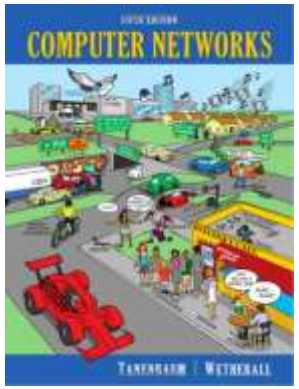
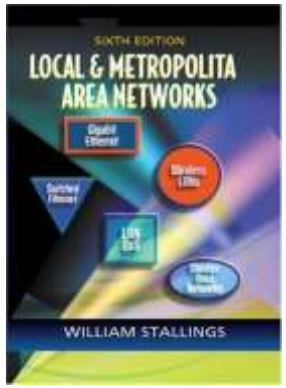
IEEE 802

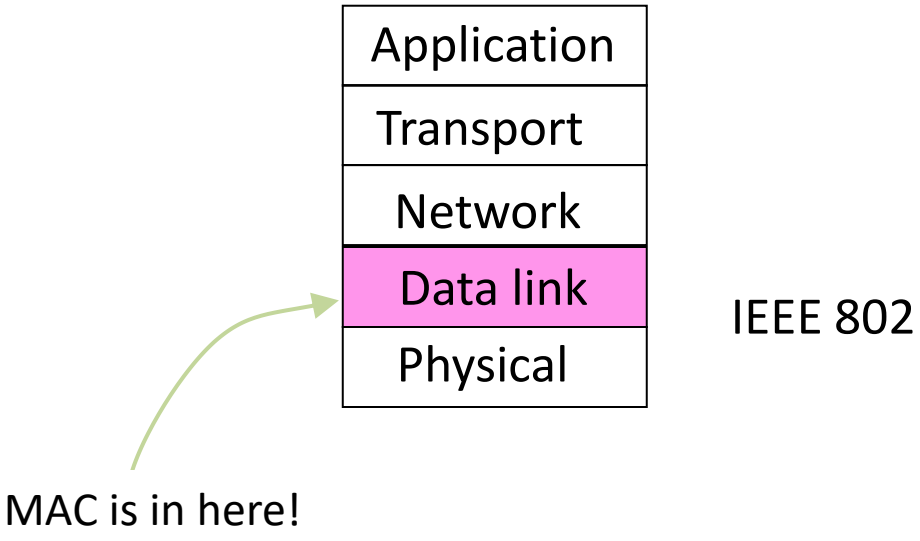
Algorithms and Topologies





The MAC Sublayer

Responsible for deciding who sends next on a multi-access (shared) link

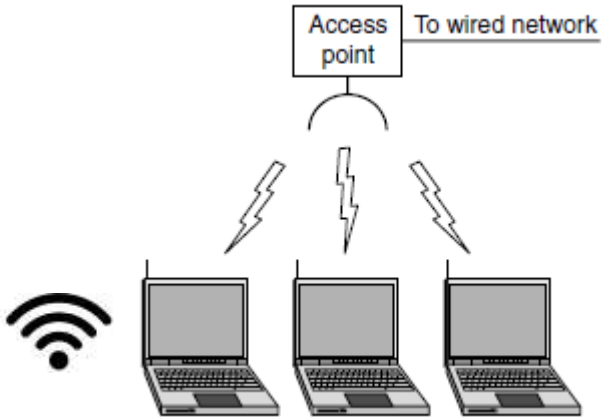


Multiple Access Protocols

ALOHA

CSMA / CD 802.3

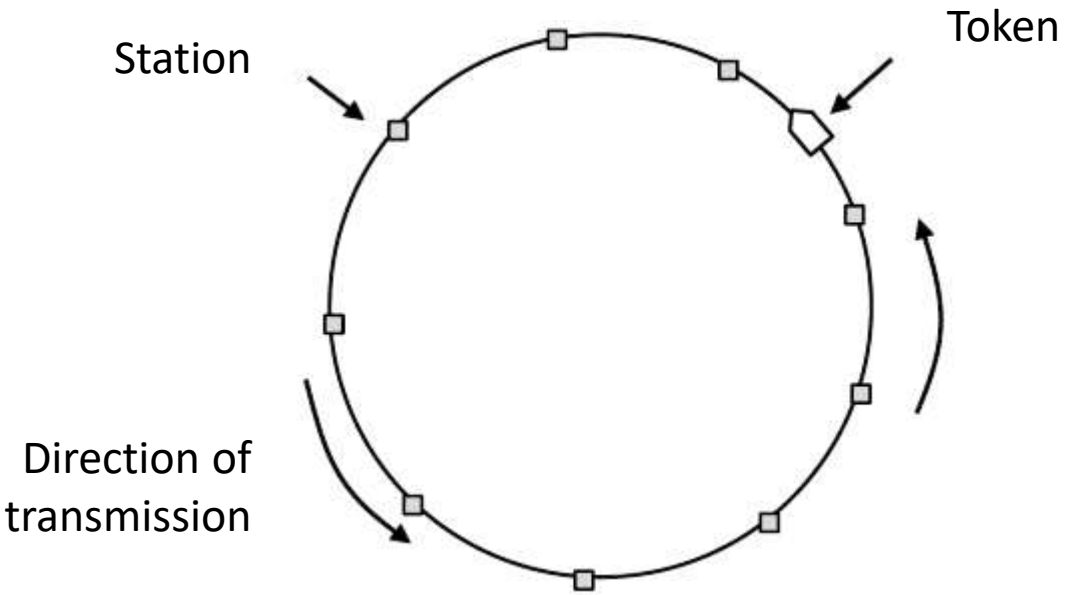
CSMA / CA 802.11



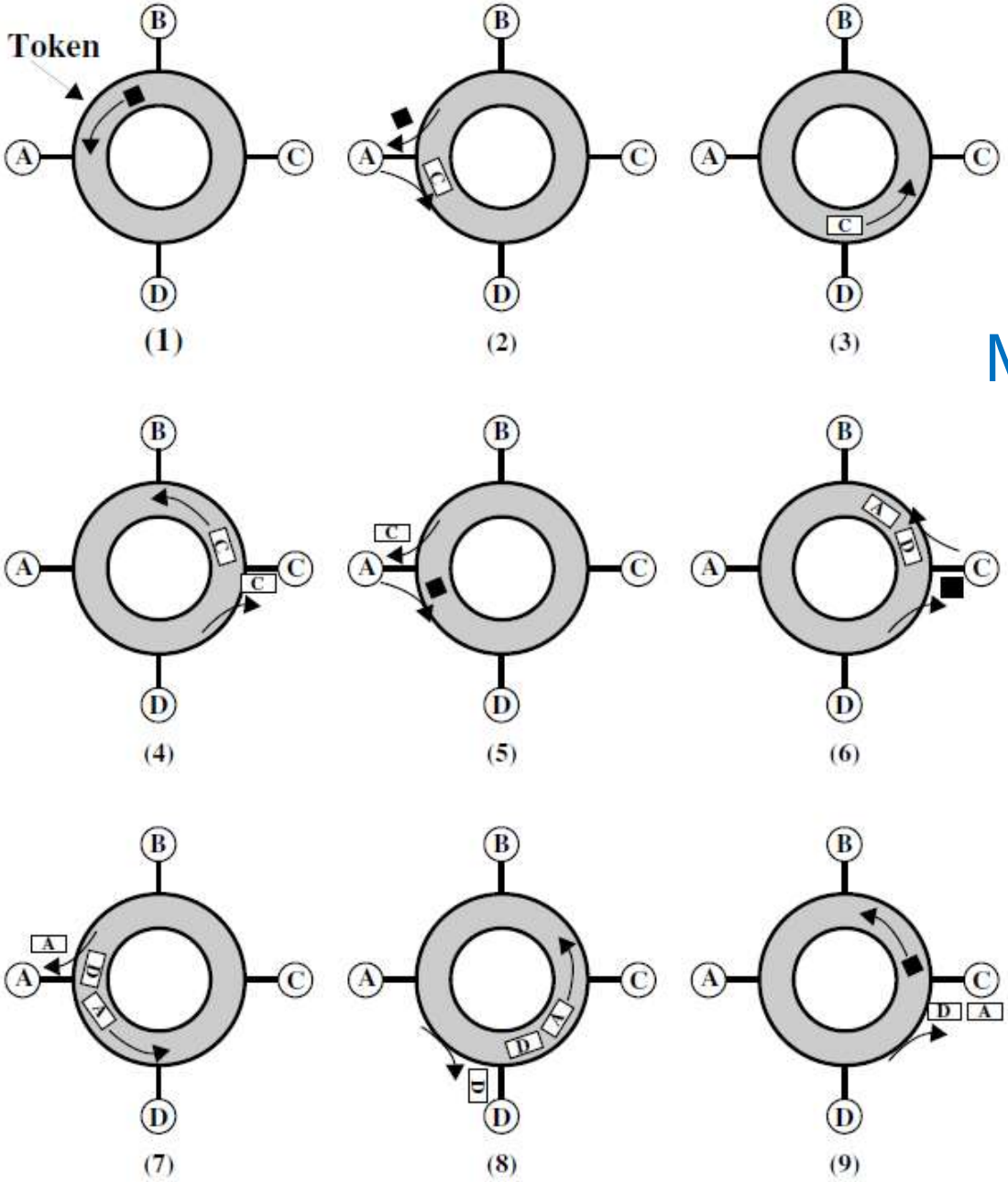
Collision-free protocols (token: 802.4 y 5)

Token Ring

A token that travels around the physical ring defines the sending order



The idea can be used in a logical ring (token bus)



Mutual exclusion

Token Ring

If a transmission error occurs and no token frame is present, the active monitor detects the deadlock and reinserts a token

All stations are capable of becoming an active monitor station if necessary (passive replication)

The active monitor is chosen through an election process

Token Ring

1. Any station detecting that the active monitor is not functioning will *broadcast* periodically a "claim token" frame, announcing that it wants to become the new active monitor

2. Any station receiving a "claim token" frame originating from a station with a higher MAC address is knocked out of the election process and becomes a repeater

Token Ring

3. When a station starts receiving its own “claim token” frames, it detects the termination of the process and knows it has won the election and becomes the active monitor

