Switched Local Area Networks

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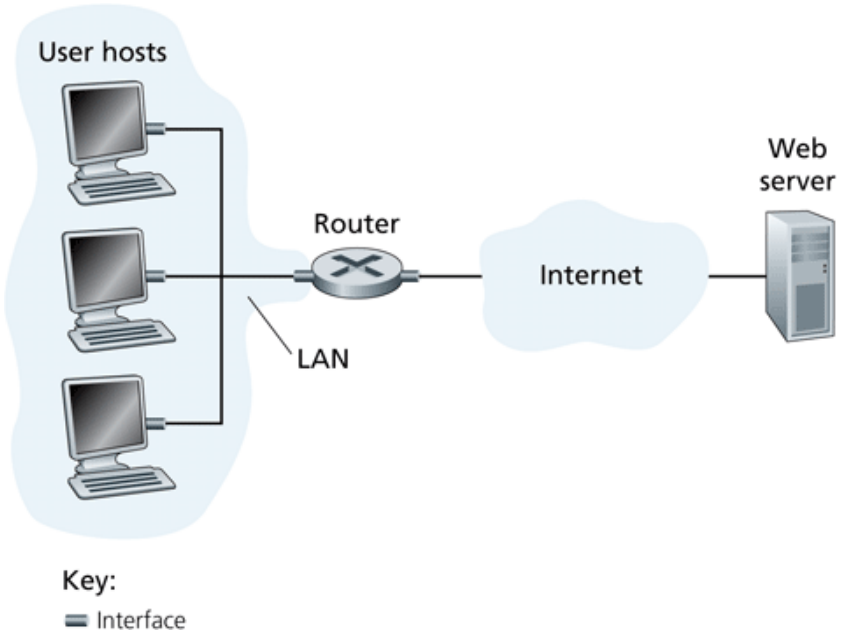
Addressing

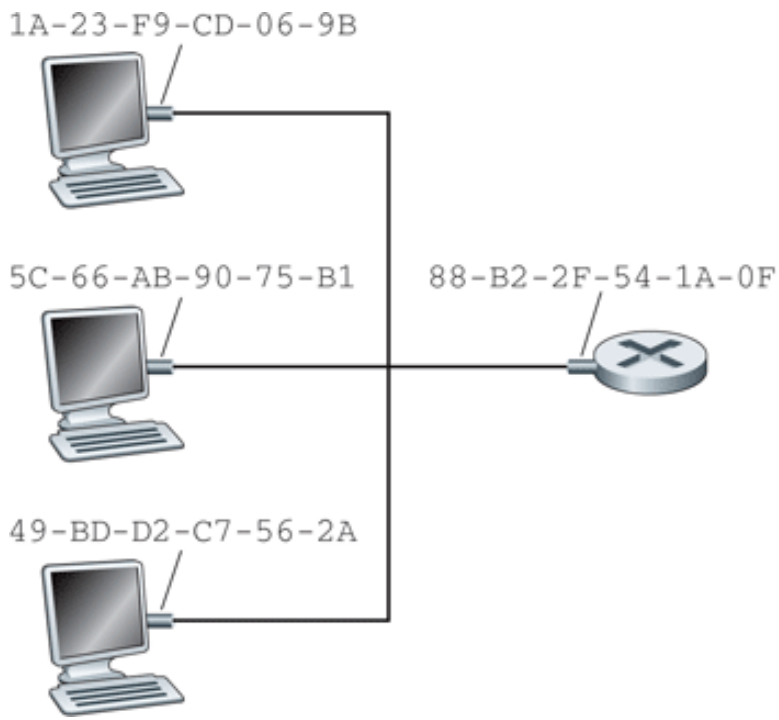
Local Area Network (LAN)

- broadcast channel shared among many hosts
  - any frames sent to the broadcast address reach all hosts on the LAN
  - earlier: all frames broadcast, those who don't want the data ignore it (bus topology)
  - now: frames sent to a particular MAC address reach only the destination host (star topology)



MAC Addresses

- used to get frame from one interface to another physically-connected interface (on the same network)
- most are 48 bits long, depends on link-layer protocol
- address burned into the adapter ROM
- broadcast address usually all ones (FF-FF-FF-FF-FF-FF)

