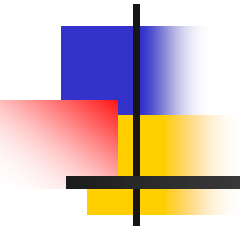
Switched Local Area Networks



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Lecture 19

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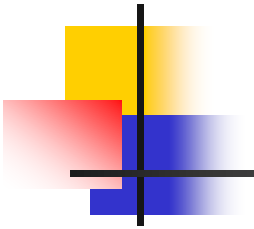
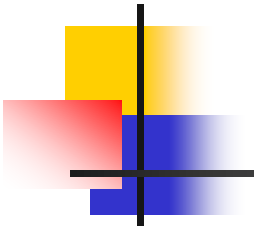


Ethernet

- Ethernet has pretty much taken over the wired LAN market
- Since its invention in the mid-1970s, Ethernet has continued to evolve and grow and has held on to its dominant position
- Today, Ethernet is by far the most prevalent wired LAN technology, and it is likely to remain so far for the foreseeable future

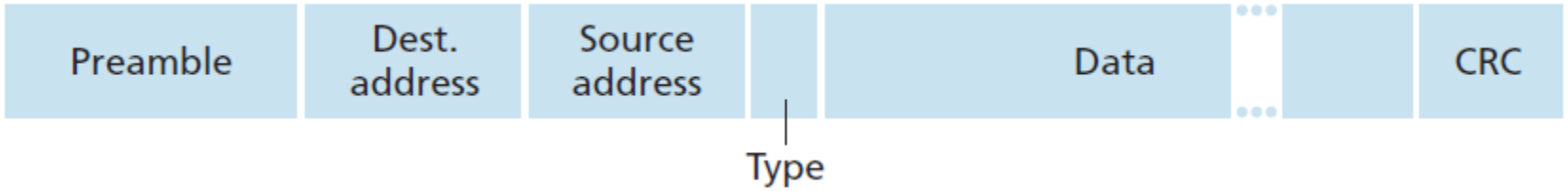


Ethernet

- There are many reasons for Ethernet's success:
  - First, Ethernet was the first widely deployed high-speed LAN
  - Second, some other techniques were more complex and expensive than Ethernet, which further discouraged network administrators from switching over.
  - Third, Ethernet hardware (in particular, adapters and switches) has become a commodity and is remarkably cheap.

Ethernet Frame Structure

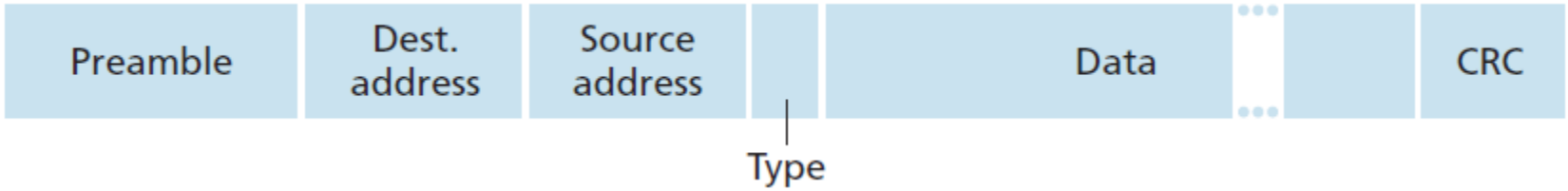
- Ethernet frame



  - Data
    - This field carries the IP datagram.
    - The maximum transmission unit (MTU) of Ethernet is 1,500 bytes.

