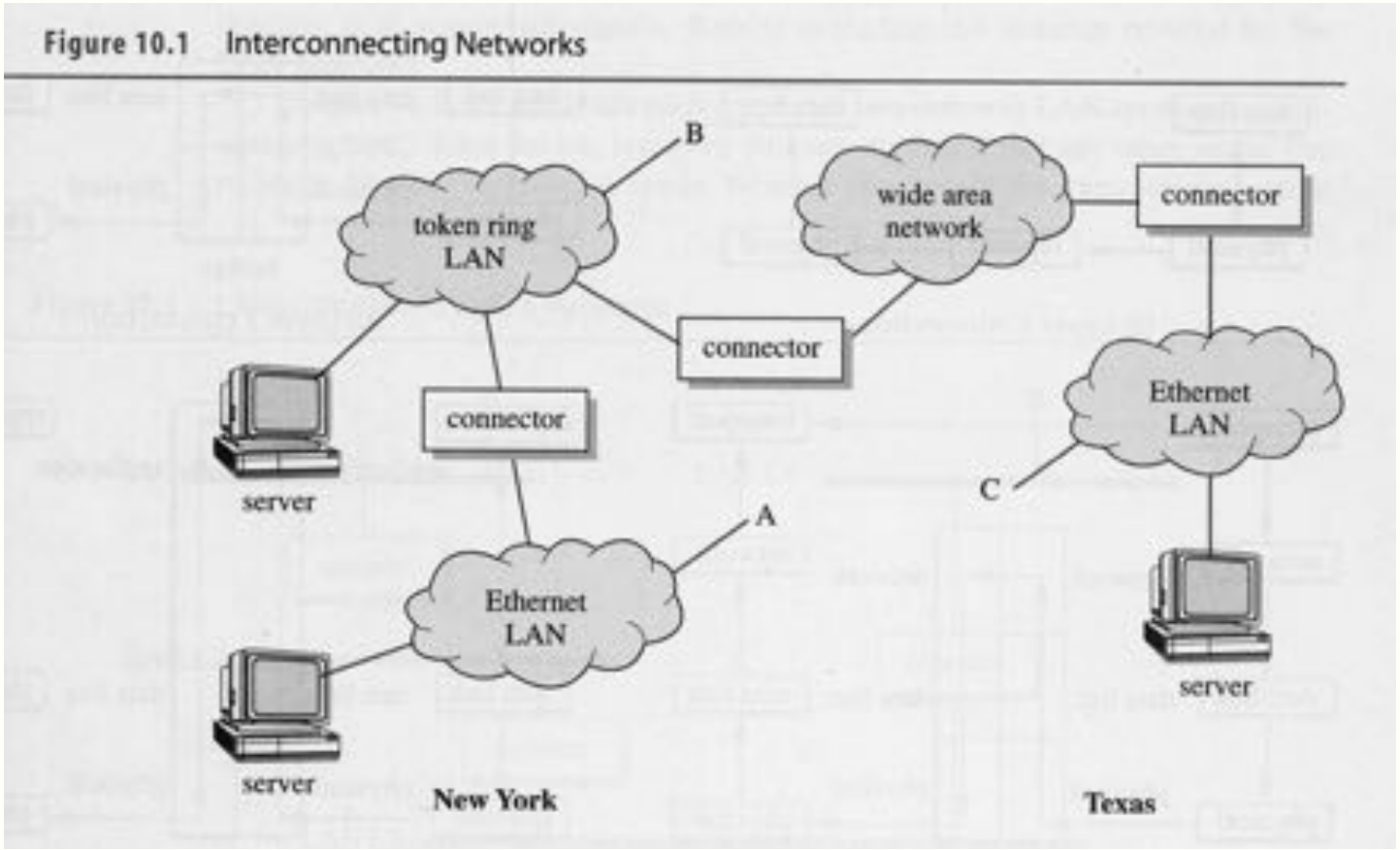
Overview

- Last Lecture
  - Local area networking 1
- This Lecture
  - Local area networking 2
  - Source: Sections 17.1-17.2
- Next Lecture
  - Wide Area Networking 1

