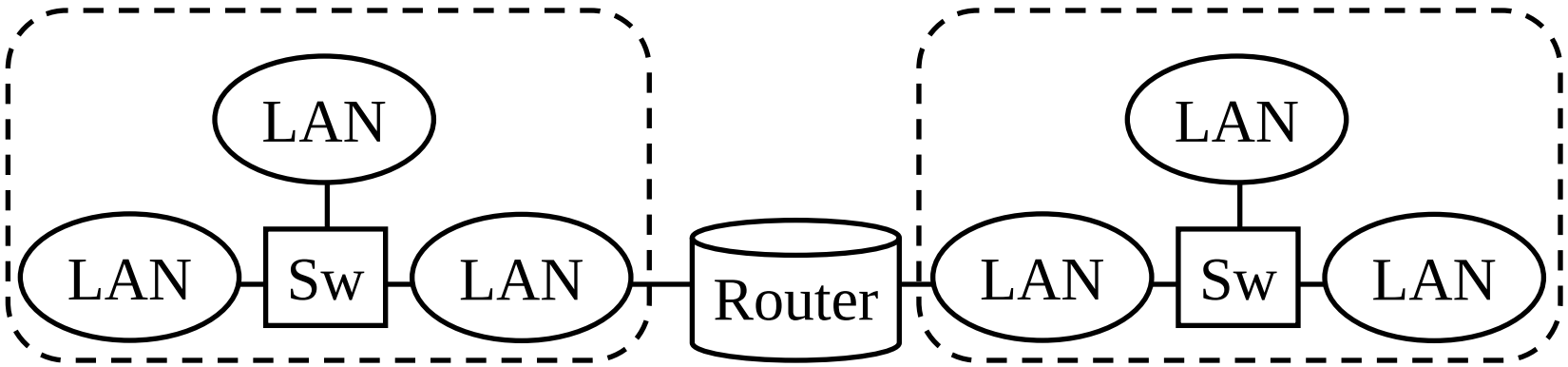
Problems with Switched Networks

- Broadcast Storms:
  - Broadcast frames are forwarded by bridges on all other ports
  - In large network, broadcast frames can create big overhead
  - Malfunctioning device can create broadcast storm
- Spanning Tree ⇒ Only one path between any two devices
  - No parallel paths ⇒ Limits performance and reliability.



Solution: Layer 3 Routing

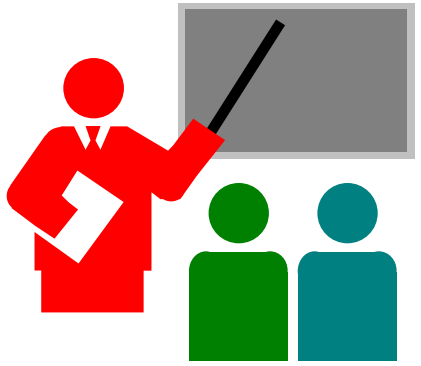
- Solution: Break up network into subnetworks connected by routers
- MAC broadcast frame limited to devices and switches contained in single subnetwork
- Routers employ sophisticated routing algorithms



Layer 3 Switches

- 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
- Solution: layer 3 switches
  - Implement packet-forwarding and address lookup logic of router in hardware

Summary



- LLC provides protocol multiplexing, flow control, and error control
- Ethernet bridges learn station locations from source addresses
- Spanning tree algorithm is used to avoid loops
- Large switched networks can have broadcast storms
- Layer 3 switches implement routing in hardware

Reading Assignment

- Read Sections 15.3, 15.4, and 15.5 of Stallings' 7th edition
- Ensure that you can answer all review questions.

Homework

- Submit answer to Exercise 15.6 from Stallings' 7th Edition
- For the following extended LAN, determine the spanning tree and indicate which bridges will be deactivated. All bridges have the same cost of 1 on all ports. When there are two equal cost paths, select the paths with lower numbered bridge or LAN.