Ethernet Frame Structure

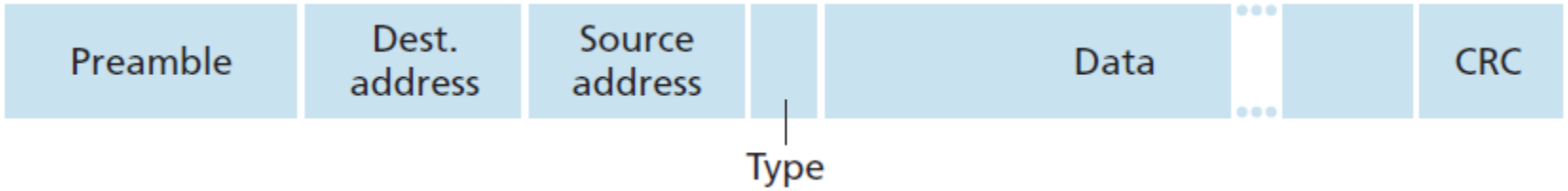
- Ethernet frame



  - Dest. address
    - This field contains the MAC address of the destination adapter

Ethernet Frame Structure

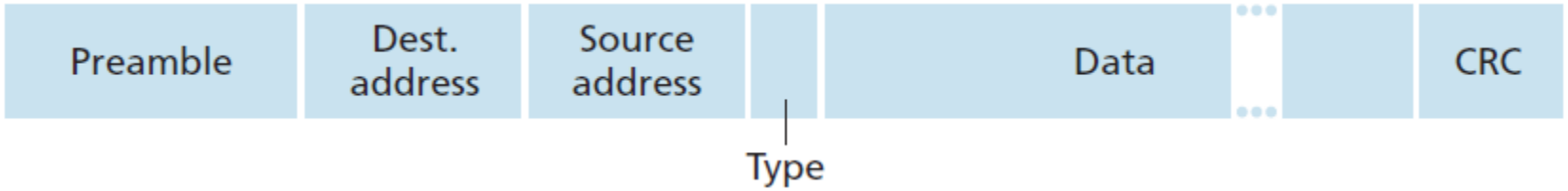
- Ethernet frame



  - Source address
    - This field contains the MAC address of the adapter that transmits the frame onto the LAN

Ethernet Frame Structure

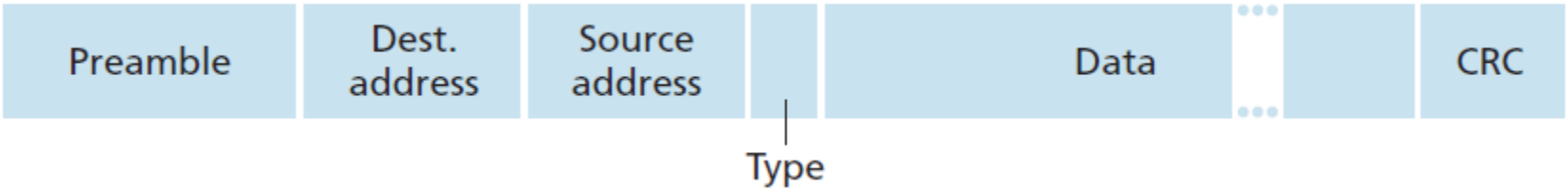
- Ethernet frame



  - Type
    - The type field permits Ethernet to multiplex network-layer protocols.

Ethernet Frame Structure

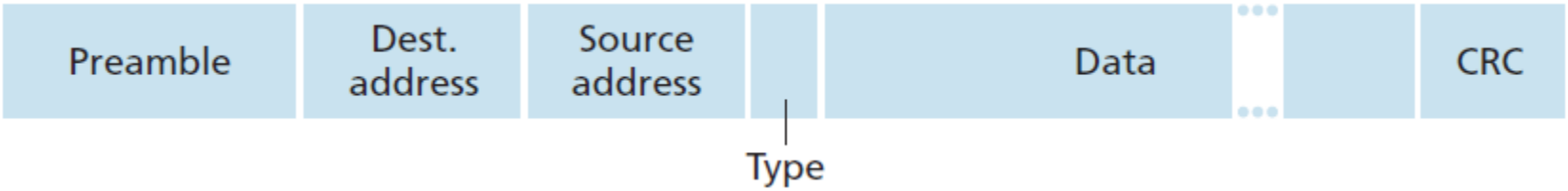
- Ethernet frame



  - CRC
    - Cyclic redundancy check
    - the purpose of the CRC field is to allow the receiving adapter, adapter B, to detect bit errors in the frame.