Interconnecting Networks

Interconnecting Networks

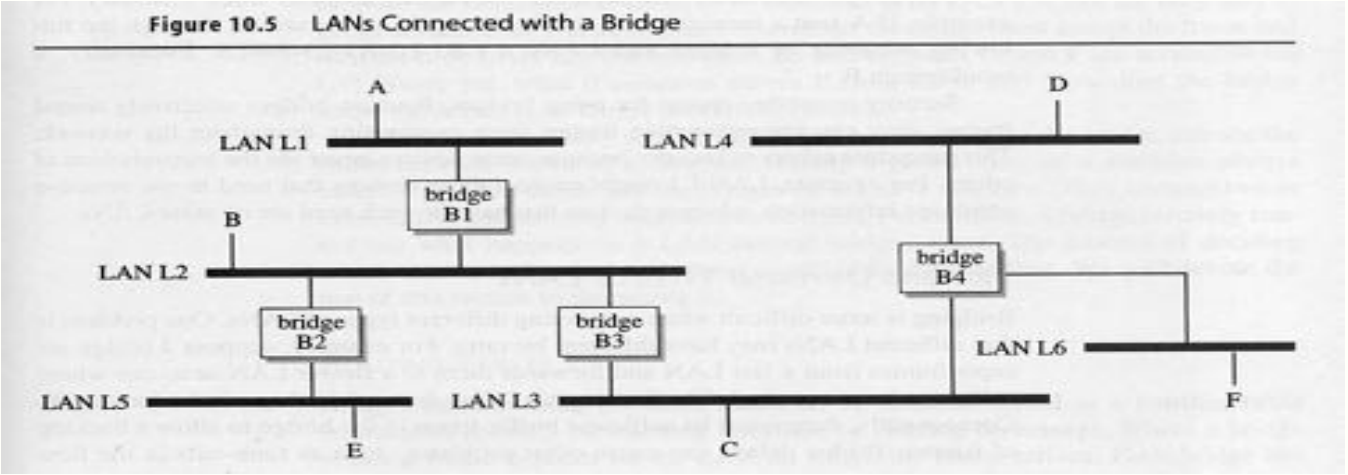


Interconnecting LANs

- Two kinds of connectors can be used to extend LANs
  - Physical layer: Repeaters
  - Data link layer: Bridges
- Repeater:
  - Devices to extend LANs at physical layer.
  - Receive signals, regenerate them and send them on.
  - Used to extend the distance covered by LAN.
  - Hub is a multiport repeater.

Bridges

- Extend LANs at data link layer.
- Error detection, frame formatting, and frame routing.
- Allow interconnecting different types of LANs
- Reasons for using bridges
  - Efficiency/Security/Interdepartmental communications



Bridging different LANs

- Speed differences require buffers
  - Suppose a bridge connects a fast LAN and a slow LAN.
  - The bridge has to provide a large buffer space for frames from the fast LAN.
- Bridge delays can cause excessive timeouts
  - Timers are used in flow control in data link layer.
  - Long delays in bridges will cause those timers to expire.
- Frame formatting differences
  - Reformat a received frame: change headers …

Bridging Different LANs (cont.)

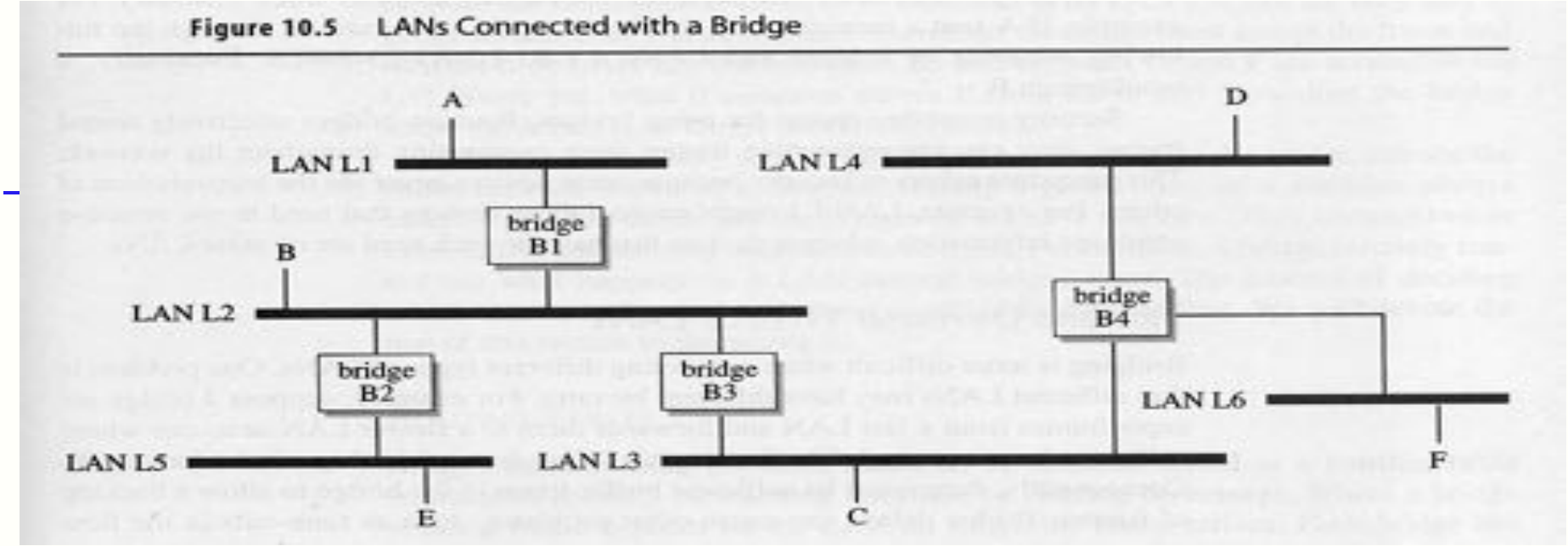
- Maximum frame sizes
  - The frame size varies between different types of LANs.
  - Solution 1 - Choose the smallest maximum frame size as the maximum frame size in the interconnected LANs.
  - Solution 2 - Break the larger frames into small fragments and send them. This requires additional logic which can be achieved at a higher layer protocol (i.e. the network layer).

