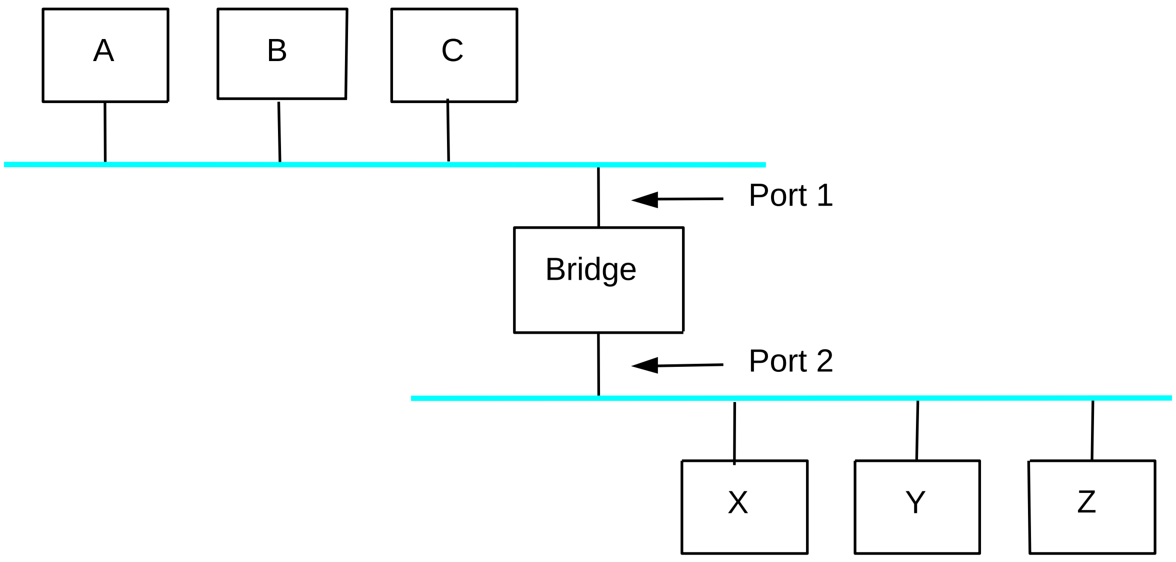
Bridges and Switches

Bridges and Extended LANs

- LANs have physical limitations (e.g., 2500m)
- Extended LAN: Interconnection of two or more LANs by one or more bridges
- Note: LAN bridges and switches are similar. They operate at layer 2. Routers are layer 3 switches
- Source routing bridge
  - Source host attaches completes address to the destination to the frame header ; token ring 802.5 group
- Transparent bridge or Spanning Tree bridge
  - Hosts need (do) not have the knowledge of the presence of bridges; CSMA/CD 802.3 group; WE STUDY TRANSPARENT BRIDGES
- A *bridge*
  - Operates in promiscuous mode; Multi-input and multi-output switch
  - An Ethernet bridge connecting n number of 10 Mbps Ethernet segments can carry up to 10n Mbps traffic
  - Operates in the data link layer .Uses accept and forward strategy; does not add packet header

An extended LAN with a bridge



Learning Bridges

- Learn the ports through which a given host can be reached
- Maintain forwarding table

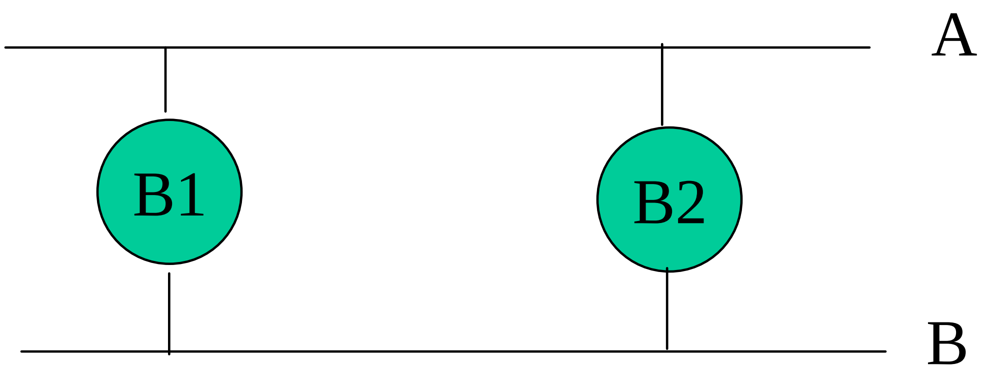
Host	Port
A	1
B	1
C	1
X	2
Y	2
Z	2

- Learn table entries based on source address
- Table need not be complete; can dynamically change (Why?)
- Always forward broadcast frames

