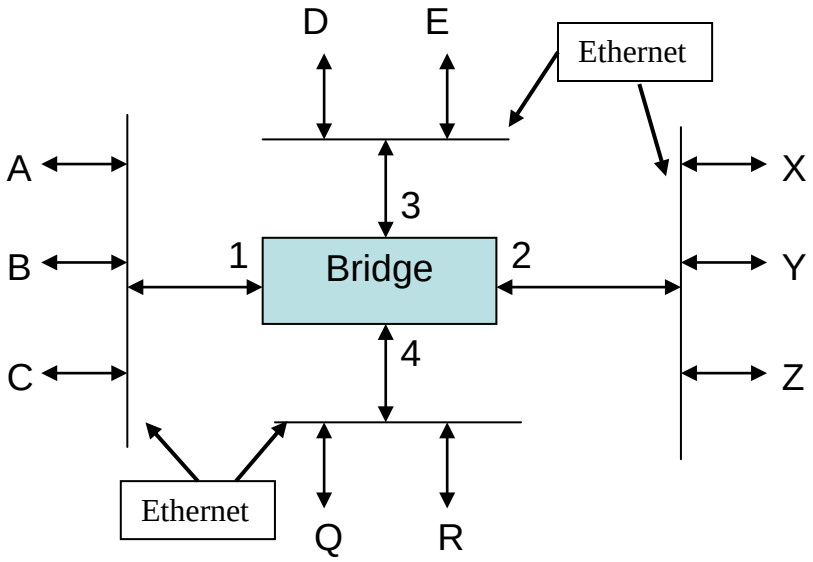
Bridges (LAN Switches)

- A bridge is an interconnection between two or more LAN's.
- Bridges are MIMO (multiple input/multiple output) devices.
- Bridges can operate in promiscuous mode - accept all frames from one LAN and forward them out on all other outputs.

Learning Bridges

- Forward traffic that needs to be forwarded only
- Use a forwarding table that indicates which port to use for each destination node/host
- Learns from traffic flow which port each host is connected to by looking at the source field of each frame
- Forwarding table entries time out after no activity from a host
- Frames destined for a host not in the table are forwarded out on all ports

Bridge and Forwarding Table Example



Host	Port
A	?
B	1
C	1
X	2
Y	?
Z	2
D	3
E	3
Q	?
R	4

? ➔ Host not known yet

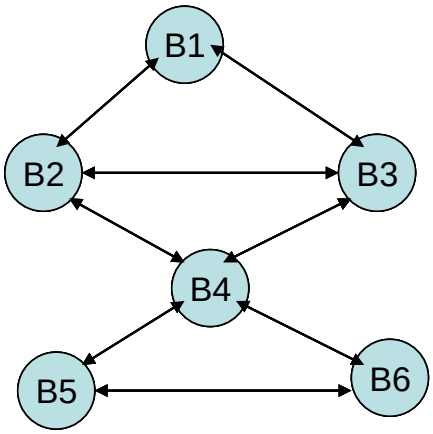
- All links are shown as bi-directional links.

- Packets coming in on port 1 that are destined for a host on port 1 are not forwarded out on the other ports.
- For the above table, if Host E is transmitting to Host A, the bridge receives the packet on port 3 and forwards it out on ports 1, 2 and 4 since it does not have a known port number for Host A.

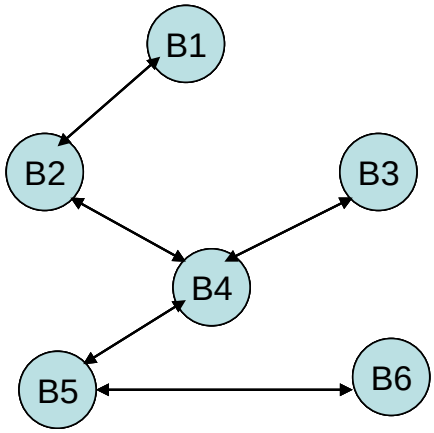
Spanning Tree Algorithm

- Removes loops (cycles) from an extended LAN – two or more LAN's connected together with bridges.
- Use graph theory notation to help. A graph shows all connections in an extended LAN.
- A spanning tree is a subgraph that shows connections for all vertices with no loops allowed.

Graph and Subgraph Example



Graph with loops



One possible spanning tree
(an acyclic (no loops) tree)

- The Spanning Tree Algorithm can result in a bridge that is temporarily removed from the extended LAN.
- The Spanning Tree Algorithm is dynamic and will allow for reconfiguration as necessary.
- The Spanning Tree Algorithm allows bridges to decide which ports to use for transmissions.

Spanning Tree Algorithm Set-up

- All bridges must have a unique ID
- Bridges must determine which bridge will be the root bridge
- Root bridge forwards packets out of all of its ports
- Each bridge determines the shortest path to the root bridge and uses the port for that path to the root
- All bridges connected to a LAN determine a designated bridge for forwarding packets.
    - This bridge is the one closest to the root bridge
    - If two or more bridges are the same distance from the root bridge, then the one with the smaller ID is chosen
- Bridges forward traffic on ports for which it is the designated bridge.