Bridge Routing

- Bridges maintain routing tables to know where to send frames.

Routing table for bridge B1

	Source LAN 1		Source LAN 2	
	Destination	Next LAN	Destination	Next Lan
	A	--	A	L1
	B	L2	B	--
	C	L2	C	--
	D	L2	D	--
	E	L2	E	--
	F	L2	F	--



Routing table for bridge B1

Source LAN 1		Source LAN 2	
Destination	Next LAN	Destination	Next Lan
A	--	A	L1
B	L2	B	--
C	L2	C	--
D	L2	D	--
E	L2	E	--
F	L2	F	--

Fixed-Routing Bridges

- Assume that once the routing table is set up it does not change.（not flexible）

Figure 10.6 Routing Tables for Bridges in Figure 10.5

Source LAN L1		Source LAN L2	
Destination	Next LAN	Destination	Next LAN
A	—	A	L1
B	L2	B	—
C	L2	C	—
D	L2	D	—
E	L2	E	—
F	L2	F	—

(a) Bridge B1

Source LAN L2		Source LAN L5	
Destination	Next LAN	Destination	Next LAN
A	—	A	L2
B	—	B	L2
C	—	C	L2
D	—	D	L2
E	L5	E	—
F	—	F	L2

(b) Bridge B2

Source LAN L2		Source LAN L3	
Destination	Next LAN	Destination	Next LAN
A	—	A	L2
B	—	B	L2
C	L3	C	—
D	L3	D	—
E	—	E	L2
F	L3	F	—

(c) Bridge B3

Source LAN L3		Source LAN L4		Source LAN L6	
Destination	Next LAN	Destination	Next LAN	Destination	Next LAN
A	—	A	L3	A	L3
B	—	B	L3	B	L3
C	—	C	L3	C	L3
D	L4	D	—	D	L4
E	—	E	L3	E	L3
F	L6	F	L6	F	—

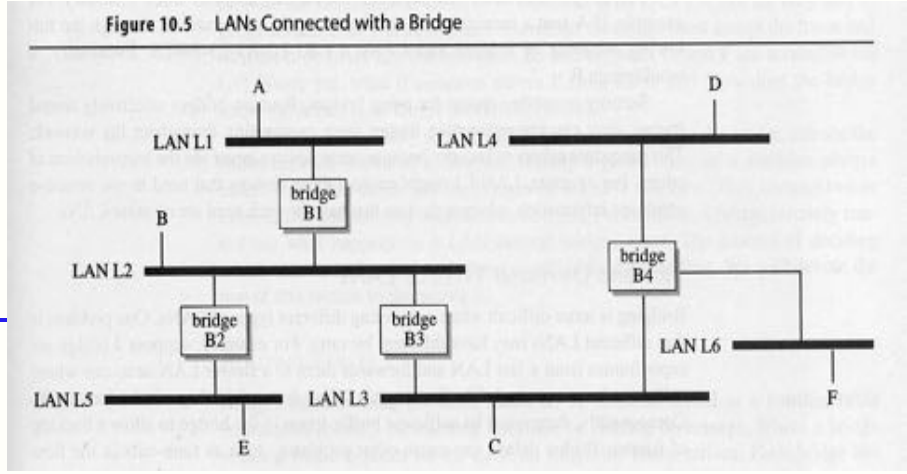
(d) Bridge B4

Transparent Bridges

- Can create and update their own routing table.
- This ability is called route learning or address learning.
  - When a bridge receives a frame, it examines the source address.
  - It then knows that the station sending the frame is accessible via the LAN on which the frame just arrived.
  - The bridge will update its routing table accordingly.
  - A similar thing happens if a station moves.