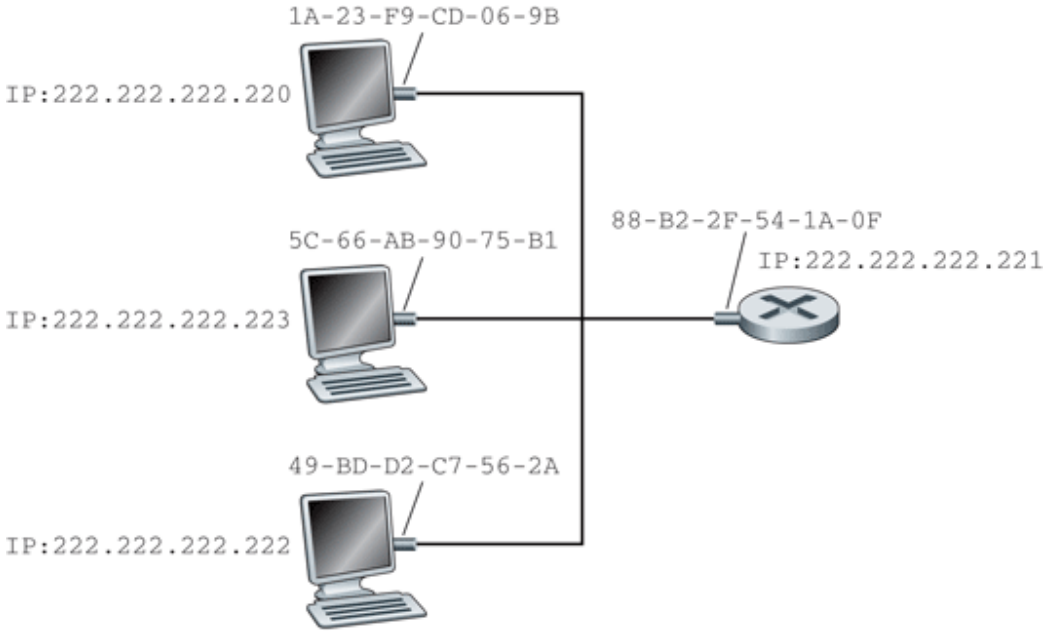


MAC Addresses are Globally Unique

- address assignment administered by IEEE
  - manufacturer buys portion of MAC address space (prefix)
  - uses that prefix for all MAC addresses and ensures it does not reuse the suffix
- uniqueness provides address portability
  - can move Ethernet card from one LAN to another
  - don't need hierarchy or aggregation like with IP addresses because MAC addresses only used on one LAN

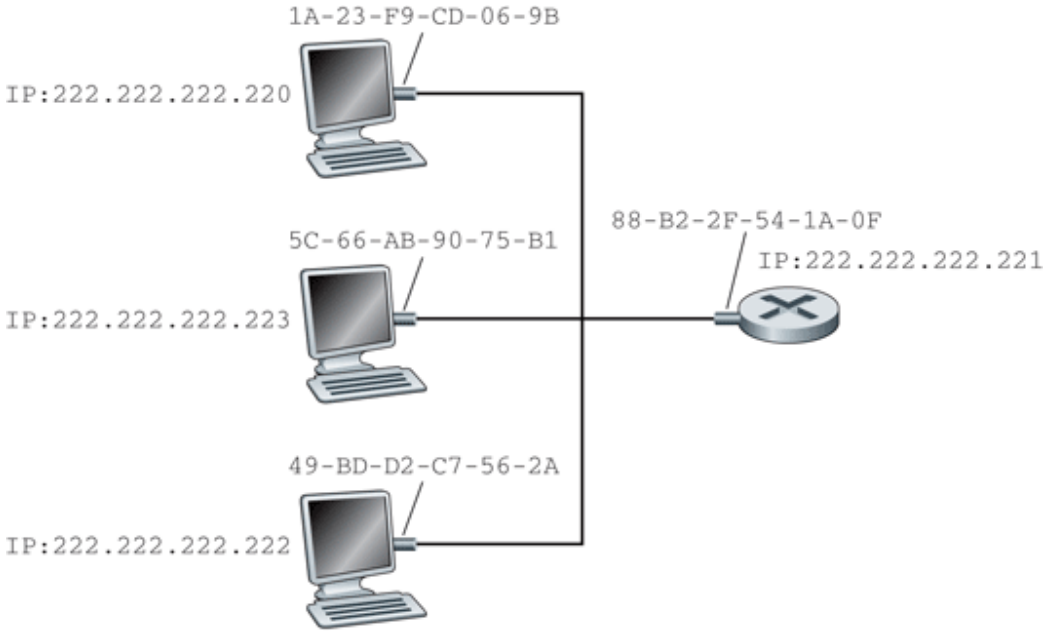
ARP

ARP: Address Resolution Protocol



- when forwarding a packet with IP, a router knows when the packet has reached its destination network
- how can the router determine the associated MAC address for a given IP address?