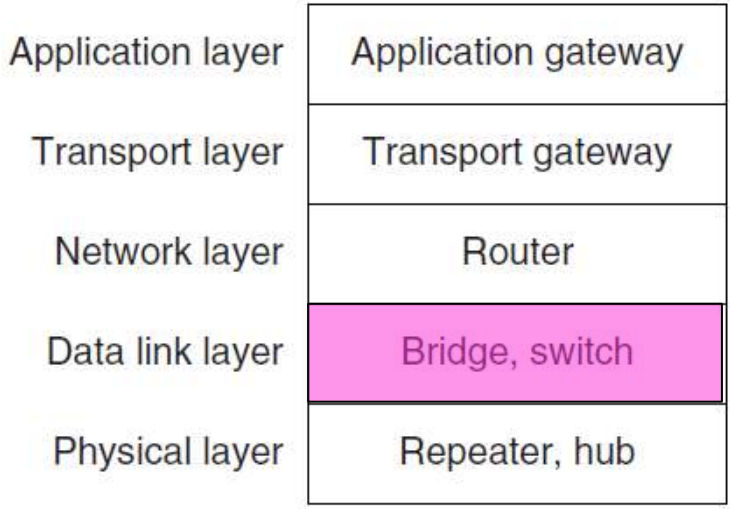
The transmitter with the highest MAC address wins the election

An anonymous self-stabilizing leader election algorithm

- First time unit:
  - S flips a coin (send or not send)
- Next time unit:
  - Case 1: Station S is participating
    - Success: S is the leader
    - Collision: S flips a coin again
  - Case 2: Station S isn't participating
    - Silence: S flips again a coin
    - Success: S detects the leader
    - Collision: S is eliminated