Routing Example

- Assume station D moves from LAN L4 to LAN L1. The previous routing table is incorrect.
- When D sends a frame to E, B1 forwards the frame to L2 according to the routing table.
- Then B1 checks the source address of the frame and knows station D is in the direction of L1. It therefore changes the fourth entry of the routing table



Before

Source LAN 1	
Destination	Next LAN
A	--
B	L2
C	L2
D	L2
E	L2
F	L2

Source LAN 2	
Destination	Next Lan
A	L1
B	--
C	--
D	--
E	--
F	--

After

Source LAN 1	
Destination	Next LAN
A	--
B	L2
C	L2
D	--
E	L2
F	L2

Source LAN 2	
Destination	Next Lan
A	L1
B	--
C	--
D	L1
E	--
F	--

Routing changes

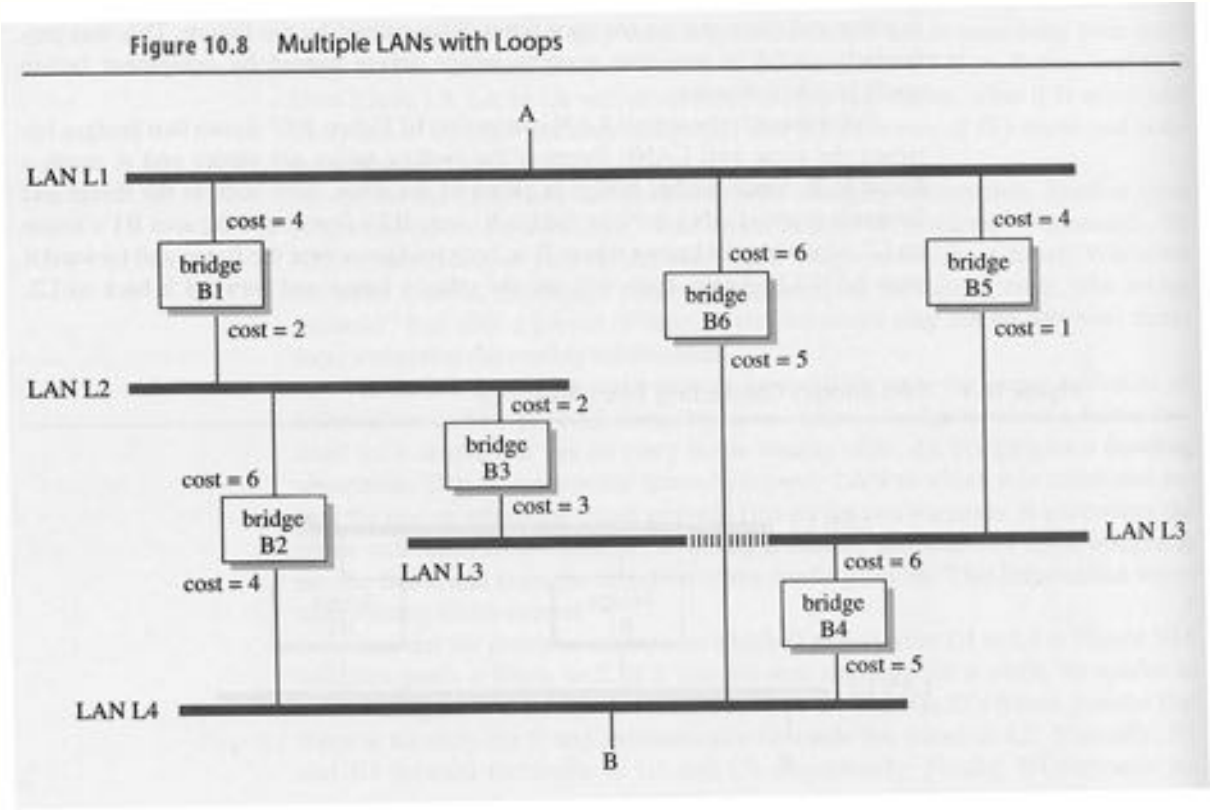
- How do other bridges know about the change?
  - A timer is used to remove entries which are not refreshed by the received frames.
  - Flooding algorithm is used for empty entries.
- Flooding algorithm
  - If there is an empty entry for the destination of a frame, it uses the flooding algorithm.
  - The bridge sends a frame over every LAN to which it is connected except the one on which the frame arrived.

