Welcome!

ELEC 8560 – Computer Networks

Connecting Devices And Virtual LANs

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Outline

- Connecting devices
- Hubs
- Switches
- Routers
- Virtual LANs

- Recommended reading: Forouzan – Chapter 6

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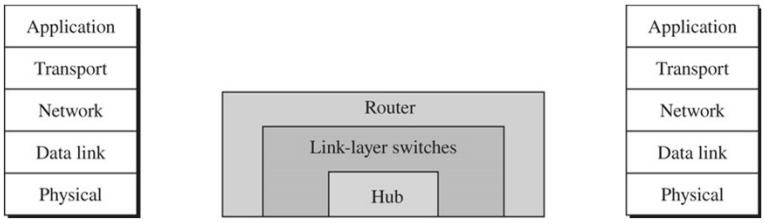
Connecting Devices

- Connecting devices are used to
  - connect hosts together to make a network, or
  - connect networks together to make an internet
- Connecting devices can operate in different layers of the Internet model
- We discuss three kinds of connecting devices:
  - Hubs
  - Link-layer switches
  - Routers



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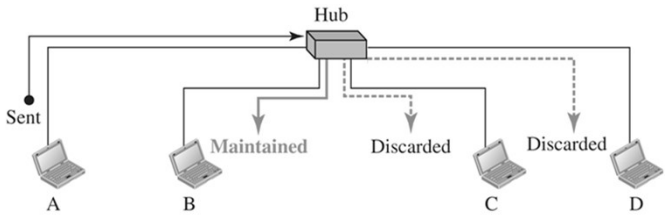
Hubs

- Hub operates only in the physical layer
- Signals that carry information within a network can travel a fixed distance before attenuation endangers the integrity of the data
- Hubs connect devices and act as a repeater
  - Receives a signal and regenerates and retimes the original bit pattern
- No filtering capability: forward packets to all ports except the source



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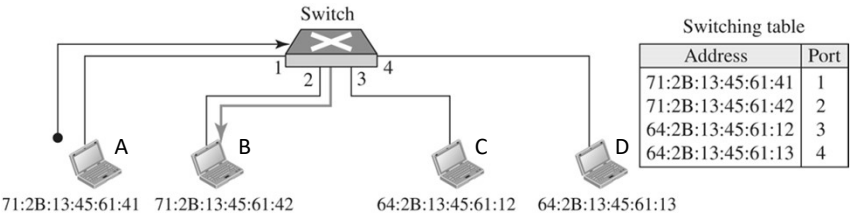
Link-Layer Switches

- A link-layer switch (or switch) operates in physical and data-link layers
- As a physical-layer device, it regenerates the signal it receives
- As a link-layer device, it checks the MAC addresses (source and destination) contained in the frame
  - Compared to hubs, a link-layer switch has filtering capability (switching table)
  - Checks the destination MAC address of a frame and decides the outgoing port
- Switches do not change the MAC addresses in the frame

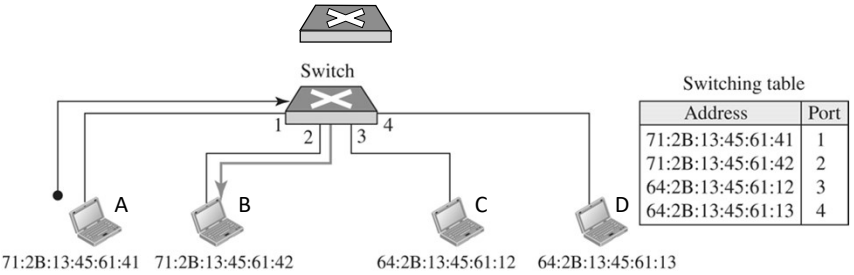


Switching table

Address	Port
71:2B:13:45:61:41	1
71:2B:13:45:61:42	2
64:2B:13:45:61:12	3
64:2B:13:45:61:13	4

Link-Layer Switches (cont.)

- Transparent switch: hosts are unaware of its existence
  - Plug-and-play: do not need to be configured when added to the system
- Compared to hubs, switches allow simultaneous transmissions
  - Store and forward frames
  - No collisions, full duplex (i.e., each link is its own collision domain
  - For example, A-to-B & C-to-D simultaneously, not A-to-B & C-to-B



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Self Learning

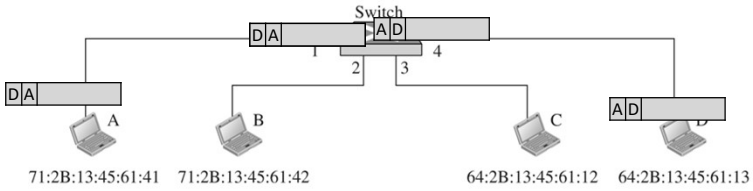
- Learn to build switching table
  - Which hosts can be reached through which interfaces
  - MAC address of host, interface to reach host, and TTL
- Algorithm when frame received at switch :

```
1  Self_Learning( )
2    record MAC address of sending host
3    index Switching Table using MAC destination address
4    if (entry found for destination)
5      forward frame on interface indicated by entry
6    Else
7      flood // forward on all interfaces except arriving interface
```

Example 1: Self Learning Switch

Suppose A sends frame to D and D responds to A. Show switch table of the switch.