- Root bridge sends out configuration messages periodically. Once a bridge stops receiving configuration messages, it restarts the algorithm by sending a configuration message claiming to be the root bridge

Spanning Tree Algorithm

- Configuration messages have 3 field:
  - Root node ID
  - Distance to Root Node
  - ID of bridge sending the configuration message
  - (Y,d,X) : Y – root bridge, d – distance from X to the root bridge, X – bridge sending message
- Initially all bridges claim to be the root bridge and transmit a configuration message of (X,0,X)
- Configuration messages are sent out on all ports
- Bridges update information for a port when a received message
  - Has a root with smaller ID
  - Has a root with same ID but smaller distance
  - Root id and distance are the same, but sending bridge has a smaller ID
  - Bridge adds one to the distance to the root when a received message is to replace the current information.
- Once a bridge is no longer considered the root bridge, it forwards configuration messages only
- Once a bridge determines it is no longer the designated bridge for a LAN connected to a port, it stops sending messages on that port.
  - Designated bridge is closer to the root
  - Designated bridge is the same distance, but has smaller ID

Bridges with multicast and Broadcast

1) Broadcast – all bridges forward the broadcast out all other ports
2) Multicast – Bridges learn over time which ports packets need to be forwarded. Currently multicast packets are treated like broadcast – all bridges transmit

Bridge Limitations

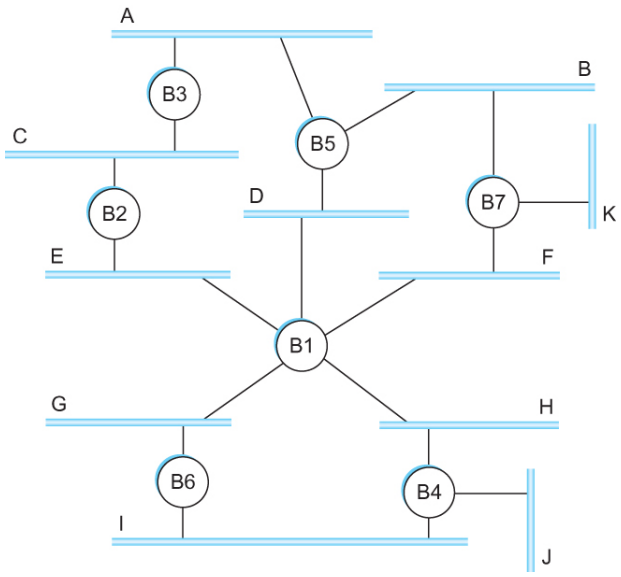
- Scaling is not realistic
  - Spanning trees scale linearly
  - Broadcast messages do not scale – can reduce the effect by using virtual LANs
- Limited on networks they can interconnect – networks must all have the same formatting for addresses

Virtual LAN (VLAN)

- Extended LAN's are broken up into LAN groups (virtual LANs)
- An extra Virtual LAN identifier is added to the packet header
- Packets are only forwarded out on ports associated with the VLAN ID contained in the header

Spanning Tree Algorithm Example

Consider the following network from the text (5th edition, figure 3.12)



Look at the following communication between bridges to determine the root bridge and designated bridges (bridges that forward traffic from a LAN toward the root bridge)
In the following table: X➔Transmit, R➔Receive, P➔Port – this number corresponds to the bridge that is connected to another bridge on the link (i.e. B3 connects to B2 using port 2 and to B5 using port 5). The following table also ignores the repeated messages from Bridge 1 and just follows the setup for B2, B3, B5 and B7

Time Slot	B2	B3	B5	B7
0	X (B2,0,B2)	X (B3, 0, B3)	X (B5, 0, B5)	X (B7, 0, B7)
	No receive	No receive	No receive	No receive
1	X (B1,1,B2)-P3	X (B2,1,B3)-P5	X (B1,1,B5)-P7 X (B1,1,B5)-P3	X (B1,1,B7)-P5
	R (B1,0,B1)-P1 R (B3,0,B3)-P3	**R (B2,0,B2)-P2** R (B5,0,B5)-P5	**R (B1,0,B1)-P1** R (B3,0,B3)-P3 R (B7,0,B7)-P7	R (B5,0,B5)-P5 **R (B1,0,B1)-P1**
2			X (B1,1,B5)-P7 X (B1,1,B5)-P3	
		R (B1,1,B2)-P2 R (B1,1,B5)-P5	R (B2,1,B3)-P3 R (B1,1,B7)-P7	R (B1,1,B5)-P5

After the first reception, Bridges 2, 5 and 7 have selected Bridge 1 as the root bridge, and Bridge 3 accepts Bridge 2 as the root bridge.

On the second reception,

1) Bridge 3 accepts Bridge 1 as the root. It also notes that Bridge 2 and Bridge 5 are closer to Bridge 1, so it stops forwarding messages on its two ports (it is not a designated bridge for either port) since bridge 2 and 5 are closer to the root bridge

2) Bridge 5 keeps Bridge 1 as root. It also notes that it will be the designated bridge for LAN B (since Bridge 7 is distance 1 from Bridge 1, but Bridge 5 has a lower ID). It also notes that it will be the designated Bridge for LAN A, since Bridge 3 has yet to select Bridge 1 as the root and the distance is the same.

3) Bridge 7 keeps Bridge 1 as the root bridge and stops forwarding message towards Bridge 5 (no longer designated bridge for LAN B) since Bridge 5 is same distance to the root, but has lower ID

By the third reception, Bridge 5 will realize it is the designated Bridge for both its ports since it does not receive messages from Bridge 3 or Bridge 7.