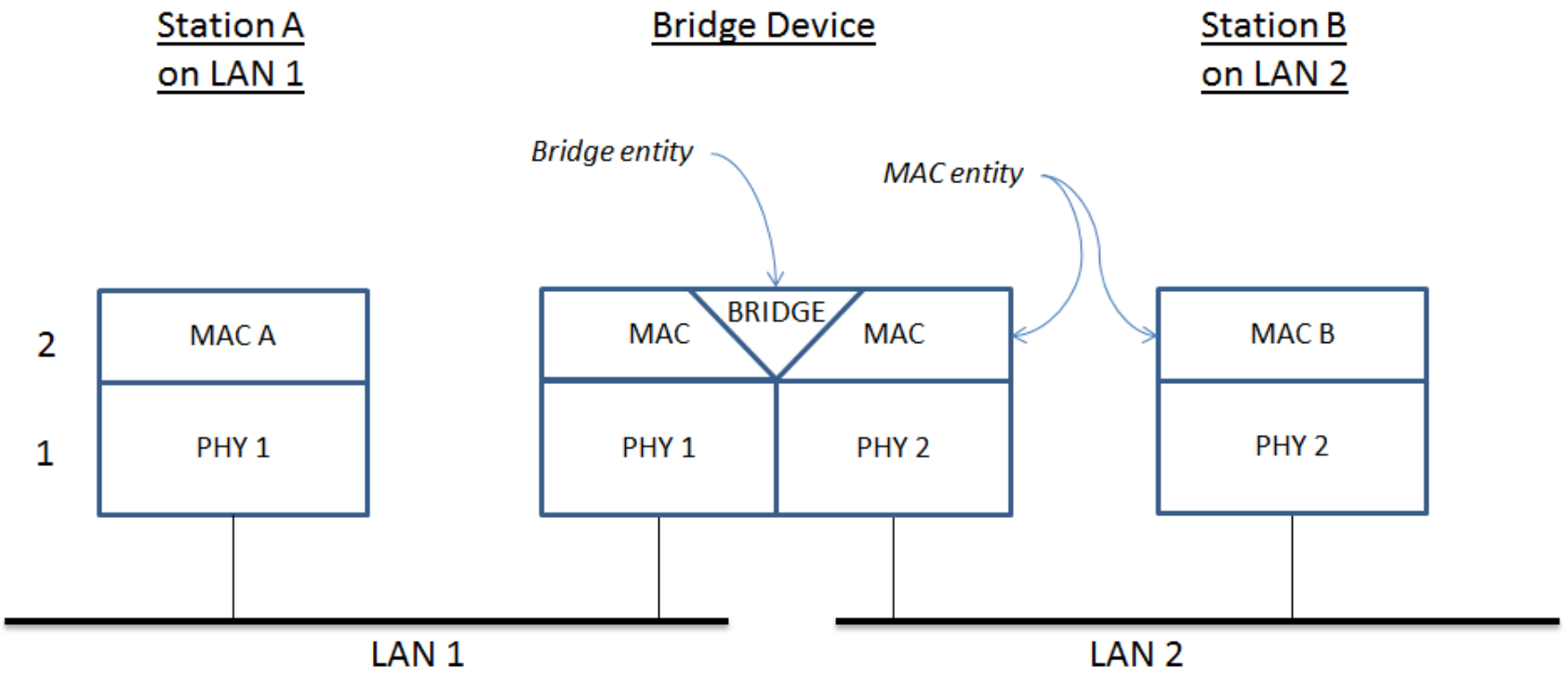
Repeaters, Hubs, Bridges, Switches

LAN switches operate in the data link layer



Bridges

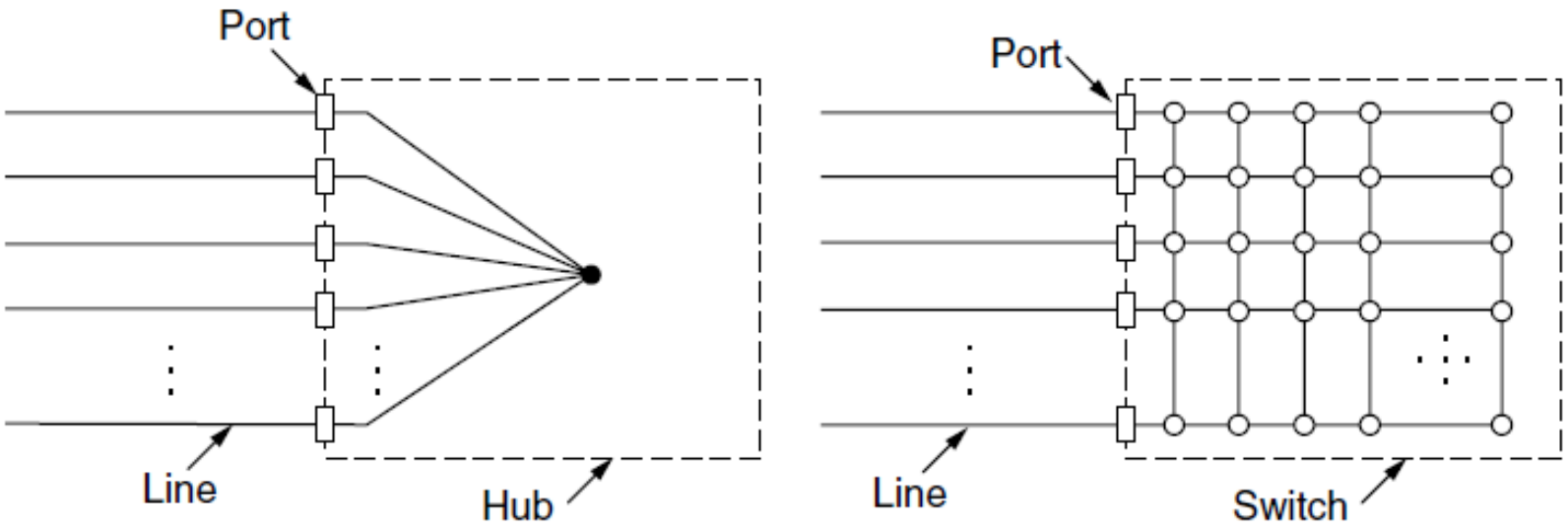
Bridges extend the data link layer



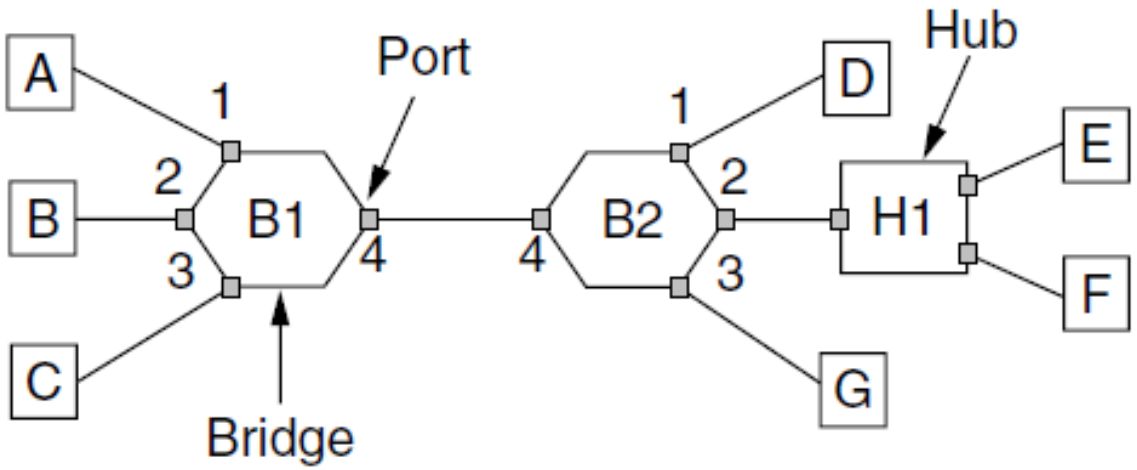
Switched Ethernet

Switches isolate each port to a separate CSMA/CD domain

- Much greater throughput for multiple ports
- No need for CSMA/CD with full-duplex lines