Solution:



Address	*Port*
71:2B:13:45:61:41	1
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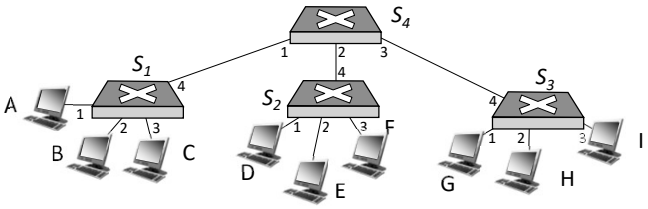
Example 2: Self Learning Switch

Suppose C sends frame to G and G responds to C. Show switch tables in all switches.

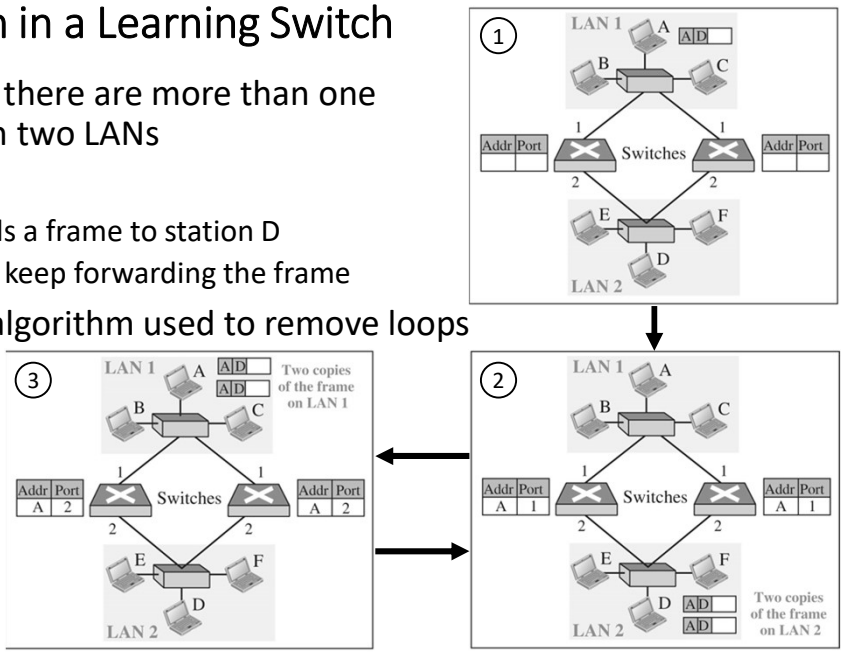
Solution:

- Interconnecting switches work the same as in single-switch case



Loop Problem in a Learning Switch

- Happens when there are more than one switch between two LANs
- Example:
  - Station A sends a frame to station D
  - Both switches keep forwarding the frame
- Spanning tree algorithm used to remove loops



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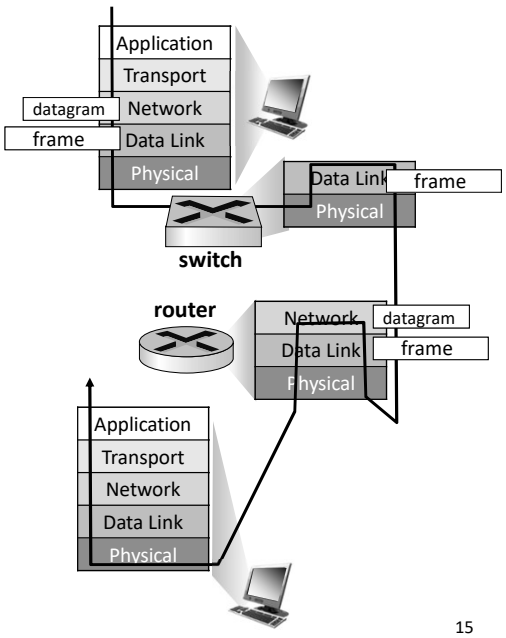
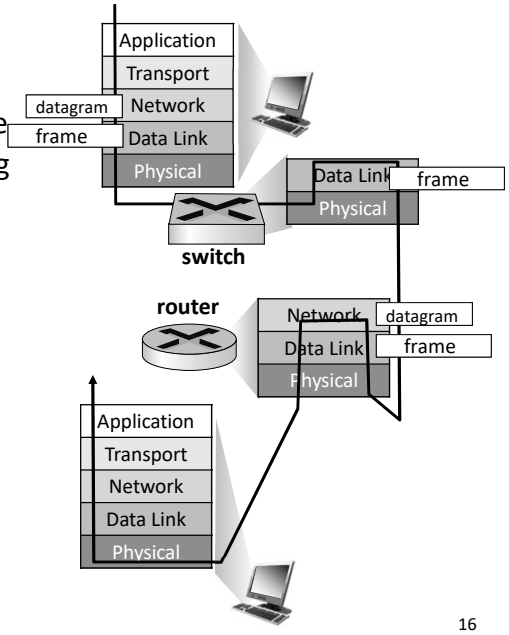
Routers

