Computer Networks

Local Area Networks

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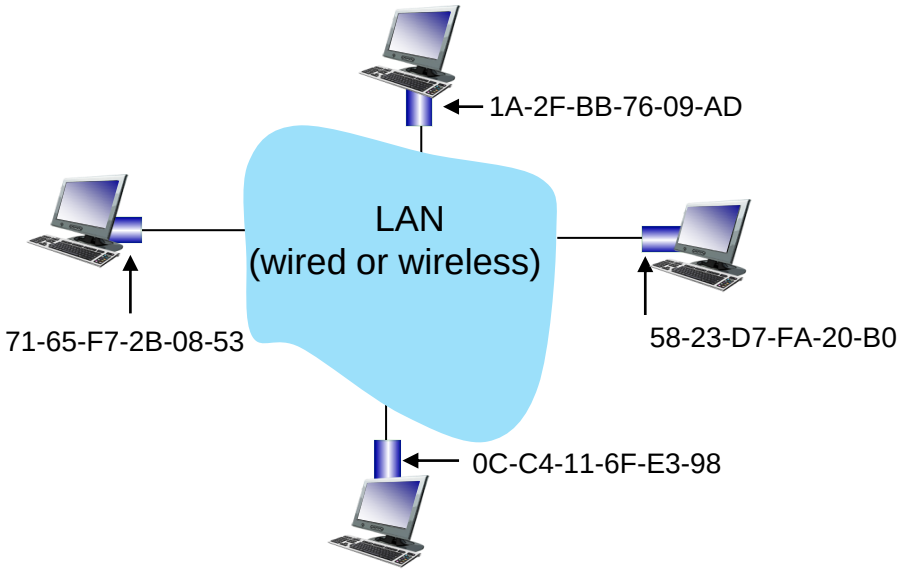
MAC Address and Framing

MAC addresses

Network interface controller

- MAC (or LAN or physical) address:
  - 48-bit MAC address (for most LANs) burned in NIC ROM, also sometimes software settable
  - Each interface on LAN has an unique MAC address
  - e.g.: 1A-2F-BB-76-09-AD



MAC addresses

- MAC address allocation administered by IEEE
- Manufacturer buys portion of MAC address space (to assure uniqueness)
- MAC address: portability
  - Can move interface from one LAN to another

In the context of MAC (Media Access Control) address portability, it refers to the ability of a network interface to be moved or transferred from one Local Area Network (LAN) to another without needing to change its MAC address

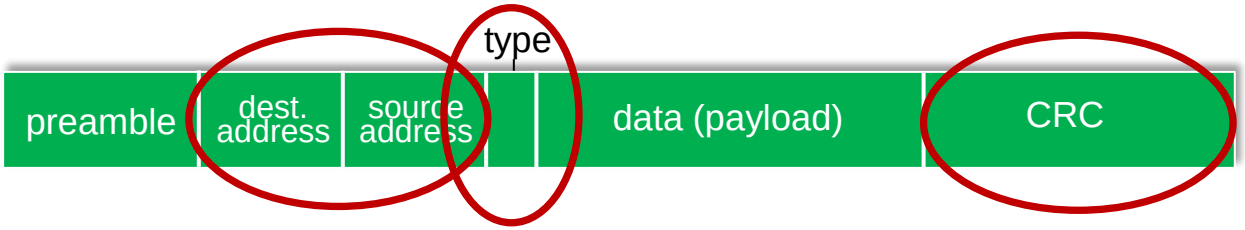
Ethernet frame structure

Sending interface encapsulates IP datagram (or other network layer protocol packet) in Ethernet frame

Preamble:

- Used to synchronize receiver, sender clock rates
- 7 bytes of 10101010 followed by one byte of 10101011

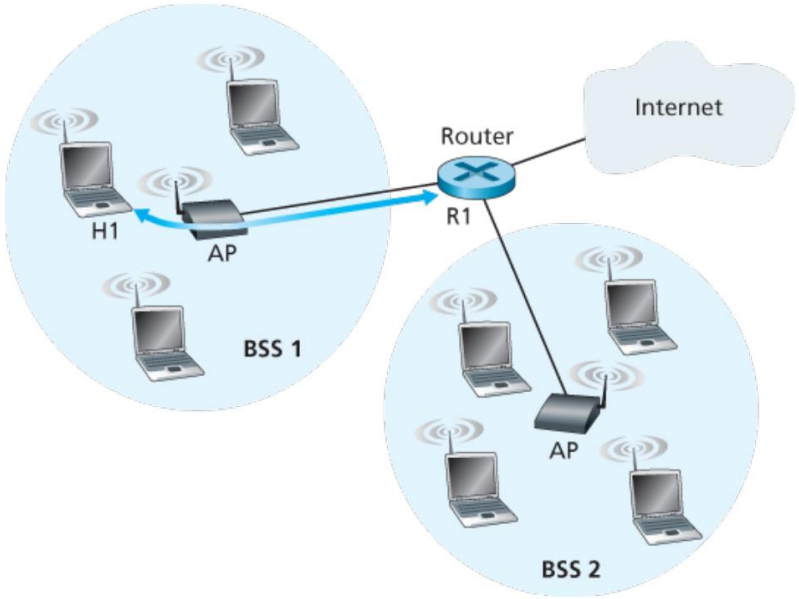
Ethernet frame structure



- Addresses: 6 byte source, destination MAC addresses
  - If adapter receives frame with matching destination address, or with broadcast address, it passes data in frame to network layer protocol
  - Otherwise, adapter discards frame
- Type: indicates higher layer protocol
  - Mostly IP but others possible, e.g., Novell IPX, AppleTalk
  - Used to demultiplex up at receiver
- CRC: Cyclic redundancy check at receiver
  - Error detected: frame is dropped