Learning Bridges



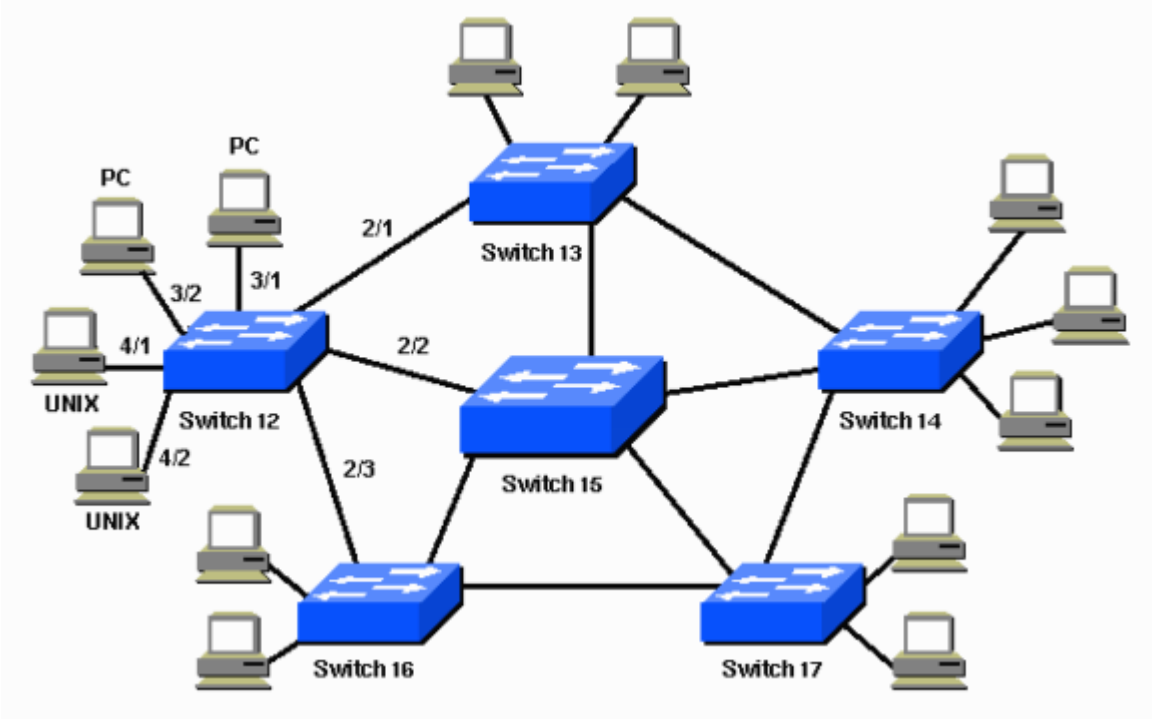
Learning Bridges

Backward learning algorithm picks the output port:

- Associates source address on frame with input port (filtering database)
- Frame with destination address in filtering database is sent to learned port
- Unlearned destinations are sent to all other ports

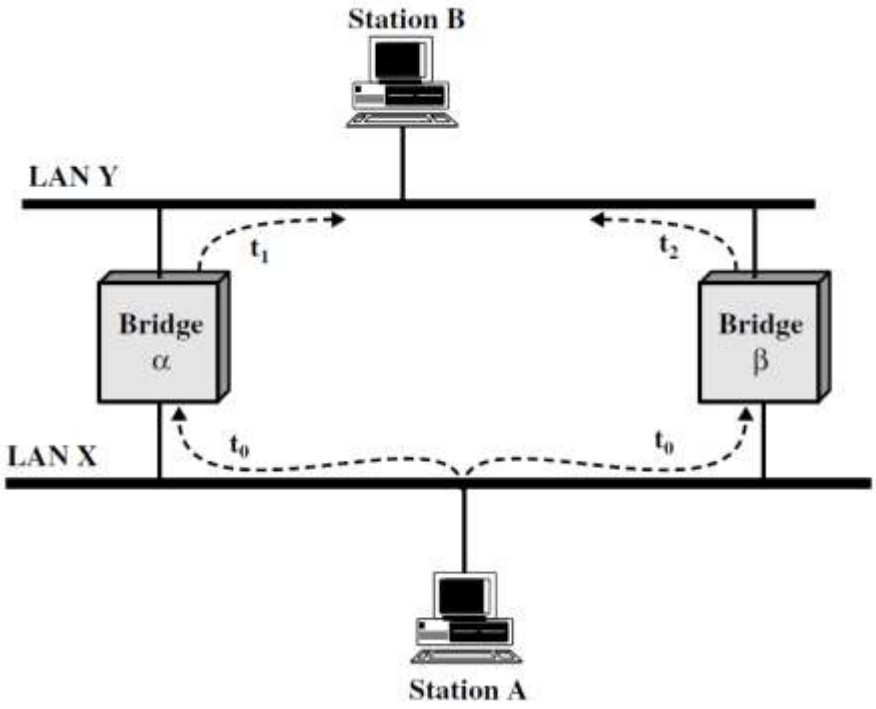
Redundant Network

Designing a redundant network is one of the key methods for keeping a network available



Redundant Network

Bridge topologies with loops and (only) backward learning will cause frames to circulate forever



Problem!

Spanning Tree Algorithm

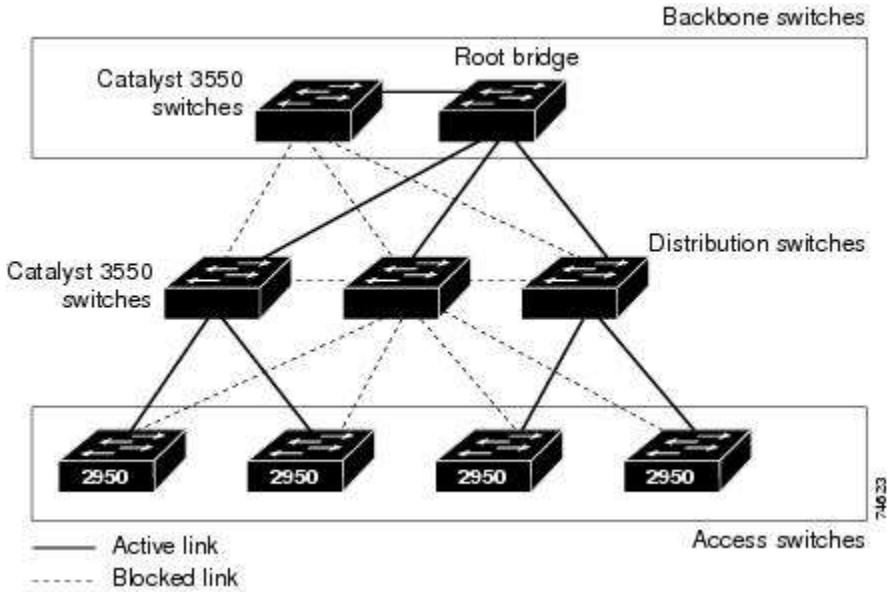
Subset of forwarding ports for data is used to avoid loops

Selected with a distributed algorithm by Perlman

I think that I shall never see
A graph more lovely than a tree.
A tree whose crucial property
Is loop-free connectivity.
A tree which must be sure to span.
So packets can reach every LAN.
First the Root must be selected
By ID it is elected.
Least cost paths from Root are traced
In the tree these paths are placed.
A mesh is made by folks like me
Then bridges find a spanning tree.