Backward Learning Method

- Initially the forwarding table is empty
- When the bridge sees a frame <A,B> with source A and destination B, it learns where A is; i.e. through which port/interface A can be reached. Since the location of B is not known, the frame is forwarded through all the ports; here port 2; as the frame was received from port 1. An entry for A is made in the table.
- When <Y,A> is received, it is forwarded to port 1 as the bridge has already learnt A's location. Now the bridge learns Y is location and makes an entry in the forwarding table.
- When <B,Z> is received, the port associated with B is learnt. Frame is forwarded to all the ports; in this case, through port 2
- When <C,B> is received, the bridge does not forward it to port 2 as it already knows that B is on port 1.

Loops - Problem

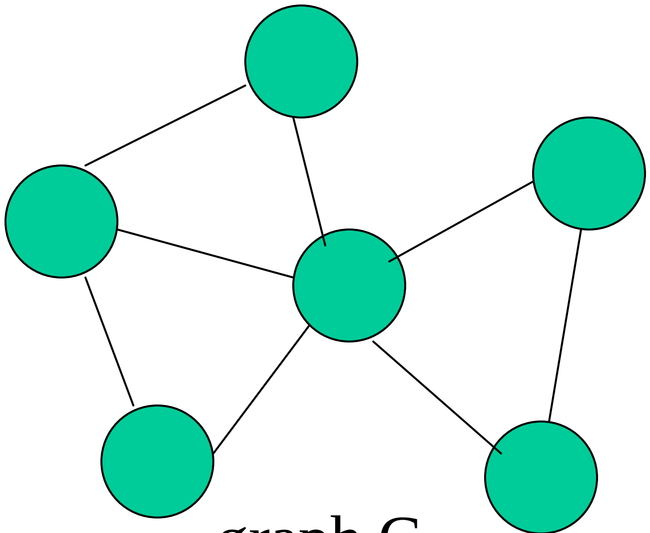


- Loops can exist to increase reliability but it may result in a situation where frames loop forever
- When frame F with unknown destination arrives at LAN B, B1 forwards it to LAN A generating frame F1, B2 forwards to LAN A generating frame F2. B1 on seeing F2 will forward it to LAN B generating F3. Similarly B2 on seeing F1 will forward it to LAN B generating F4. This continues forever.

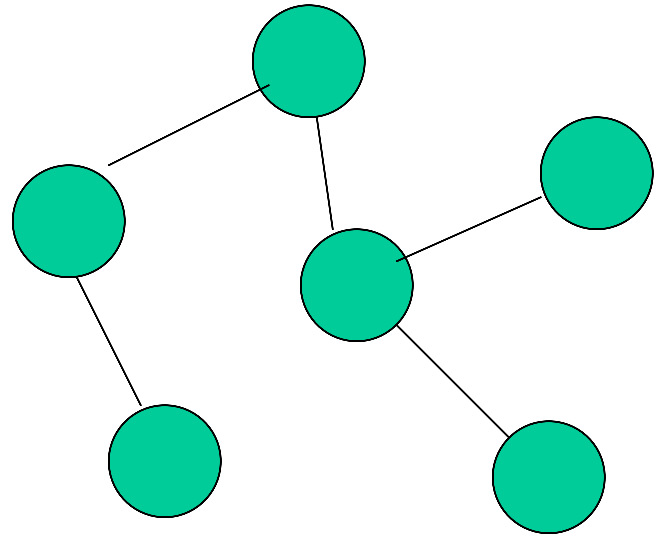
Spanning tree Bridges

- To avoid loops, generate a spanning tree topology over the actual topology
  - Graph: A set of nodes and edges
  - Spanning tree of a graph: subgraph with all nodes and a subset of edges; no loops; unique path from the root to any node; unique path between any two nodes
- The spanning tree spans all the LANs; but some bridges may be removed to avoid loops
- There is a unique path between any two LANS
- Using a distributed spanning tree algorithm all bridges agree on the spanning tree
  - select which bridges on which ports actively forward
  - developed by Radia Perlman
  - now IEEE 802.1 D specification