Ethernet Frame Structure

- Ethernet frame



  - Preamble
    - The Ethernet frame begins with an 8-byte preamble field.
    - Each of the first 7 bytes of the preamble has a value of 10101010; the last byte is 10101011.
    - The first 7 bytes of the preamble serve to "wake up" the receiving adapters and to synchronize their clocks to that of the sender's clock.

Ethernet Frame Structure

- All of the Ethernet technologies provide ***connectionless service*** to the network layer.

- That is, when adapter A wants to send a datagram to adapter B, adapter A encapsulates the datagram in an Ethernet frame and sends the frame into the LAN, without first handshaking with adapter B.

Ethernet Frame Structure

- Ethernet technologies provide an ***unreliable service*** to the network layer.
- Specifically, when adapter B receives a frame from adapter A, it runs the frame through a CRC check, but neither sends an acknowledgment when a frame passes the CRC check nor sends a negative acknowledgment when a frame fails the CRC check.
- When a frame fails the CRC check, adapter B simply discards the frame.
- Thus, adapter A has no idea whether its transmitted frame reached adapter B and passed the CRC check.
- This lack of reliable transport (at the link layer) helps to make Ethernet simple and cheap. But it also means that the stream of datagrams passed to the network layer can have gaps.

Ethernet Frame Structure

- If there are gaps due to discarded Ethernet frames, does the application at Host B see gaps as well?

- If the application is using TCP, then TCP in Host B will not acknowledge the data contained in discarded frames, causing TCP in Host A to retransmit.
  - Note that when TCP retransmits data, the data will eventually return to the Ethernet adapter at which it was discarded.

- Thus, in this sense, Ethernet does retransmit data, although Ethernet is unaware of whether it is transmitting a brand-new datagram with brand-new data, or a datagram that contains data that has already been transmitted at least once.

Link-Layer Switches

- The role of the switch is to receive incoming link-layer frames and forward them onto outgoing links.
- The switch itself is ***transparent*** to the hosts and routers in the subnet; that is, a host/router addresses a frame to another host/router (rather than addressing the frame to the switch) and happily sends the frame into the LAN, unaware that a switch will be receiving the frame and forwarding it.
- The rate at which frames arrive to any one of the switch's output interfaces may ***temporarily exceed the link capacity*** of that interface.
- To accommodate this problem, switch output interfaces have ***buffers***, in much the same way that router output interfaces have buffers for datagrams.

Forwarding and Filtering

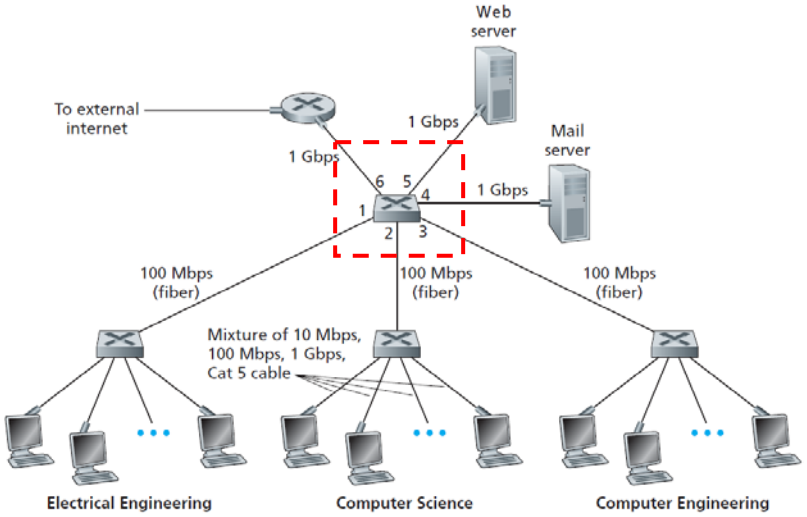
- ***Filtering*** is the switch function that determines whether a frame should be forwarded to some interface or should just be dropped.

- ***Forwarding*** is the switch function that determines the interfaces to which a frame should be directed, and then moves the frame to those interfaces.