LANs with Loops

- A problem for the flooding algorithm is the endless propagation of frames caused by loops in the LANs.
- Spanning tree algorithm can be used to eliminate the loop in the LANs.
  - Associate a cost with each bridge port.
  - Create a graph of the topology with its costs.
    - LANs and bridges are nodes
    - Interconnections are edges.
  - The algorithm eventually turns the graph into one in which the cheapest bridges interconnect the network with no loops.

LANs with Loops (cont.)

Associate a cost with each bridge port.



Spanning Tree

Create a graph of the topology with its costs.

LANs and bridges are nodes
Interconnections are edges.

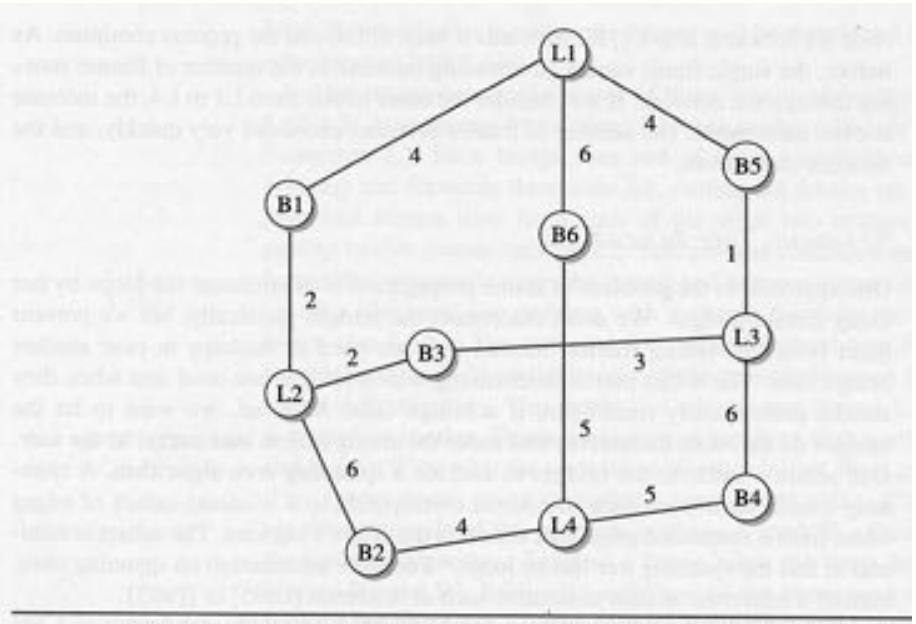
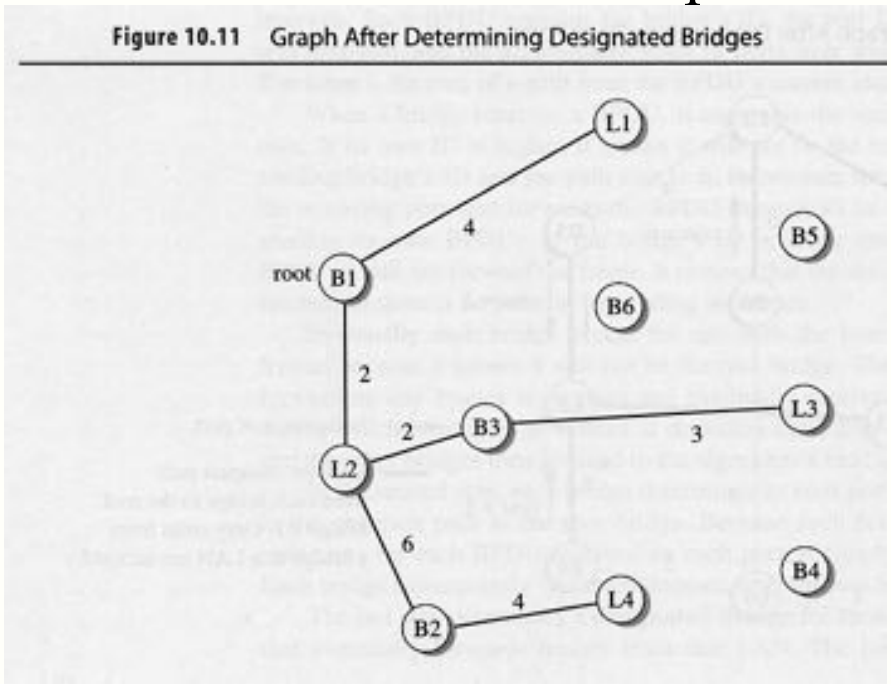