– Algorhyme, Radia Perlman, 1985

Redundant Network



Redundant fat-tree topology

Spanning Tree Protocol

The STP uses two steps to *converge* on a loop-free topology

1. Elect one root bridge
2. Determine least cost paths to the root
   - Elect **r**oot ports
   - Elect **d**esignated ports

802.1D

BPDU

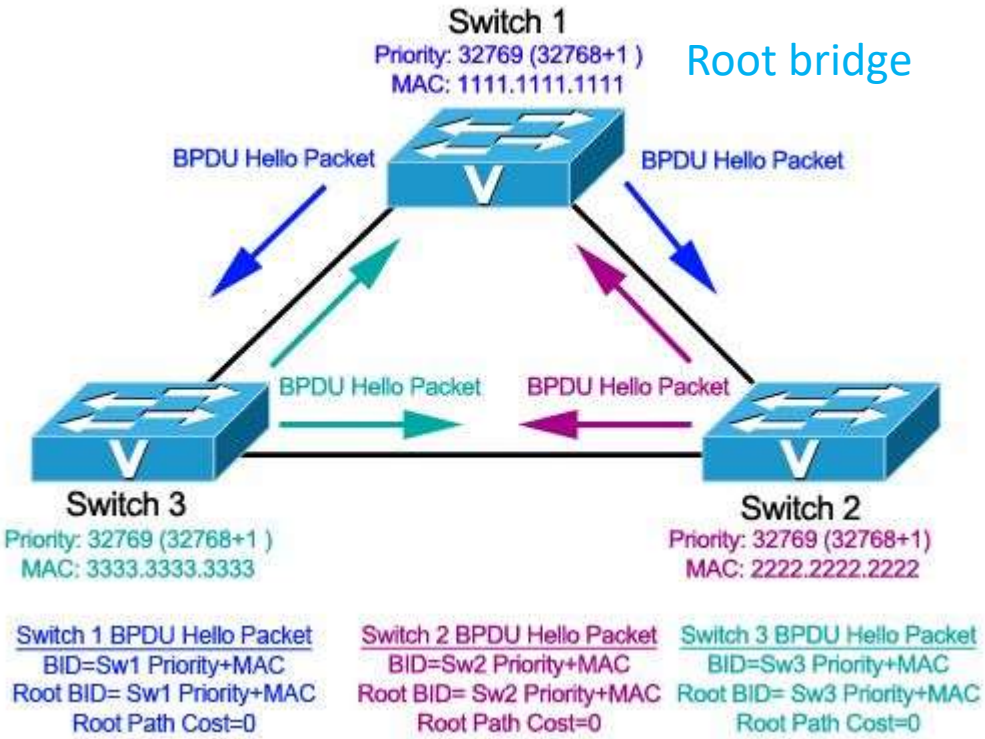
Bytes	Field
2	Protocol ID
1	Version
1	Message type
1	Flags
8	Root ID
4	Cost of path
8	Bridge ID
2	Port ID
2	Message age
2	Max age
2	Hello time
2	Forward delay

Cost vector

Elect one root bridge

- To begin, all bridges consider themselves to be the root bridge
- Each bridge will *multicast* a BPDU on each of its LANs that asserts this claim
- On any given LAN, only one claimant will have the lowest Root ID and will maintain its belief
- Overtime, as BPDUs *diffuse*, the identity of the (elected) root bridge will be know to all bridges