- More details later in network layer
- A router is a three-layer device that operates in the physical, data-link, and network layers
  - As a physical-layer device, it regenerates the signal it receives
  - As a link-layer device, it checks the MAC addresses
  - As a network-layer device, it checks IP addresses
- Routers connect networks to form an internetwork (i.e., internet)



Routers (cont.)

- Switches vs. routers:
  - Routers have a MAC address for each interface
  - Routers change MAC address when forwarding packets
  - Both are store-and-forward
    - routers: examine network-layer headers
    - switches: examine link-layer headers
  - Both have forwarding tables
    - routers: compute tables using routing algorithms, IP addresses
    - switches: learn forwarding table using flooding, learning, MAC addresses



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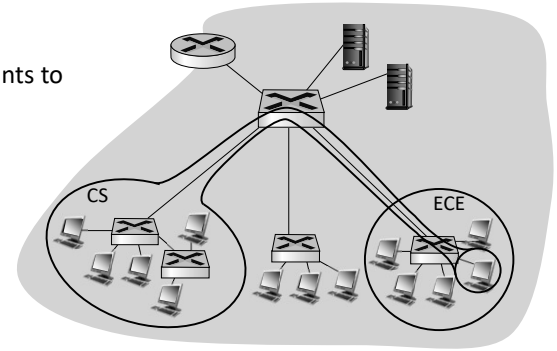
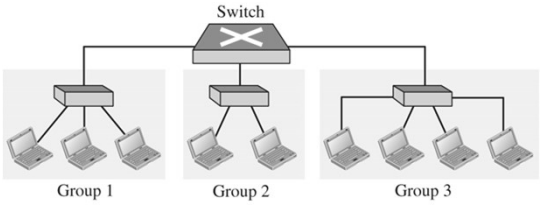
Virtual Local Area Networks (VLANs)

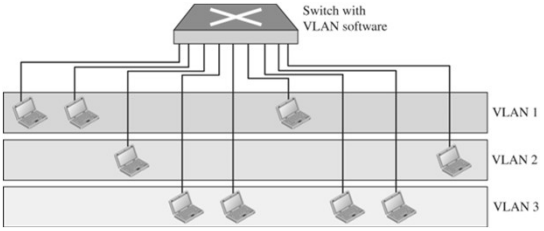
- A station is considered part of a LAN if it is physically attached to it
- When LAN sizes scale:
  - Single broadcast domain:
    - All layer-2 broadcast traffic (ARP, DHCP, flooding, etc.) must cross entire LAN
    - Efficiency, security, and privacy issues
  - Administrative issues:
    - For example, CS user moves office to ECE (physically attached to ECE switch) but wants to remain logically attached to CS switch



Virtual LANs (VLANs)

- A VLAN is a LAN configured by software, not by physical wiring
  - Enables a virtual connection between two stations belonging to two different physical LANs
- Switches supporting VLAN capabilities can be configured to define multiple virtual LANs over single physical LAN infrastructure





Advantages of VLANs

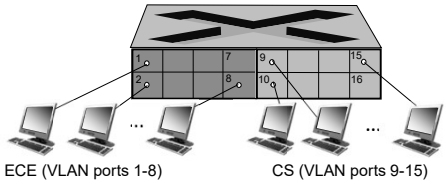
- Cost and time reduction:
  - Reduce migration cost of stations going from one group to another
  - Physical reconfiguration takes time and is costly
  - Much easier and quicker to move a station to another location by software
- Creating virtual work groups:
  - For example, send broadcast messages to researchers on same project without the necessity of belonging to the same department, reduces traffic
- Security:
  - People belonging to the same group can send broadcast messages with the guaranteed assurance that users in other groups will not receive these messages