ARP: Address Resolution Protocol



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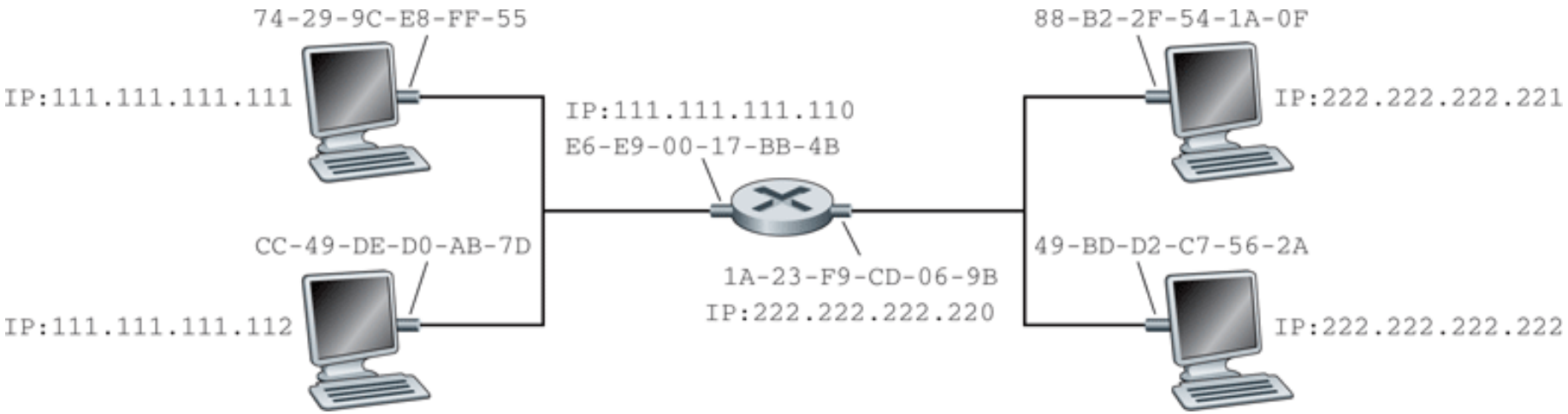
- how can the router determine the associated MAC address for a given IP address?
- keep an ARP table: maps an IP address to a MAC address

Building an ARP Table

- ARP table entry
  - IP address
  - MAC address
  - TTL (e.g. 20 minutes)
- host A has no entry for IP address B in table
  - A broadcasts ARP query for B
  - all hosts on LAN receive query
  - host with address B responds by unicast to A with its MAC address
  - all hosts hear query and response, cache translations for A and B in their ARP tables
    - all hosts process all ARP packets, even if not addressed to themselves