Elect one root bridge

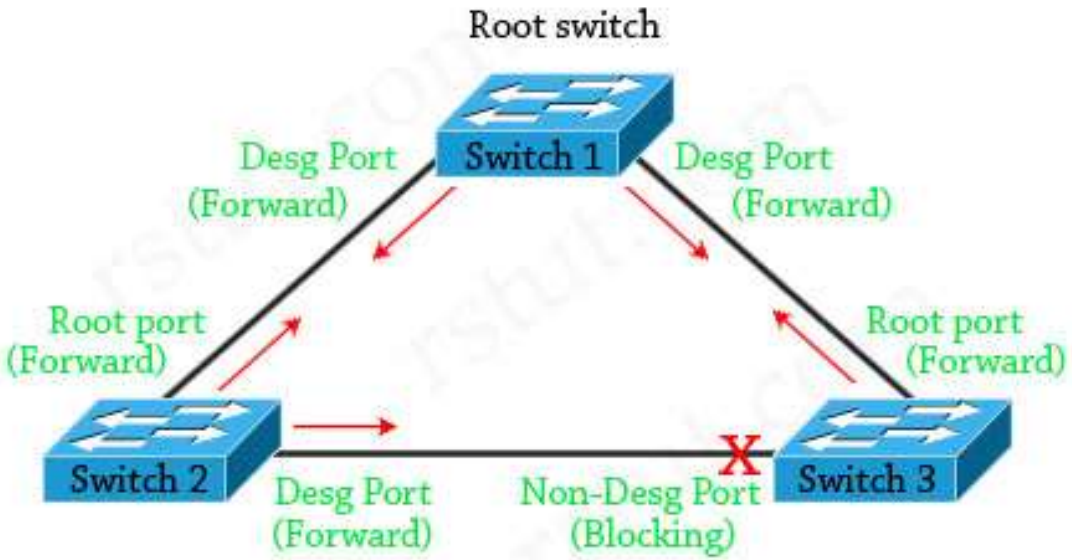


Determine least cost path to the root

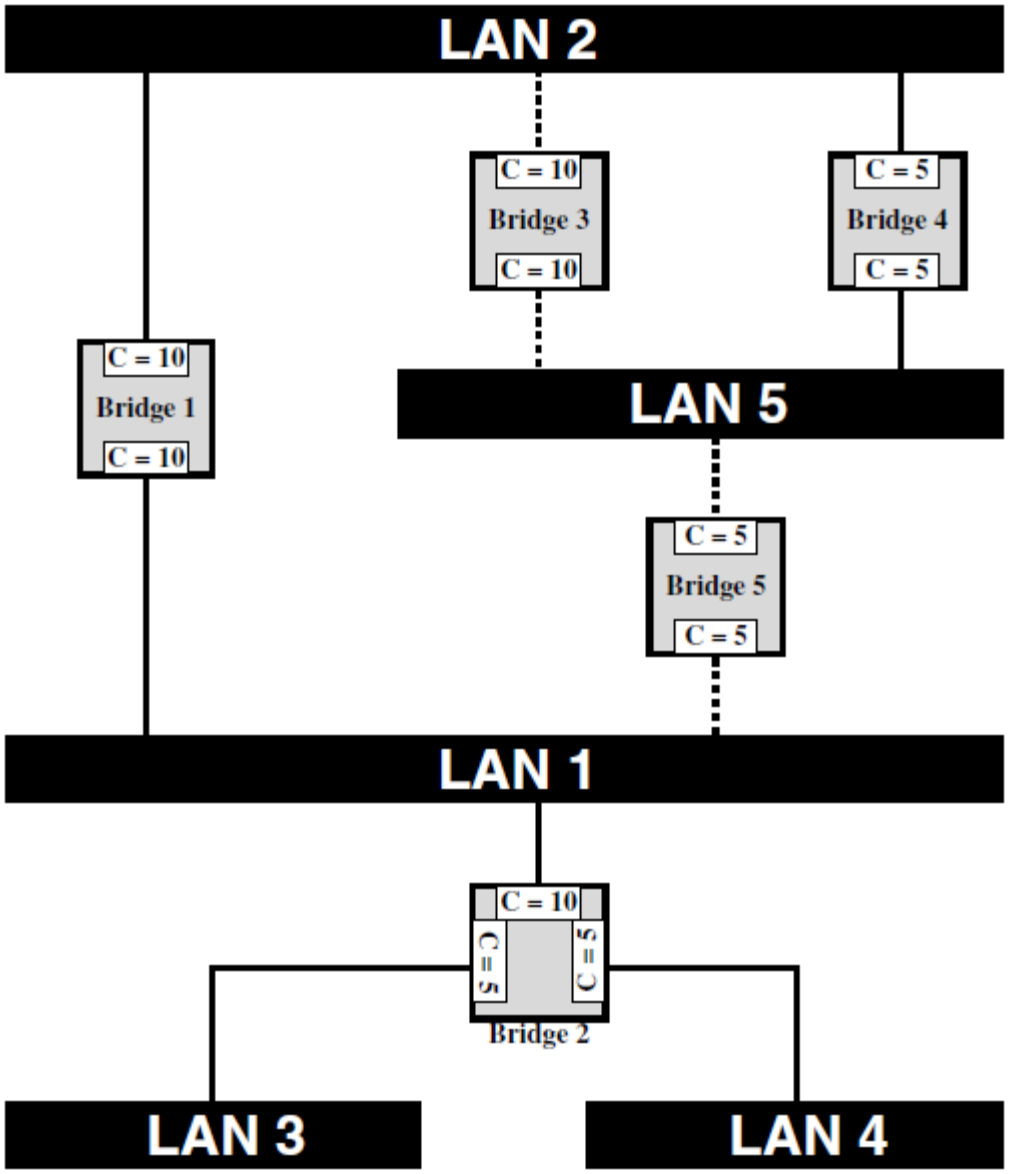
- The port on which the smallest (best) BPDU is received becomes the root port

- Other ports must be active (designated) or passive (no forwarding)
  - if the bridge generated the best BPDU for the link then the port is designated
  - if a smaller BPDU than the one generated by the bridge is received then the port is blocked

Determine least cost path to the root



Example


LAN 2
C = 10
Bridge 3
C = 10
C = 5
Bridge 4
C = 5
C = 10
Bridge 1
C = 10
LAN 5
C = 5
Bridge 5
C = 5
LAN 1
C = 10
C = 5
C = 5
Bridge 2
LAN 3
LAN 4