Figure 10.9 Graph Representation of the LAN Topology in Figure 10.8

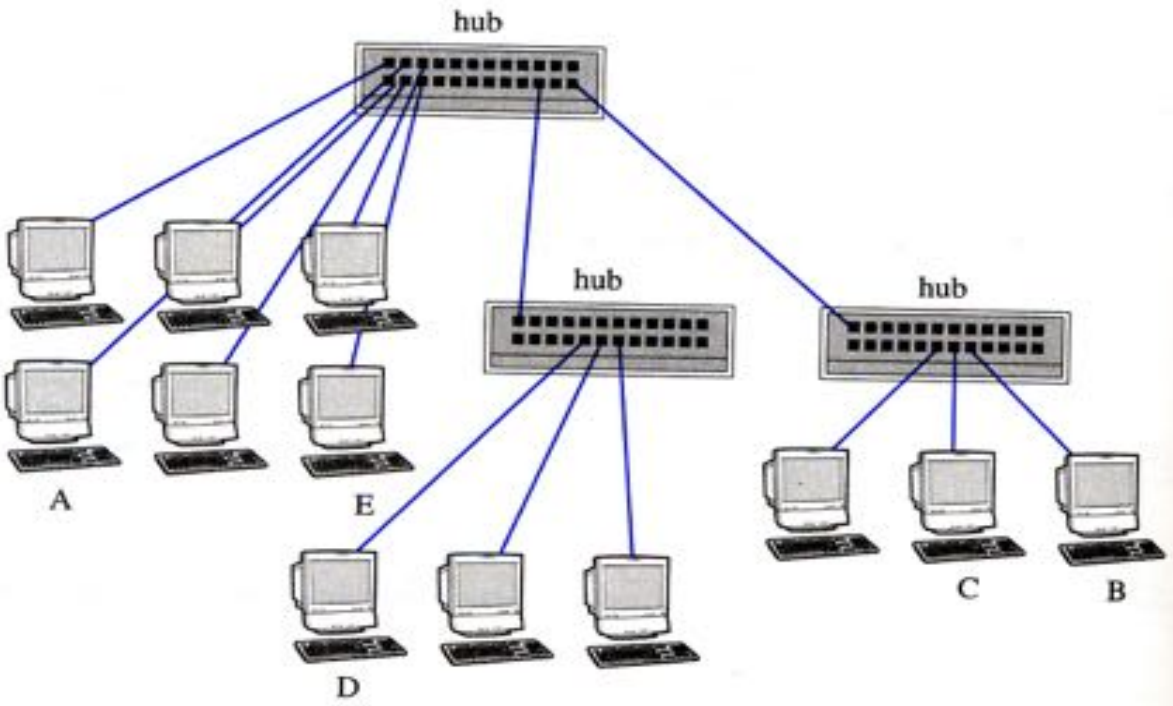
The algorithm eventually turns the graph into one in which the cheapest bridges interconnect the network with no loops.