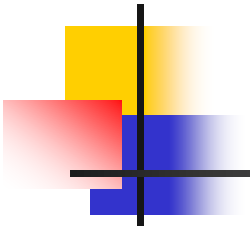
- Switch filtering and forwarding are done with a ***switch table***.

Forwarding and Filtering

- The switch table contains entries for some, but not necessarily all, of the hosts and routers on a LAN
- An entry in the switch table contains
  - (1) a MAC address
  - (2) the switch interface that leads toward that MAC address, and
  - (3) the time at which the entry was placed in the table



Address	Interface	Time
62-FE-F7-11-89-A3	1	9:32
7C-BA-B2-B4-91-10	3	9:36
....	....	....



Forwarding and Filtering

- Suppose a frame with destination address DD-DD-DD-DD-DD-DD arrives at the switch on interface x.
- The switch indexes its table with the MAC address DD-DD-DD-DD-DD-DD.
- There are three possible cases:
  - There is no entry in the table for DD-DD-DD-DD-DD-DD.
  - In this case, the switch forwards copies of the frame to the output buffers preceding all interfaces except for interface x.
    - In other words, if there is no entry for the destination address, the switch broadcasts the frame.

Forwarding and Filtering

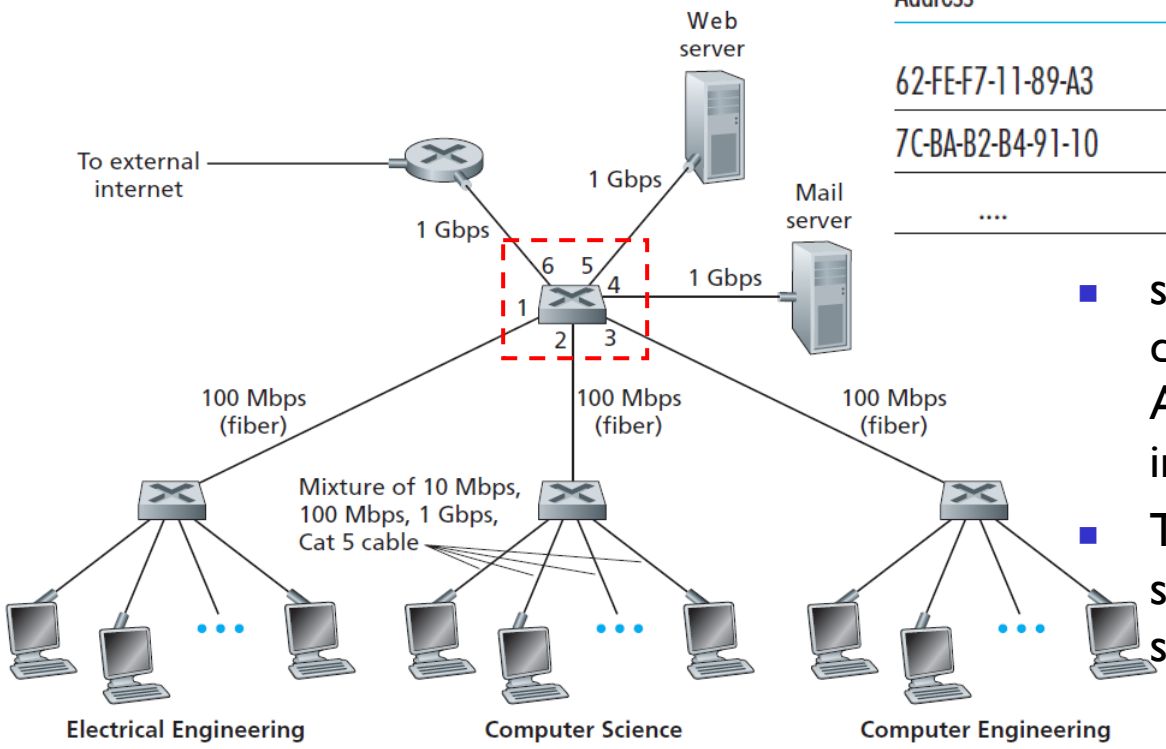
- Suppose a frame with destination address DD-DD-DD-DD-DD-DD arrives at the switch on interface x.
- The switch indexes its table with the MAC address DD-DD-DD-DD-DD-DD.
- There are three possible cases:
  - There is an entry in the table, associating DD-DD-DD-DD-DD-DD with interface x.
  - In this case, the frame is coming from a LAN segment that contains adapter DD-DD-DD-DD-DD-DD.
    - There being no need to forward the frame to any of the other interfaces, the switch performs the filtering function by discarding the frame.