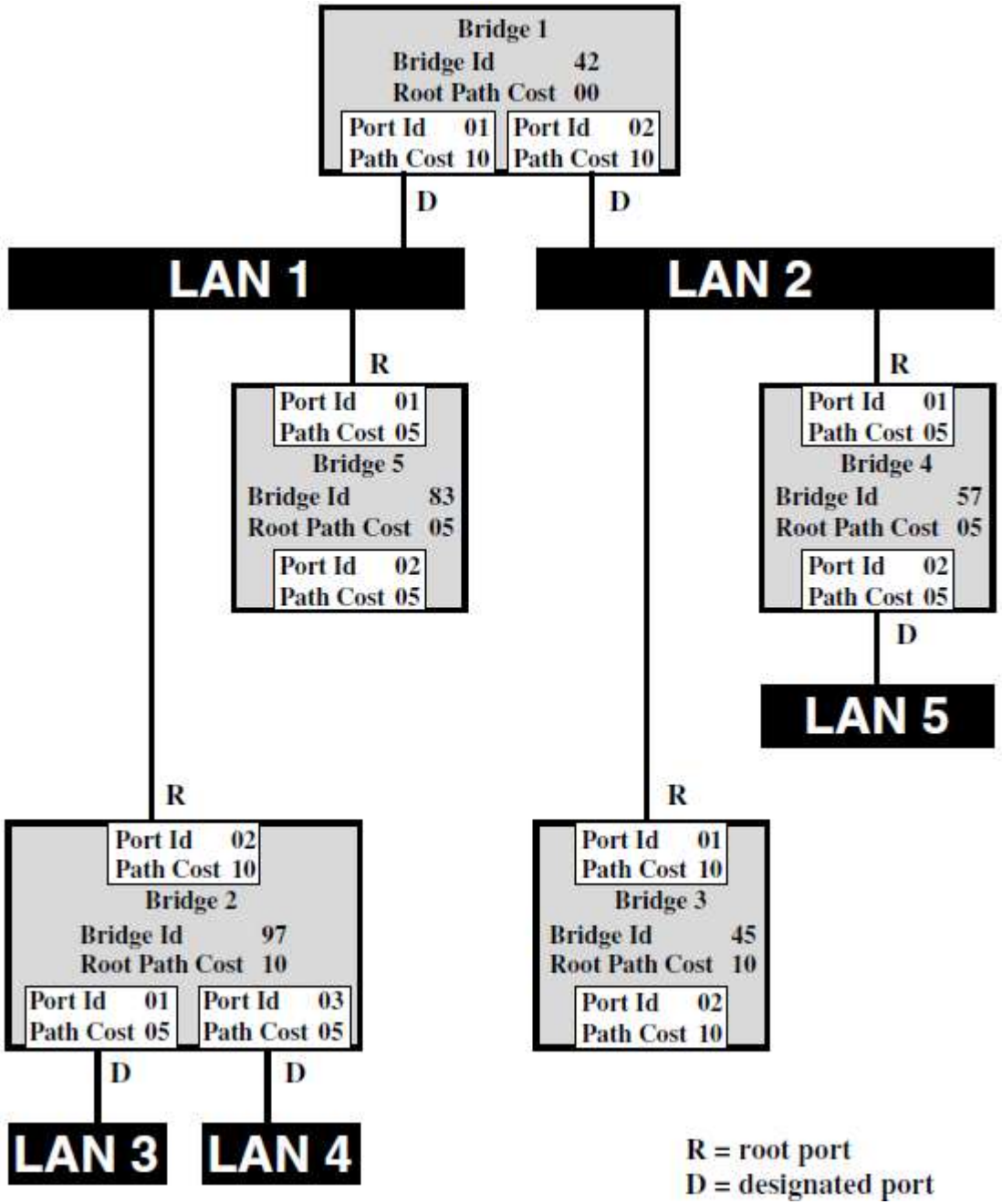
Spanning Tree Protocol

1. At startup time, bridges 1, 3, and 4 all transmit BPDUs on LAN 2 claiming to be the root bridge
2. When bridge 3 receives the transmission from bridge 1, it recognize a superior claim and defers
3. Bridge 3 also receives a claiming BPDU from bridge 5 via LAN 5. Bridge 3 recognizes that bridge 1 has a superior claim, it assigns its LAN 2 port to be its root port and sets the root path cost to 10
4. By similar actions, bridge 4 ends up with a root path cost of 5 via LAN 2, bridge 5 has a root path cost of 5 via LAN 1, and bridge 2 has a root path cost of 10 via LAN 1

Spanning Tree Protocol

5. On LAN 5, all three bridges transmit BPDUs to assert a claim to be the designated bridge
6. Bridge 3 defers because it receives BPDUs from the other bridges that have a lower root path cost.
7. Bridges 4 and 5 have the same root path cost, but bridge 4 has the lowest ID and therefore becomes the designated bridge

Example


Bridge 1
Bridge Id 42
Root Path Cost 00
Port Id 01
Path Cost 10
Port Id 02
Path Cost 10
D
D
LAN 1
LAN 2
R
Port Id 01
Path Cost 05
Bridge 5
Bridge Id 83
Root Path Cost 05
Port Id 02
Path Cost 05
R
Port Id 01
Path Cost 05
Bridge 4
Bridge Id 57
Root Path Cost 05
Port Id 02
Path Cost 05
D
LAN 5
R
Port Id 02
Path Cost 10
Bridge 2
Bridge Id 97
Root Path Cost 10
Port Id 01
Path Cost 05
Port Id 03
Path Cost 05
R
Port Id 01
Path Cost 10
Bridge 3
Bridge Id 45
Root Path Cost 10
Port Id 02
Path Cost 10
D
D
LAN 3
LAN 4
R = root port
D = designated port