Fundamentals of Computer Networks
ECE 478/578

Lecture #13: Packet Switching (2)
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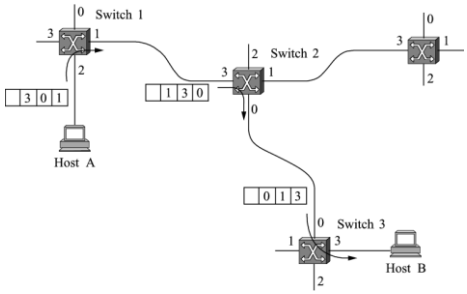
Source Routing

Idea: Include the entire route to be followed in the header
Nodes must know the network topology in advance



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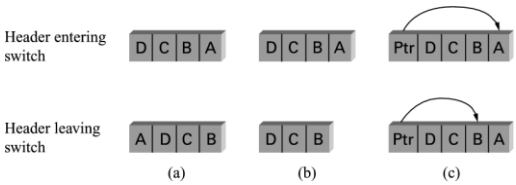
Possible Header Implementations



Header has variable length
Used in both datagram and VC switching (connection setup)
May be "loose" or "strict" routing

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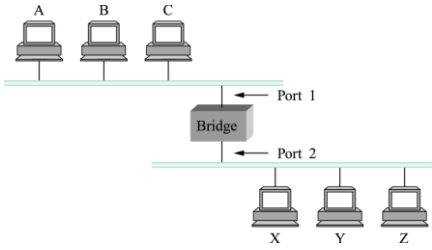
Bridges

Bridges are special switches that interconnect Ethernet networks
Act as simple nodes on each Ethernet
Early bridges forwarded all packets between the two networks



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Bridges Vs. Repeaters

Repeaters are analog amplifiers of the signal
- Monitor the existence of analog signal on the line
- Amplify and repeat the signal
- Physical layer function, no message parsing

Bridges "repeat" frames rather than signals
- They forward received frames among different LANs
- Message parsing is performed to decide whether to fwd the packet or not

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Limitations of Repeaters

All hosts connected via repeaters belong to the same collision domain
- Every bit is sent everywhere
- So, aggregate throughput is limited
- E.g., three departments each get 10 Mbps independently
- … and then connect via a hub and must share 10 Mbps

Multiple LAN technologies not compatible
- No message parsing – analog process
- No interoperability between different rates and formats
- E.g., 10 Mbps Ethernet and 100 Mbps Ethernet

Limited geographical distances and # of nodes

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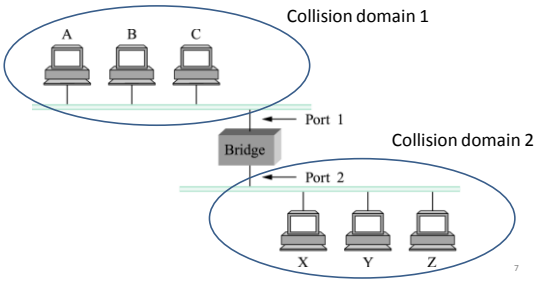
Advantages of Bridges

Facilitate breaking of network into isolated collision domains

Message parsing may avoid unnecessary packet forwarding



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Bridge Forwarding Table

Not all packets need to be forwarded. E.g., packets from A to B need not be forwarded on port 2

Bridges maintain a forwarding table

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

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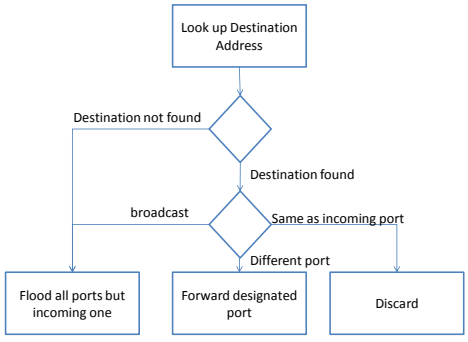
Forwarding Algorithm



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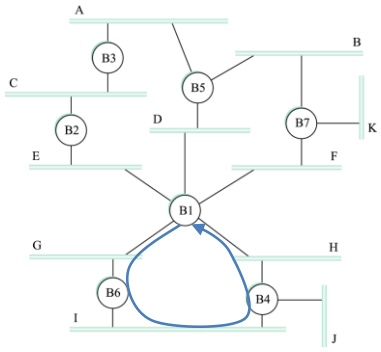
Problem with Flooding