Hubs

Video 2: hub switch and VLAN

Figure 10.4 Making Connections Using Hubs



Switches

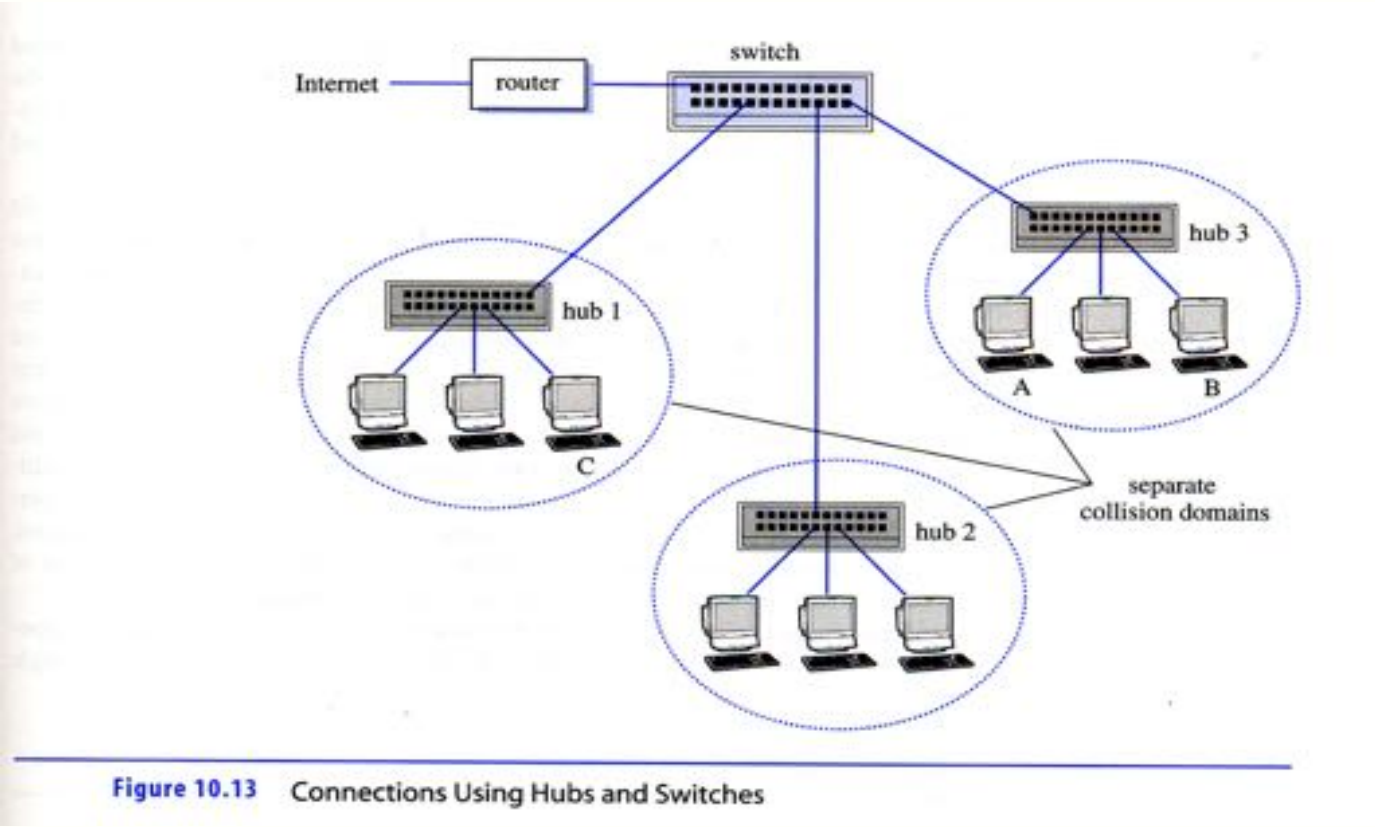
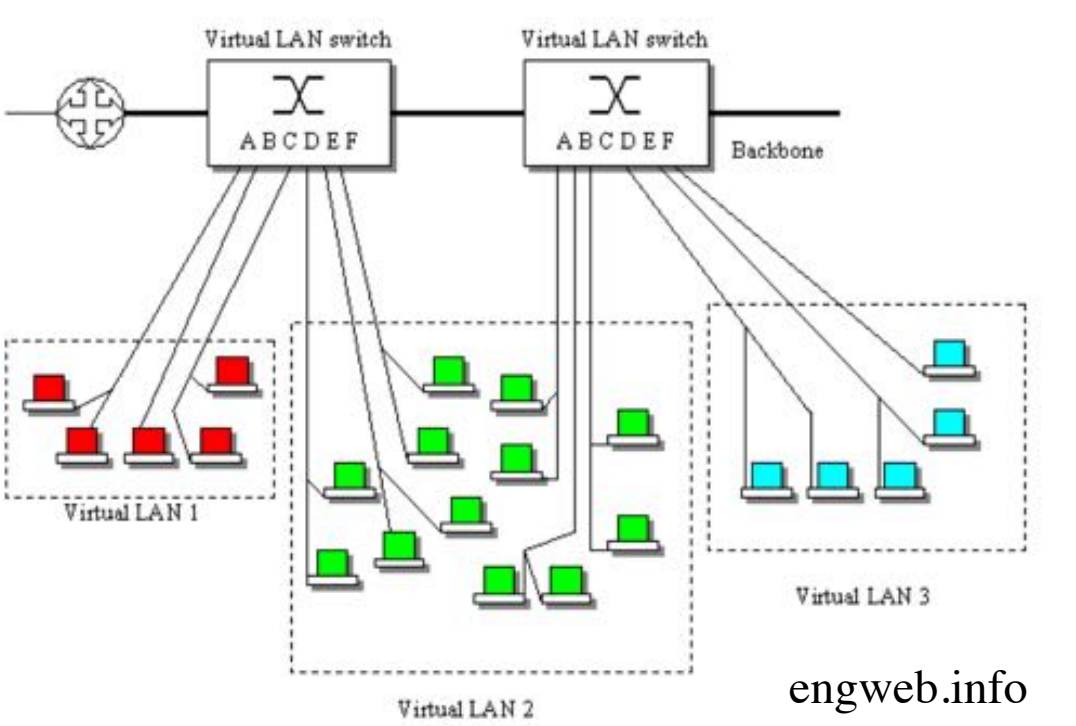