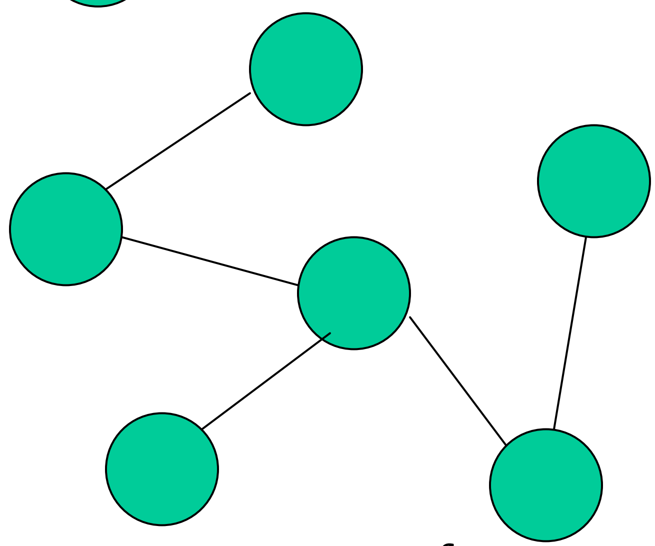
SPANNING TREE : EXAMPLES



graph G



s.tree T1 of G

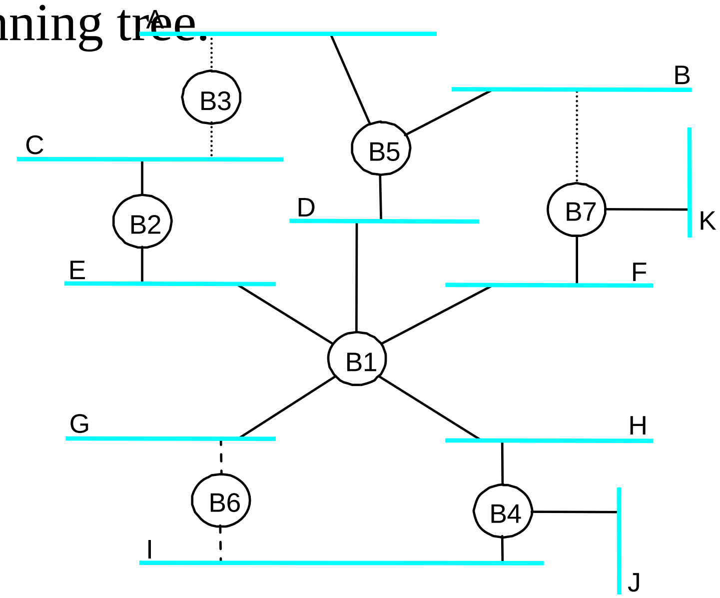


s.tree T2 of G

Spanning Tree Algorithm Overview

- Each bridge has unique id (e.g., B1, B2, B3) (*See figure - Ref book by Peterson and Davie)*
- Select bridge with smallest id as root
- Create a tree of shortest paths from every bridge to the root
- Select bridge on each LAN closest to root as designated bridge (use id to break ties)
- Forward frames following the spanning tree.

- Each bridge forwards frames over each LAN for which it is the designated bridge



Algorithm Details

- Bridges exchange configuration messages:(Y,d,X)
  - Id (X) for bridge sending the message
  - id (Y) for what bridge X believes to be root bridge
  - distance (hops) (d) from sending bridge to root bridge
- Each bridge records current best configuration message for each port
- Initially, each bridge believes it is the root

Algorithm Detail (contd.)