Forwarding and Filtering

- Suppose a frame with destination address DD-DD-DD-DD-DD-DD arrives at the switch on interface x.
- The switch indexes its table with the MAC address DD-DD-DD-DD-DD-DD.
- There are three possible cases:
  - There is an entry in the table, associating DD-DD-DD-DD-DD-DD with interface y != x.
  - In this case, the frame needs to be forwarded to the LAN segment attached to interface y.
  - The switch performs its forwarding function by putting the frame in an output buffer that precedes interface y.

Forwarding and Filtering

- walkthrough these rules for the uppermost switch

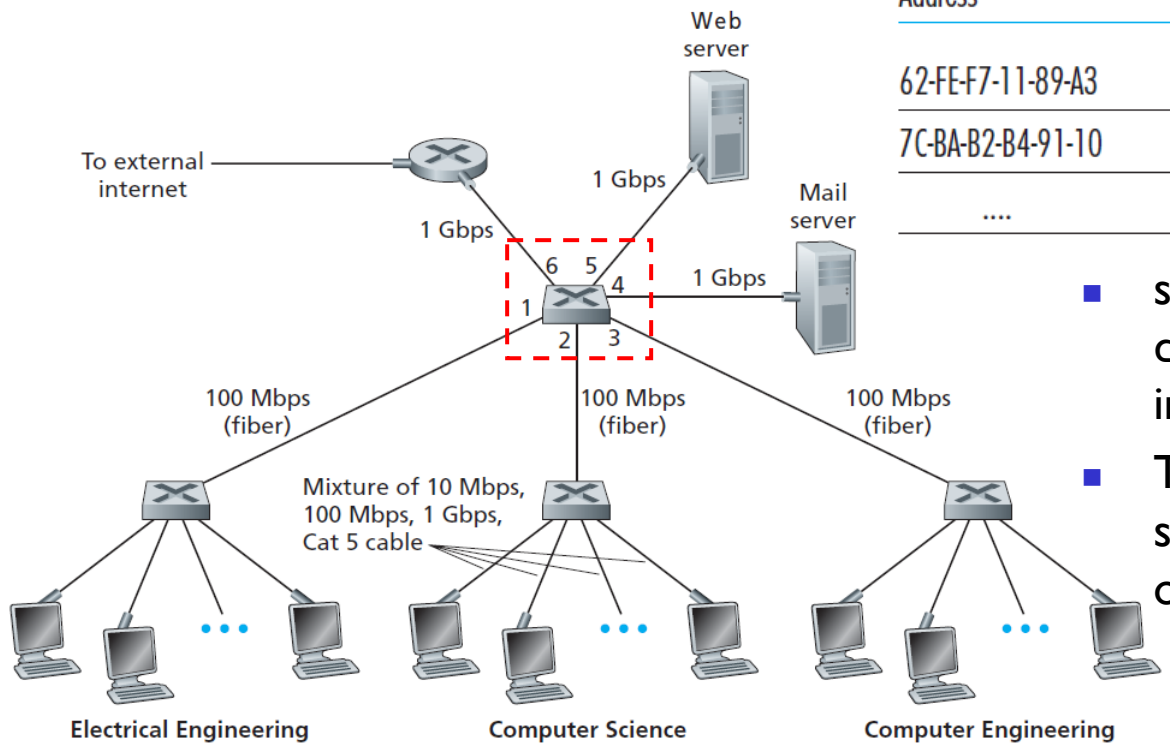


Address	Interface	Time
62-FE-F7-11-89-A3	1	9:32
7C-BA-B2-B4-91-10	3	9:36
....	....	....