VLAN Membership

- To group stations in a VLAN, different characteristics may be used:
  - Interface numbers
  - MAC addresses
  - IP addresses
  - or a combination of two or more of these or other

Interface-based VLANs

- Some VLAN vendors use switch interface (port) numbers as a membership characteristic
  - For example, an administrator can define that stations connecting to ports 1-8 belong to ECE VLAN; stations connecting to ports 9-15 belong to CS VLAN; and so on
  - Traffic isolation: frames to/from ports 1-8 can only reach ports 1-8
  - Dynamic membership: ports can be dynamically assigned among VLANs
  - Forwarding between VLANS: done via routing, in practice vendors sell combined switches plus routers



MAC Address-based VLANs

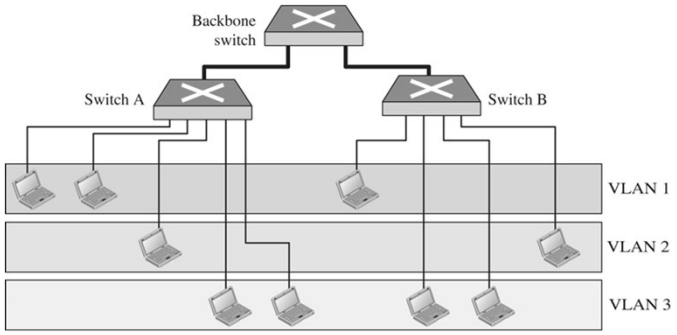
- We can also define VLAN based on MAC addresses of endpoints rather than switch port
- Some VLAN vendors use the 48-bit MAC address as a membership characteristic
  - For example, the administrator can stipulate that stations having MAC addresses E2:13:42:A1:23:34 and F2:A1:23:BC:D3:41 belong to ECE VLAN

Configuration

- Remember: logical configuration not physical configuration
- Stations grouped into different VLANs are configured:
  - Manually:
    - Network administrator manually assign stations into different VLANs at setup
    - Manually means typing port numbers, or other characteristics, using the VLAN software
    - Migration from one VLAN to another is also done manually
  - Automatically:
    - Stations are automatically connected or disconnected from a VLAN using criteria defined by the administrator
    - For example, define department as the criterion to be a member of a group. When a user changes department, automatically migrates to a new VLAN
  - Semi-automatically:
    - Somewhere between both. Usually, initialize manually and migrations done automatically

VLANS Spanning Multiple Switches

- In a multi-switched backbone, each switch must know:
  - which station belongs to which VLAN
  - membership of stations connected to other switches
- Three methods have been devised for this purpose:
  - Table maintenance
  - Time-division multiplexing
  - Frame tagging



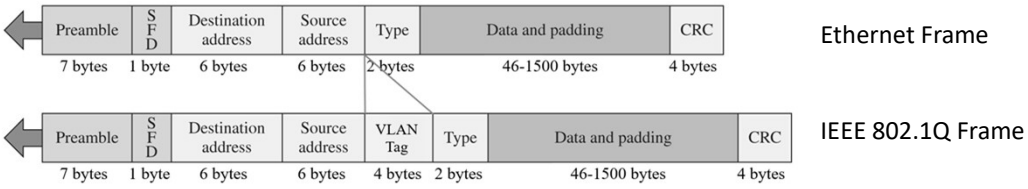
Two Switches in a Backbone Using VLAN Software

VLANS Spanning Multiple Switches (cont.)

- Table Maintenance:
  - When a station sends a broadcast frame to its group members, the switch creates an entry in a table and records station membership
  - Switches send their tables to one another periodically for updating
- Time-Division Multiplexing (TDM):
  - The connection (trunk) between switches is divided into time-shared channels (such as TDM)
    - For example, if the total number of VLANs in a backbone is five, each trunk is divided into five channels
    - The traffic destined for VLAN 1 travels in channel 1, the traffic destined for VLAN 2 travels in channel 2, and so on
  - The receiving switch determines the destination VLAN by checking the channel from which the frame arrived

VLANS Spanning Multiple Switches (cont.)

- Frame Tagging:
  - When a frame is traveling between switches, an extra header is added to the MAC frame to define the destination VLAN ID
  - Frame tag is used by the receiving switches to determine the VLANs to be receiving the broadcast message
  - IEEE 802.1Q standard defines the format for frame tagging
    - Format of extra header fields for frames forwarded between trunk ports in multi-switched backbones
    - This enables the use of multivendor equipment in VLANs



Summary

- We covered:
  - Connecting devices: hubs, switches, and routers
  - VLANs and their advantages