- When learn not root, stop generating config messages
  - in steady state, only root generates configuration messages
- When learn not designated bridge, stop forwarding config messages
  - in steady state, only designated bridges forward config messages
- Root continues to periodically send config messages
- If any bridge does not receive config message after a period of time, it starts generating config messages claiming to be the root

Spanning Tree Algorithm: An illustration

- B3 receives (B2, 0, B2). Bridge B3
  - accepts B2 as root since 2<3; sends (B2, 1, B3) to B5
- B2 receives (B1, 0, B1). Bridge B2
  - accepts B1 as root; sends (B1,1,B2) to B3
- B5 receives (B1, 0, B1). Bridge B5
  - accepts B1 as root; sends (B1,1,B5) to B3
- B3 receives (B1, 1, B2). Bridge B3
  - Accepts B1 as root; stops forwarding to LAN C as B2 is closer to B1 than itself
- B3 receives (B1, 1, B5). Bridge B3
  - Accepts B1 as root; stops forwarding to LAN A as B5 is closer to B1 than itself

Broadcast and Multicast

- Forward all broadcast/multicast frames
  – Currently followed; let the hosts decide if the multicast frame is meant for it
- Alternatively, Learn when no group members downstream
- Accomplished by having each member of group G send a frame to bridge multicast address with G in source field . This is done periodically.