ARP Example

- send packet from A to B via R
- need ARP from A to R, R to B



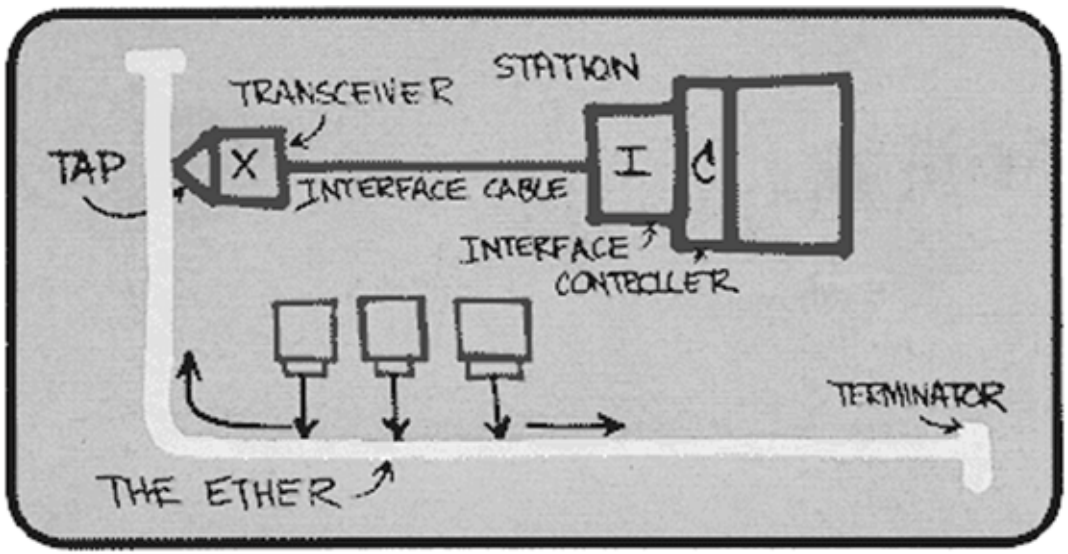
- ARP table for node 222.222.222.220

IP Address	MAC Address	TTL
222.222.222.221	88-B2-2F-54-1A-0F	13:45:00
222.222.222.223	5C-66-AB-90-75-B1	13:52:00

Ethernet

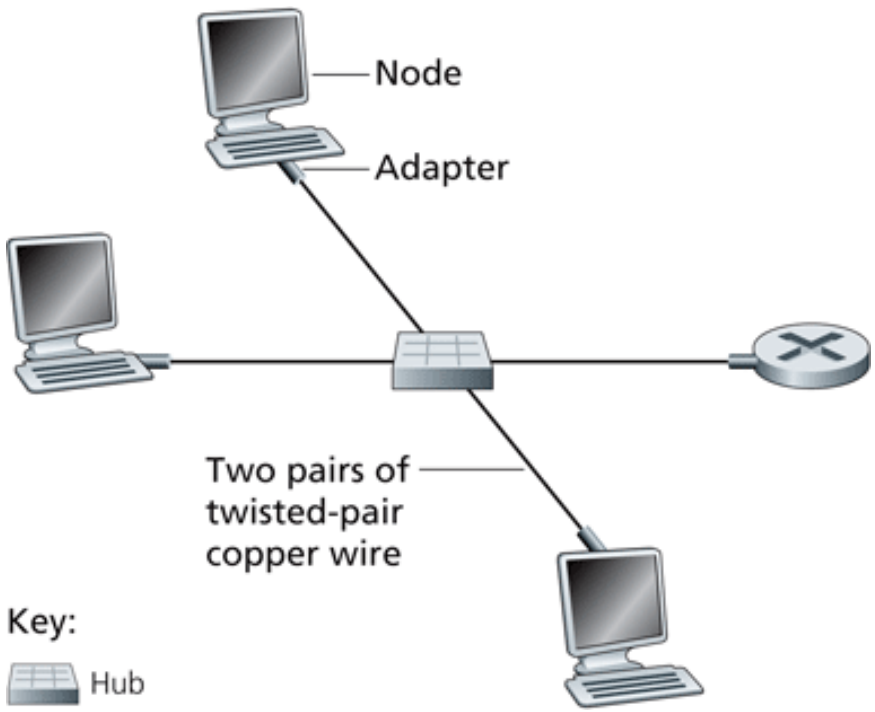
Ethernet

- dominant wired LAN technology
- very inexpensive: $20 for 100 Mbps
- simpler and cheaper than FDDI (token ring), ATM
- speeds have improved dramatically over the years: 10 Mbps - 10 Gbps