Figure 10.13 Connections Using Hubs and Switches

VLAN

- Virtual LAN
- Logical groups that are not spatially grouped
- Independent broadcast group



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VLAN (cont.)

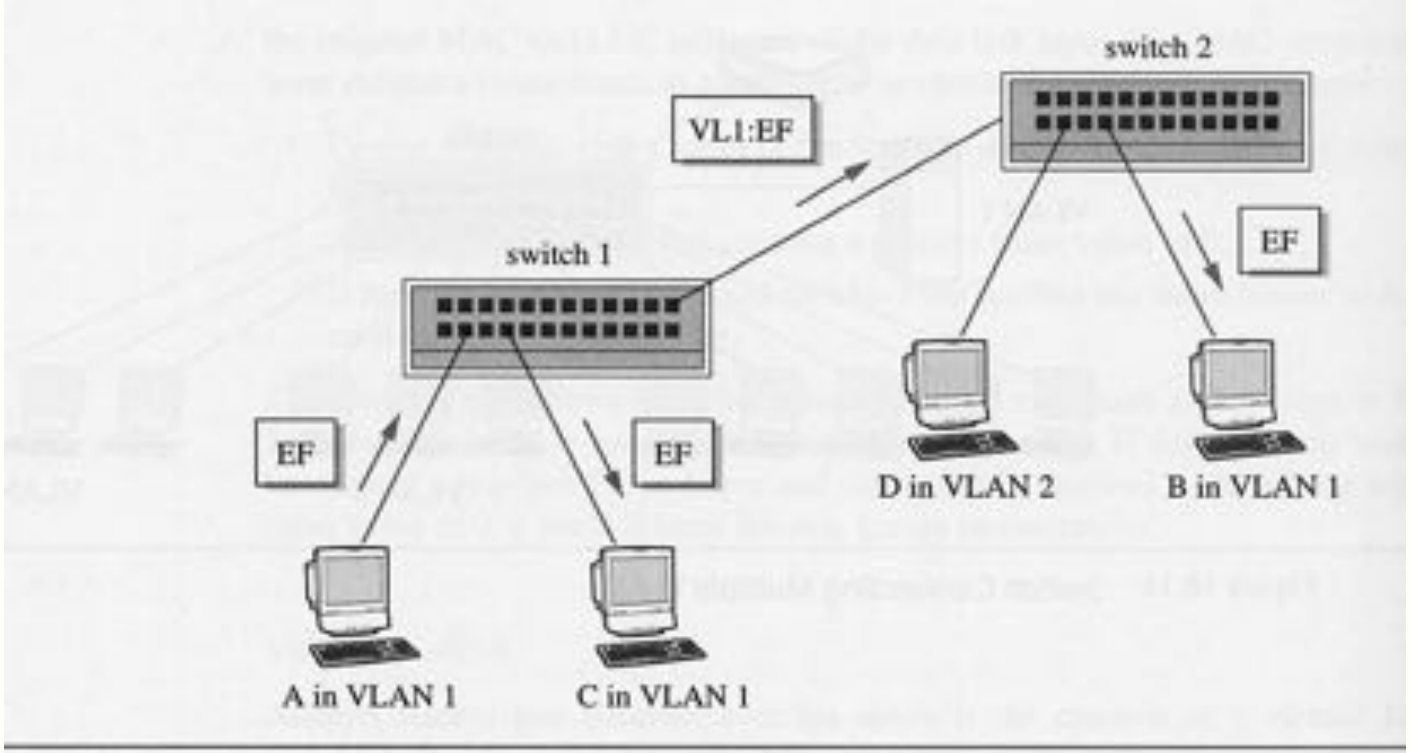

Figure 10.17 VLANs across Switches

Summary

- Interconnecting LANs
  - Repeaters, Bridges, Hubs, Switches
- Summary of data link layer (MAC&LLC)
  - Service - deliver frames reliably between two computers connected by a physical link.
  - Protocol - CSMA/CD, token, sliding window protocols