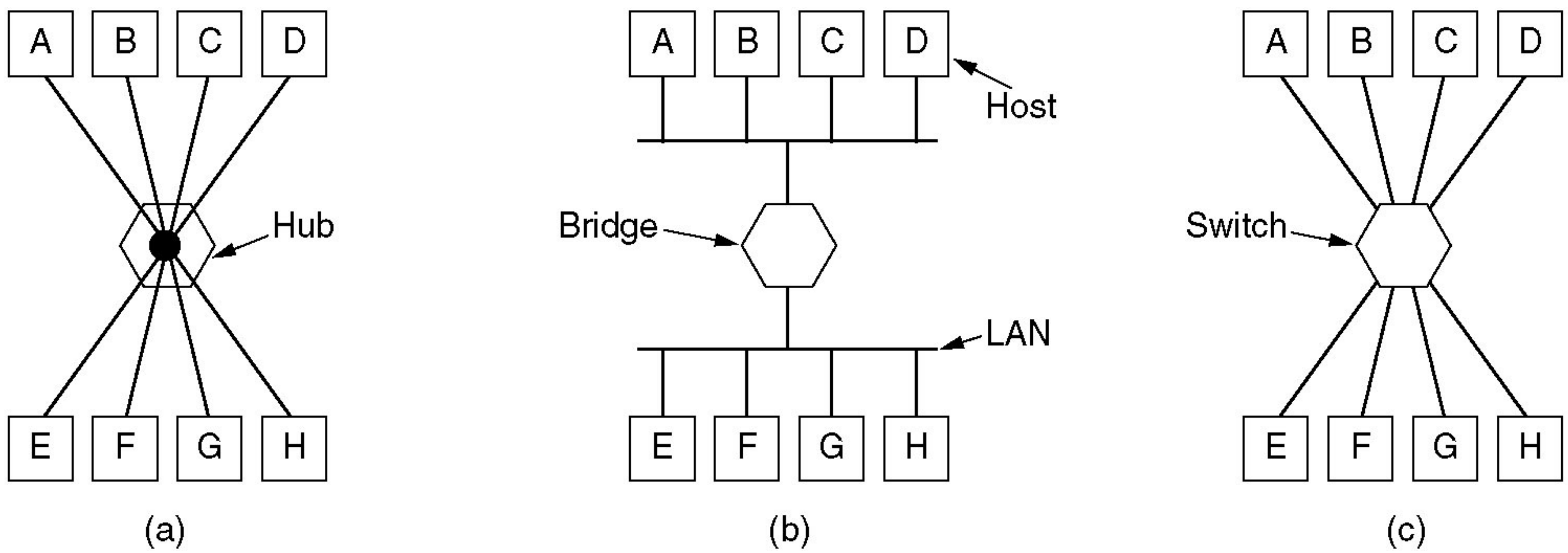
Limitations of Bridges

- Do not scale
  - spanning tree algorithm does not scale
  - The spanning tree may not optimize the traffic routing, i.e. no optimal use of bandwidth
  - broadcast does not scale
- Do not accommodate heterogeneity
  - 802.3 and 802.5 mix well as both support 48 bit addresses; However, interconnecting them to networks such as ATM is difficult
- Drawbacks of transparency
  - Hosts are not aware of the presence of bridges
  - Bridges may drop frames (may be due to congestion)

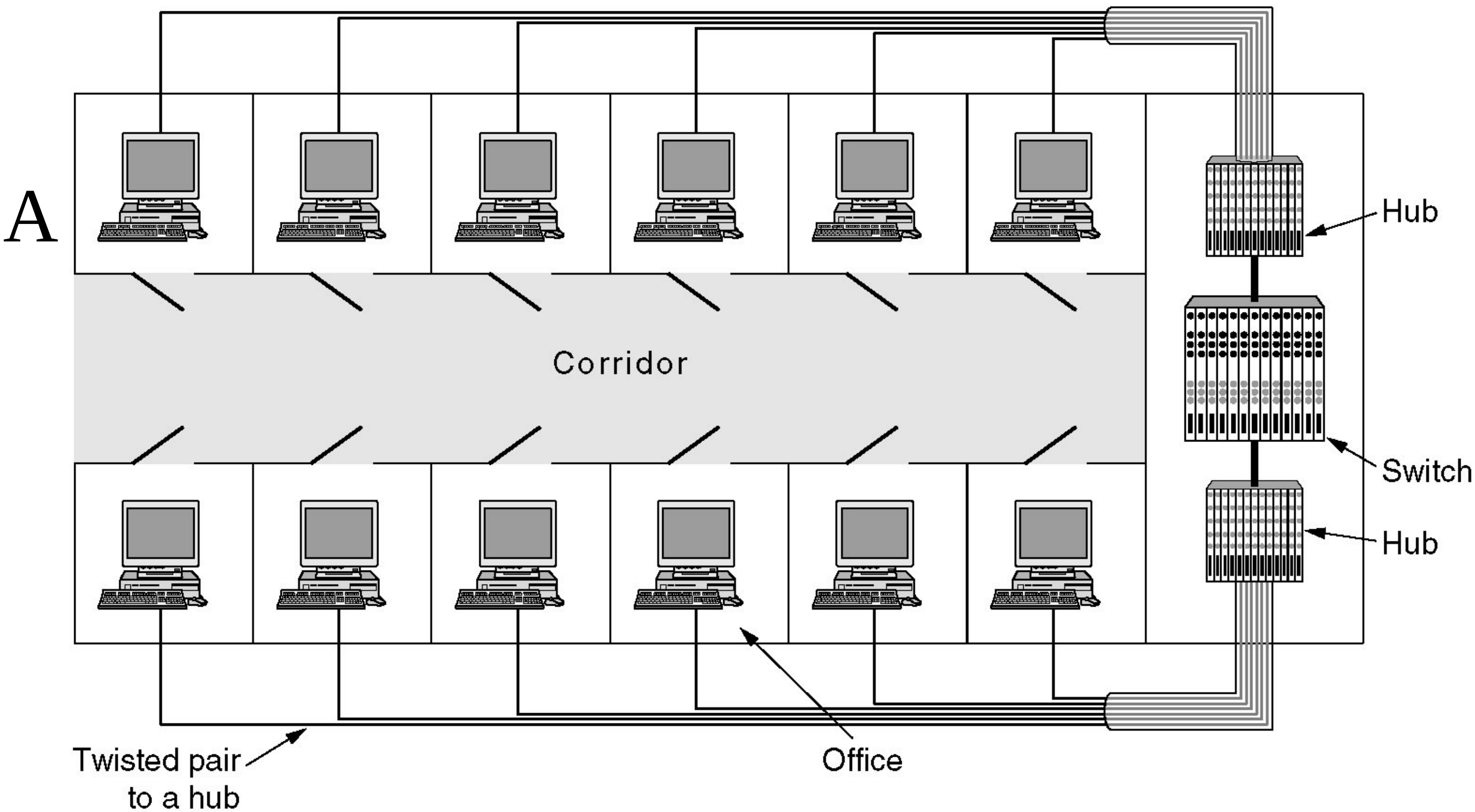
Virtual LANs (VLANs)