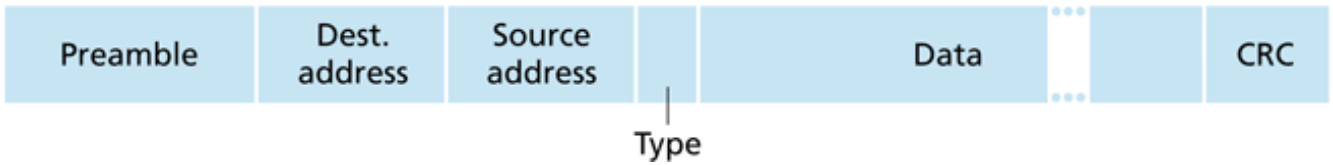


Ethernet Topologies

- originally used a bus
- now nearly all installations use a star: hub or switch



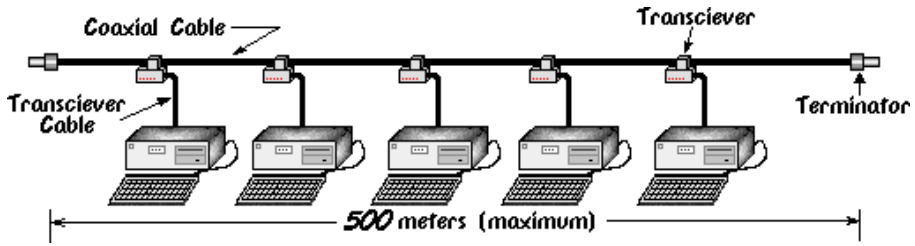
Ethernet Frame Format



- IP packet encapsulated inside Ethernet Frame
- preamble: 7 bytes of 10101010 followed by one byte of 10101011
  - used to synchronize the receiver and sender clock rates
- addresses: 6 bytes
- type: higher level protocol (IP, IPX (Netware), AppleTalk)
- CRC: error detection/correction

Historic Ethernet

- 10base5 *(thick ethernet)*
  - original standard
  - coaxial cable, 500 meters max length, 10 Mbps
  - bus topology, BNC connectors, must be terminated
- 10Base-2 *(thin ethernet)*
  - coaxial cable, 185 meters max length, 10 Mbps
  - bus topology, BNC connectors, must be terminated



Modern Ethernet

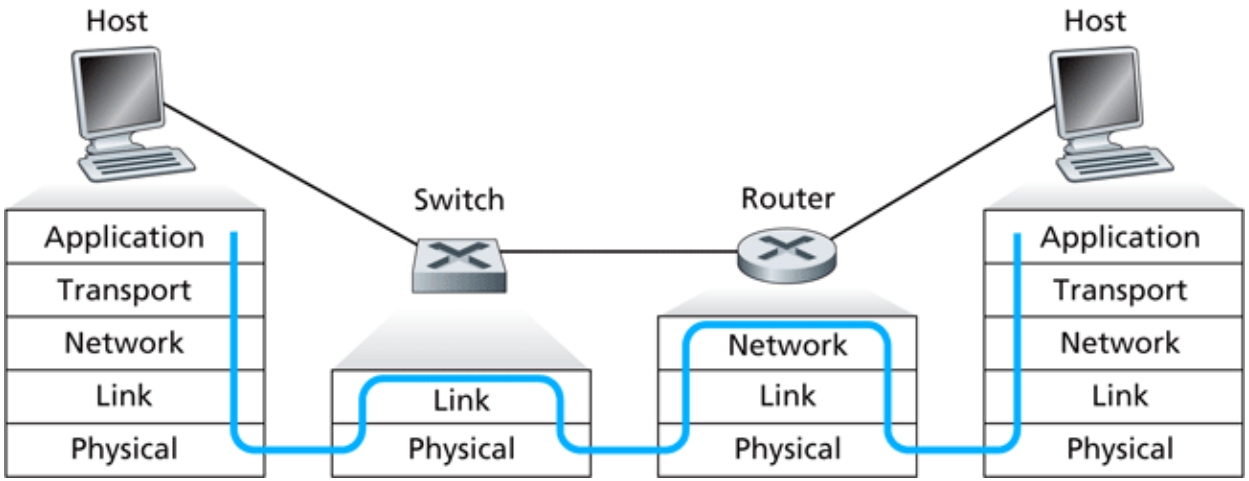
- 10BaseT and 100BaseT *(fast ethernet)*
  - star topology
  - twisted pair, 100 m max distance between node and hub
  - hub is a physical-layer bit repeater, no frame buffering
  - all nodes effectively on same link
- Gigabit ethernet
  - point-to-point links and shared links
  - CSMA/CD only for shared links
  - full duplex at 1 Gbps and now 10 Gbps for point-to-point links

