

Bridges and LAN Switches

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Ethernet Backoff revisited

- After N collisions, pick a number k between 0 and $2^N - 1$
- Wait for $k * 51.2$ us
- Send frame if no one has started using the channel

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Repeated Collisions

- Suppose A, B, and C each have a frame to send, causing a collision
- A picks $k=0$, B and C pick $k=1$
 - A wins, sends frame
- After A is done, B and C both try to send again
 - Collision again
 - Increase collision counter

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Capture Effect

- A and B collide
 - A picks 0, B picks 1
 - A wins, transmits frame
- Suppose A has *another* frame to send
 - A and B collide again
 - A's collision counter is 1, pick k from 0,1
 - B's collision counter is 2, pick k from 0,1,2,3
- A is likely to win *again*
 - And keep winning!

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Bridges: Building Extended LAN's

- Traditional LAN
 - Shared medium (e.g., Ethernet)
 - Cheap, easy to administer
 - Supports broadcast traffic
- Problem
 - Scale LAN concept
 - Larger geographic area ($> O(1$ km))
 - More hosts ($> O(100)$)
 - But retain LAN-like functionality
- Solution
 - bridges

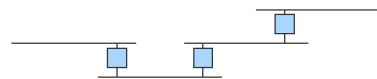
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Bridges

- Problem
 - LANs have physical limitations
 - Ethernet – 1500m
- Solution
 - Connect two or more LANs with a bridge
 - Accept and forward
 - Level 2 connection (no extra packet header)
 - A collection of LANs connected by bridges is called an extended LAN



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Bridges vs. Switches

- Switch
 - Receive frame on input port
 - Translate address to output port
 - Forward frame
- Bridge
 - Connect shared media
 - All ports bidirectional
 - Repeat subset of traffic
 - Receive frame on one port
 - Send on all other ports

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Uses and Limitations of Bridges

- Bridges
 - extend LAN concept
 - Limited scalability
 - to O(1,000) hosts
 - not to global networks
 - Not heterogeneous
 - some use of address, but
 - no translation between frame formats

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Bridges with Loops

- Problem
 - If there is a loop in the extended LAN, a packet could circulate forever
 - Side question: Are loops good or bad?
- Solution
 - Select which bridges should actively forward
 - Create a spanning tree to eliminate unnecessary edges
 - Adds robustness
 - Complicates learning/forwarding

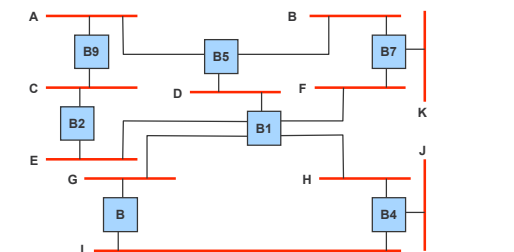
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Example Extended LAN with LOOPS



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Spanning Tree Algorithm

- View extended LAN as bipartite graph
 - LAN's are graph nodes
 - Bridges are also graph nodes
 - Ports are edges connecting LAN's to bridges
- Spanning tree required
 - Connect all LAN's
 - Can leave out bridges

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Defining a Spanning Tree

- Basic Rules
 - Bridge with the lowest ID is the **root**
 - For a given bridge
 - A port in the direction of the **root bridge** is the **root port**
 - For a given LAN
 - The bridge closest to the root (or the bridge with the lowest ID to break ties) is the **designated bridge** for a LAN
 - The corresponding port is the **designated port**
 - Bridges with no designated ports and ports that are neither a root port nor a designated port are not part of the tree.

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Bridges: Limitations

- Does not scale
 - Spanning tree algorithm scales linearly
 - Broadcast does not scale
- Virtual LANs (VLAN)
 - An extended LAN that is partitioned into several networks
 - Each network appears separate
 - Limits effect of broadcast
 - Simple to change virtual topology

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Bridges: Limitations

- Does not accommodate heterogeneity
 - Networks must have the same address format
 - e.g. Ethernet-to-Ethernet
- Caution
 - Beware of transparency
 - May break assumptions of the point-to-point protocols
 - Frames may get dropped
 - Variable latency
 - Reordering
 - Bridges happen!