- Reference: A.S. Tanenbaum, “Computer Networks” 4th Edition, Prentice Hall PTR, 2003 (or 5th Edition, 2011)

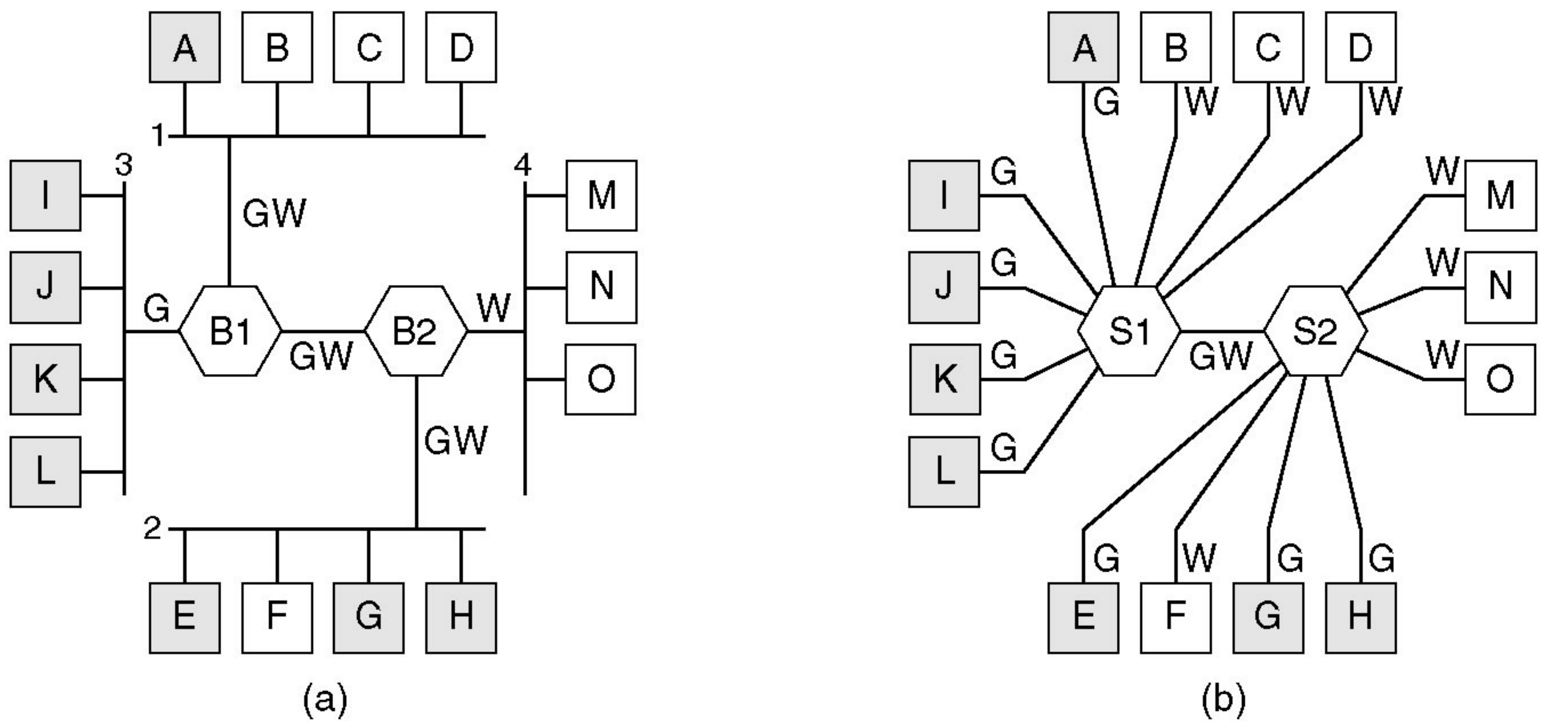
Hubs, Bridges, and Switches,



An example extended LAN

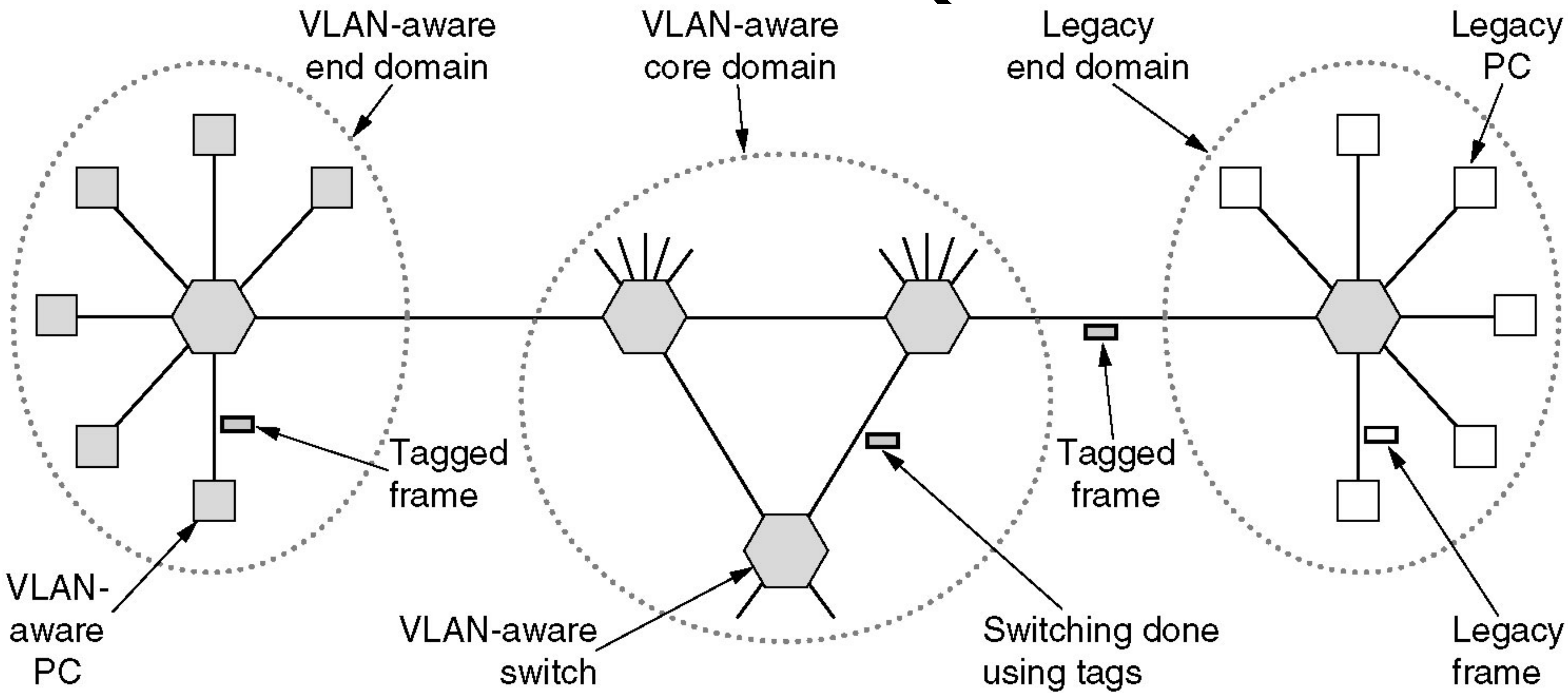


Virtual LANs



(a) Four physical LANs organized into two VLANs, gray and white, by two bridges. (b) The same 15 machines organized into two VLANs by switches. G: Grey, W: White

The IEEE 802.1Q Standard



The IEEE 802.1Q Standard (2)