Switches

Hubs versus Switches

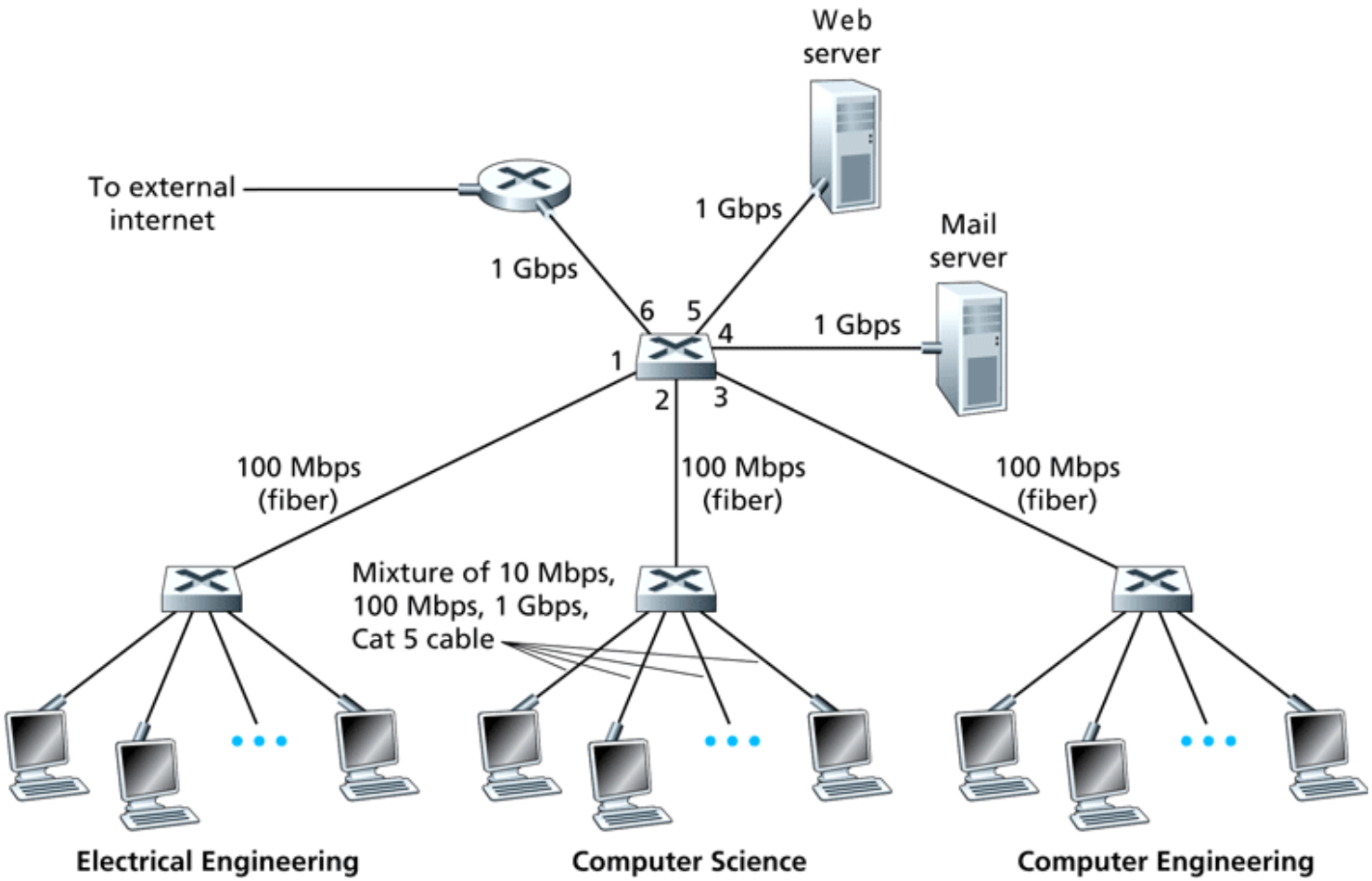
- hub: a bit repeater and signal amplifier
  - connects two LAN segments together
  - extends maximum distance between two nodes
  - connects *collision domains*
- switch: link layer forwarding device
  - stores and forwards frames using MAC address
  - uses link-layer protocol when forwarding frames
  - separates *collision domains*
- Ethernet switch: only handles Ethernet frames, uses CSMA/CD on each LAN segment

Switches versus Routers



- both use store-and-forward
  - switches forward frames
  - routers forward IP packets
- routers compute paths between IP networks using routing algorithms
- switches use a learning algorithm to connect links forming a single IP network