- suppose that a frame with destination address 62-FE-F7-11-89-A3 arrives at the switch from interface 1
- The switch examines its table and see that the dest. is on the LAN segment connected to interface 1
  - The frame has already been broadcasted on the LAN segment that contains the destination

Forwarding and Filtering

- walkthrough these rules for the uppermost switch



Address	Interface	Time
62-FE-F7-11-89-A3	1	9:32
7C-BA-B2-B4-91-10	3	9:36
....	....	....

- suppose that a frame with the same destination address arrives from interface 2
- The switch examines its table and see that the dest. is in the direction of interface 1
  - forwards the frame to the output buffer preceding interface 1

Self-Learning

- A switch has the wonderful property (particularly for the already-overworked network administrator) that its table is built automatically, dynamically, and autonomously—without any intervention from a network administrator or from a configuration protocol.

- In other words, switches are ***self-learning***.

Self-Learning

- This capability is accomplished as follows:
  1. The switch table is initially empty.

Self-Learning

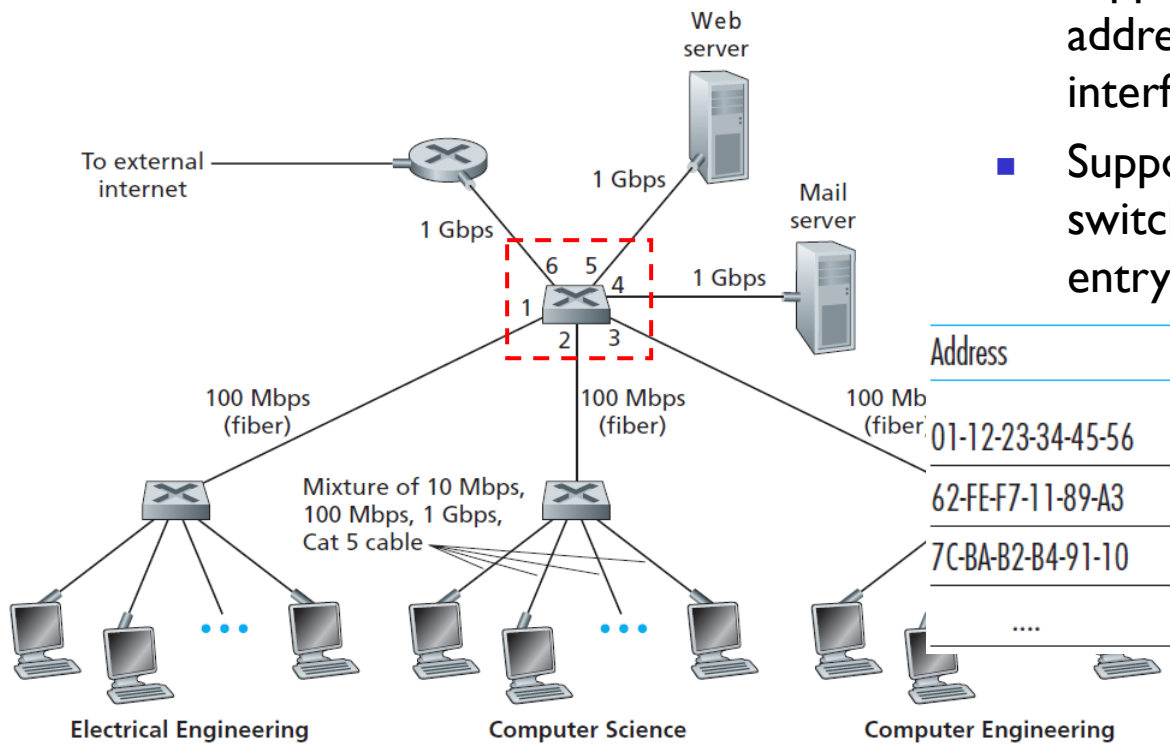
- This capability is accomplished as follows:
  2. For each incoming frame received on an interface, the switch stores in its table (1) the MAC address in the frame's source address field, (2) the interface from which the frame arrived, and (3) the current time.
     - In this manner the switch records in its table the LAN segment on which the sender resides.
     - If every host in the LAN eventually sends a frame, then every host will eventually get recorded in the table.