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Switch

- Link layer device
 - stores and forwards Ethernet frames
 - examines frame header and selectively forwards frame based on MAC dest address
 - when frame is to be forwarded on segment, uses CSMA/CD to access segment
- transparent
 - hosts are unaware of presence of switches
- plug-and-play, self-learning
 - switches do not need to be configured

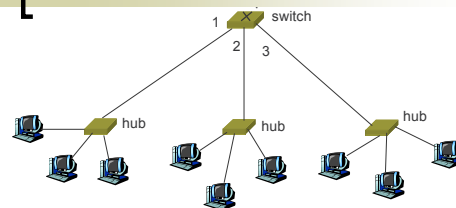
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Forwarding



- How do determine onto which LAN segment to forward frame?
- Looks like a routing problem...

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Self learning

- A switch has a switch table
- entry in switch table:
 - (MAC Address, Interface, Time Stamp)
 - stale entries in table dropped (TTL can be 60 min)
- switch learns which hosts can be reached through which interfaces
 - when frame received, switch "learns" location of sender: incoming LAN segment
 - records sender/location pair in switch table

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Filtering/Forwarding

- When switch receives a frame:
index switch table using MAC dest address
if entry found for destination then {
if dest on segment from which frame arrived
then drop the frame
else forward the frame on interface indicated
}
else flood

forward on all but the interface on which the frame arrived

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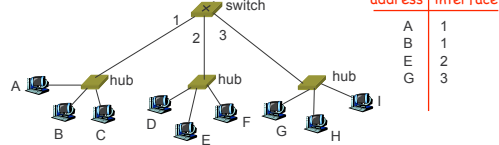
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Switch example

Suppose C sends frame to D



- Switch receives frame from C
 - notes in bridge table that C is on interface 1
 - because D is not in table, switch forwards frame into interfaces 2 and 3
- frame received by D

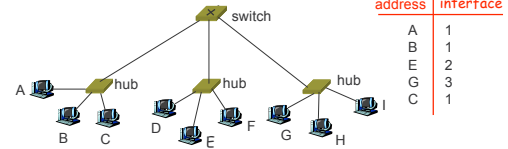
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Switch example

Suppose D replies back with frame to C.



- Switch receives frame from D
 - notes in bridge table that D is on interface 2
 - because C is in table, switch forwards frame only to interface 1
- frame received by C

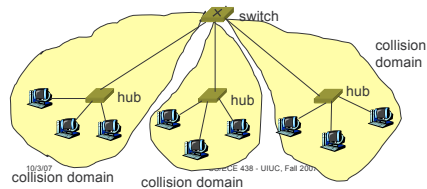
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Switch: traffic isolation

- switch installation breaks subnet into LAN segments
- switch filters packets:
 - same-LAN-segment frames not usually forwarded onto other LAN segments
 - segments become separate collision domains



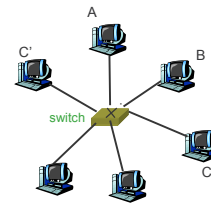
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Switches: dedicated access

- Switch with many interfaces
- Hosts have direct connection to switch
- No collisions; full duplex



Switching: A-to-A' and B-to-B' simultaneously, no collisions

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More on Switches

- cut-through switching: frame forwarded from input to output port without first collecting entire frame
 - slight reduction in latency
- combinations of shared/dedicated, 10/100/1000 Mbps interfaces

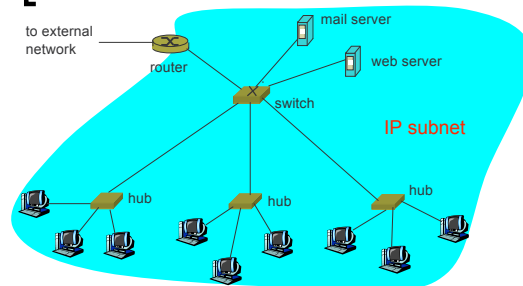
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Institutional network



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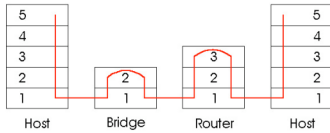
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Switches vs. Routers

- both store-and-forward devices
 - routers: network layer devices (examine network layer headers)
 - switches are link layer devices
- routers maintain routing tables, implement routing algorithms
- switches maintain switch tables, implement filtering, learning algorithms



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Summary comparison

	Bridges	Switches	Routers
Traffic isolation	No	Yes	Yes
Plug and play	Yes	Yes	No
Optimal Routing	No	No	Yes
Cut-through	Yes	Yes*	No

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