Example Configuration



Traffic Isolation

- each segment is a separate collision domain
  - each segment receives data at its full link rate
  - pairs of communicating hosts can operate at full speed simultaneously
- cut-through-switching: switch begins forwarding frame as soon as it reads the header

Self-Learning Switches

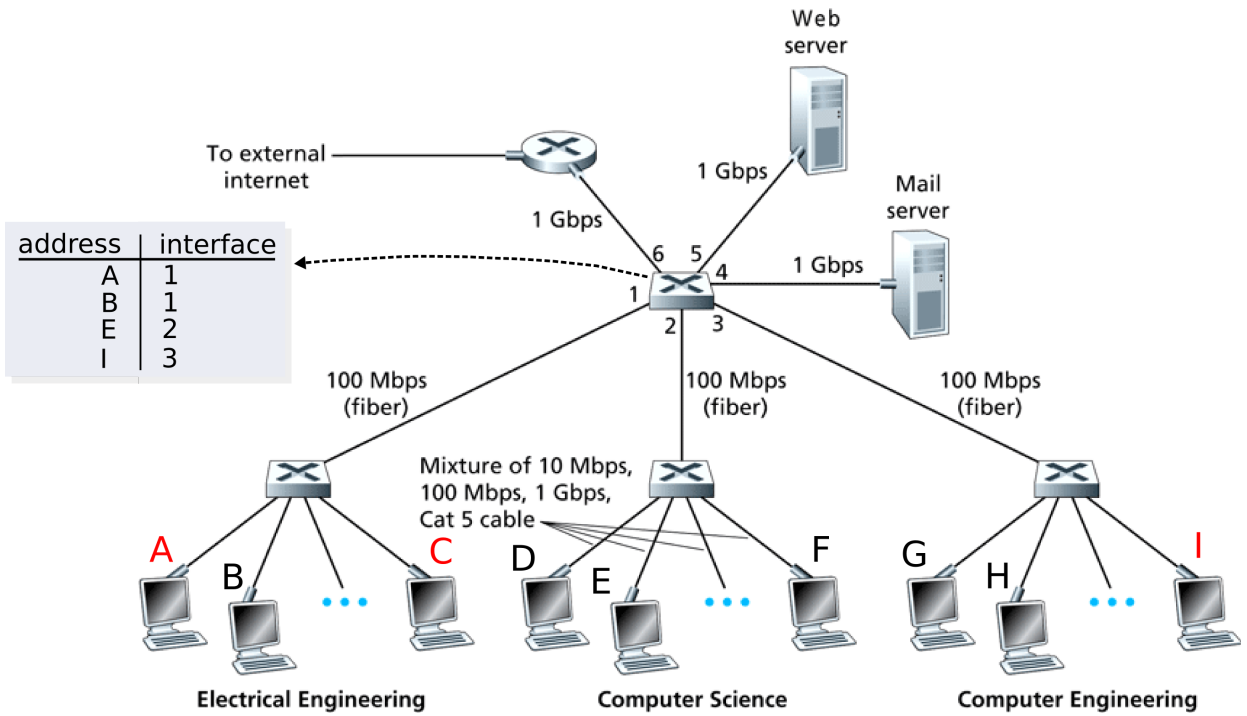
- switch could forward all frames on all links: high overhead
- use a self-learning algorithm to determine where to forward each frame
  - learn which host can be reached on a given interface
  - when the switch receives a frame, it *learns* that the source host is on this interface
  - record interface for the host in a switch table
- switch table entries
  - MAC address
  - interface
  - timestamp (stale entries deleted)

Switch Forwarding Algorithm

```
entry = switch_table{MACdestAddress}
if entry:
    if MACdestAddress on arriving interface
        drop frame
    else:
        entry.interface.forwardframe()
else:
    for i in interfaces:
        if i != arriving interface:
            i.forwardframe()
```

- can the switch topology have loops?

Switch Example



- switch delivers a frame from A to I - sends only on interface 3
- switch delivers a frame from A to C - sends on all interfaces
- switch delivers a frame from C to I - sends only on interface 3, learns that C is on interface 1

VLANs

- motivation
  - want to limit the spread of broadcast traffic
  - want to isolate traffic for small subnets, without requiring a separate, physical switch for each subnet
  - want the flexibility of moving hosts between subnets without physically rewiring them
- use a single switch with intelligence that knows which ports belong to which VLAN
- use a router within the switch to route between VLANs