Self-Learning

- This capability is accomplished as follows:
  3. The switch deletes an address in the table if no frames are received with that address as the source address after some period of time (the aging time).
     - In this manner, if a PC is replaced by another PC (with a different adapter), the MAC address of the original PC will eventually be purged from the switch table.

Self-Learning

- walkthrough these rules for the uppermost switch

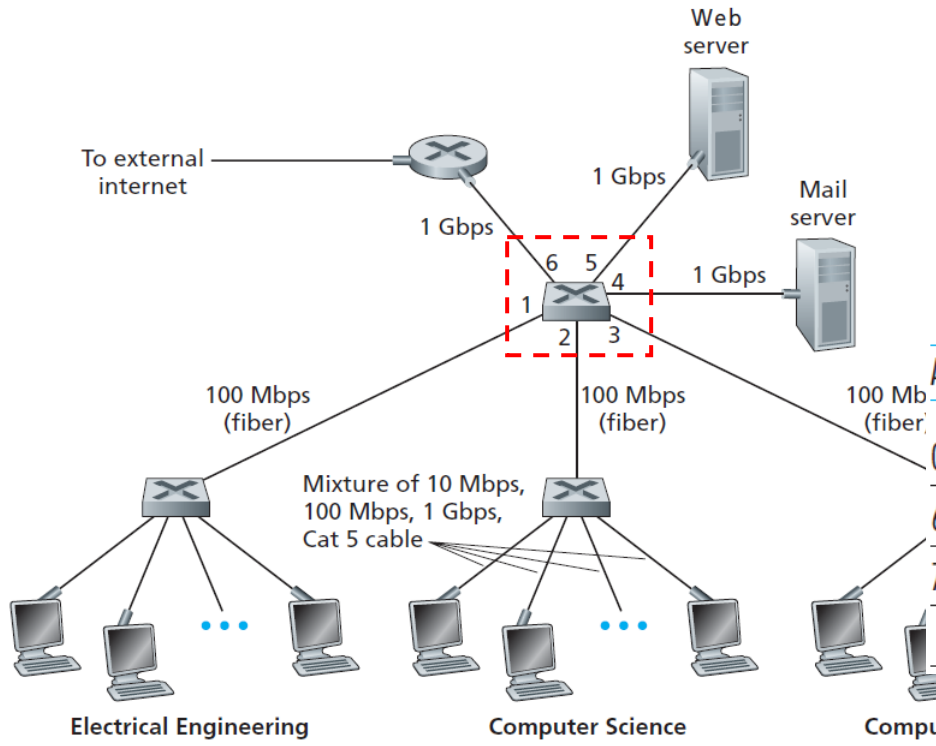


- suppose at time 9:39 a frame with source address 01-12-23-34-45-56 arrives from interface 2
- Suppose that this address is not in the switch table. Then the switch adds a new entry to the table

Address	Interface	Time
01-12-23-34-45-56	2	9:39
62-FE-F7-11-89-A3	1	9:32
7C-BA-B2-B4-91-10	3	9:36
....	....	....

Self-Learning

- walkthrough these rules for the uppermost switch



- suppose that the aging time for this switch is 60 minutes, and no frame with source address 62-FE-F7-11-89-A3 arrive to the switch between 9:32 and 10:32
- Then at time 10:32, the switch removes this address from its table.

Address	Interface	Time
01-12-23-34-45-56	2	9:39
~~62-FE-F7-11-89-A3~~	~~1~~	~~9:32~~
7C-BA-B2-B4-91-10	3	9:36
....	....	....

Self-Learning

- Switches are plug-and-play devices because they require no intervention from a network administrator or user.
- A network administrator wanting to install a switch need do nothing more than connect the LAN segments to the switch interfaces.
- The administrator need not configure the switch tables at the time of installation or when a host is removed from one of the LAN segments.
- Switches are also full-duplex, meaning any switch interface can send and receive at the same time.