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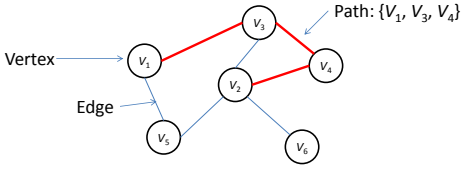
Some Preliminaries on Graphs

Graph G(V, E) : Collection of vertices and edges

V: Set of vertices

E: Set of edges, $e(x, y) = 1$, if x, y connected, 0 otherwise

Path: sequence of vertices with an edge between subsequent vertices (can be defined as sequence of edges as well)



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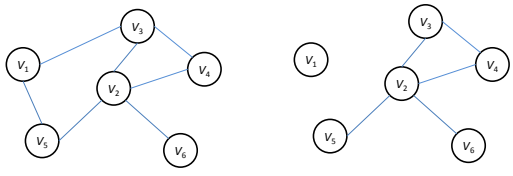
Connected Graph

A graph is said to be connected, if there is a path from any node to any other node



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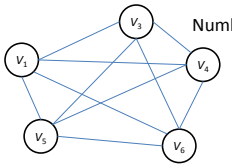
k-Connected Graph

Vertex degree: # of edges adjacent to the vertex

A graph is *k*-connected if the degree of each vertex is at least *k*. Alternatively, if removal of any *k-1* edges does not leave the graph disconnected

A graph of *N* vertices is fully connected if each node has a degree (*N* – 1) (directly connected network)



Number of edges: N(N-1)/2

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(A)Cyclic Graphs

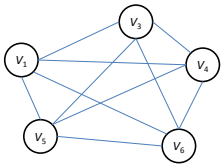
Cycle: a path with the same first and last vertex

Cyclic graph: A graph that contains at least one cycle

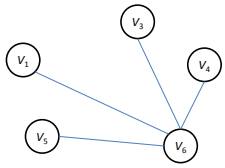
Acyclic graph: A graph with no cycles

Tree: An acyclic connected graph (spanning tree, spans all vertices)

Forest: A disconnected acyclic graph (a graph with many trees)



Cyclic graph



Tree

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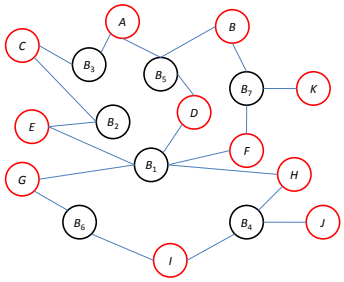
Mapping Extended LAN to a Graph

Bridges and LANs become vertices, ports become edges

Goal: Make a tree that spans only LANs (red vertices)



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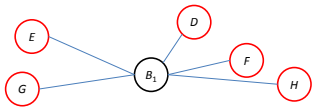
Spanning Tree Algorithm(1)

Each bridge has a unique identifier

Pick bridge with smallest ID, make it the root of the tree



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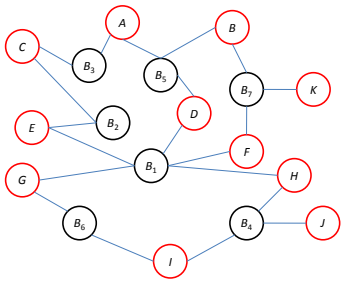
Spanning Tree Algorithm(2)

Compute shortest path (in terms of hops) from each bridge to root



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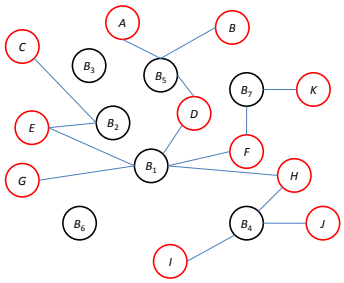
Spanning Tree Algorithm(3)

Each LAN remains connected to the bridge with shortest path to the root. In case of a tie use smallest ID



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Message Exchange

Initially, all bridges consider themselves as roots

Broadcast on all ports ID, root bridge, and distance to root

If bridge hears a message from another bridge with smaller ID it adjusts root/distance, and forwards

Ex., Let (Y, d, X) denote (root, distance, bridge ID)

- B3 receives (B2, 0, B2)
- B3 accepts B2 as root
- B3 adds one on its distance to B2, and fwds to B5 (B2, 1, B3)
- B2 accepts B1 as root and updates B3 with (B1, 1, B2)
- B5 accepts B1 as root and updates B3 with (B1, 1, B3)
- B3 accepts B1 as root, and note that both B2, B5 are closer to root in both ports. Hence, B3 blocks all ports

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