802.11 frame structure

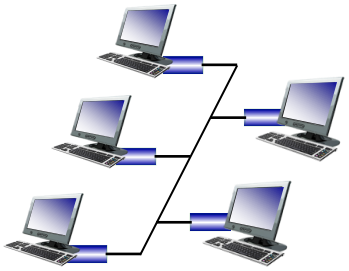
Bytes	2	2	6	6	6	2	0–2312	4
	Frame control	Duration	Address 1 (recipient)	Address 2 (transmitter)	Address 3	Sequence	Data	Check sequence



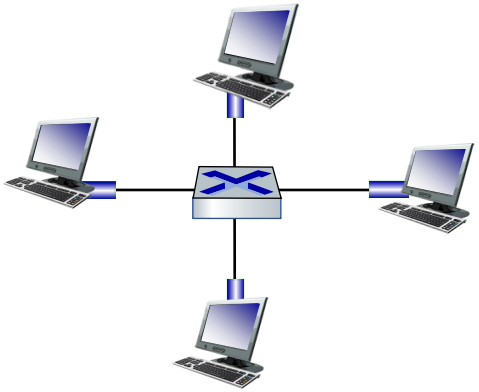
Ethernet Switches

Ethernet: physical topology

- Bus: popular through mid 90s
  - All nodes in same collision domain (can collide with each other)
- Switched: prevails today
  - Active link-layer 2 switch in center
  - Each “spoke” runs a (separate) Ethernet protocol (nodes do not collide with each other)



Bus



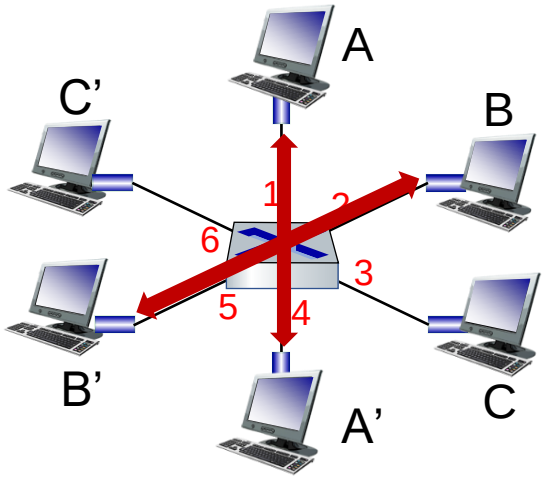
Switched

Ethernet switch

- Switch is a link-layer device
  - Store, forward Ethernet frames
  - Examine incoming frame's MAC address, selectively forward frame to one-or-more outgoing links when frame is to be forwarded on segment, uses CSMA/CD to access segment
- Transparent: hosts unaware of presence of switches
- Plug-and-play, self-learning
  - Switches do not need to be configured

Ethernet switch

- Hosts have dedicated, direct connection to switch
- Switches buffer packets
- Ethernet protocol used on each incoming link, so:
  - No collisions; full duplex
  - Each link is its own collision domain
- Switching: A-to-A’ and B-to-B’ can transmit simultaneously, without collisions



switch with six interfaces (1,2,3,4,5,6)

https://www.ciscopress.com/articles/article.asp?p=2111396

Ethernet switch

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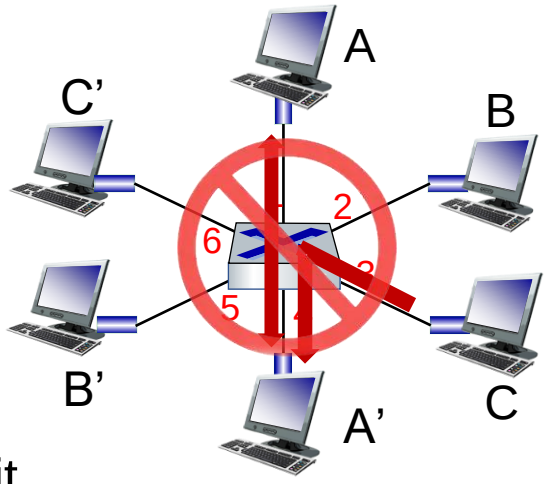
- Switches buffer packets
- Ethernet protocol used on each incoming link, so:
  - No collisions; full duplex
  - Each link is its own collision domain
- Switching: A-to-A' and B-to-B' can transmit simultaneously, without collisions
  - But A-to-A' and C to A' can not happen simultaneously



switch with six interfaces (1,2,3,4,5,6)

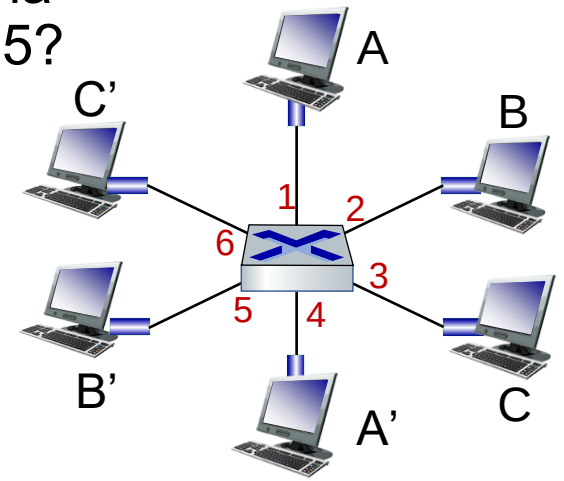
https://study-ccna.com/half-duplex-and-full-duplex/

Switch forwarding table

Q: How does switch know A' reachable via interface 4, B' reachable via interface 5?

A: Each switch has a forwarding table, each entry:

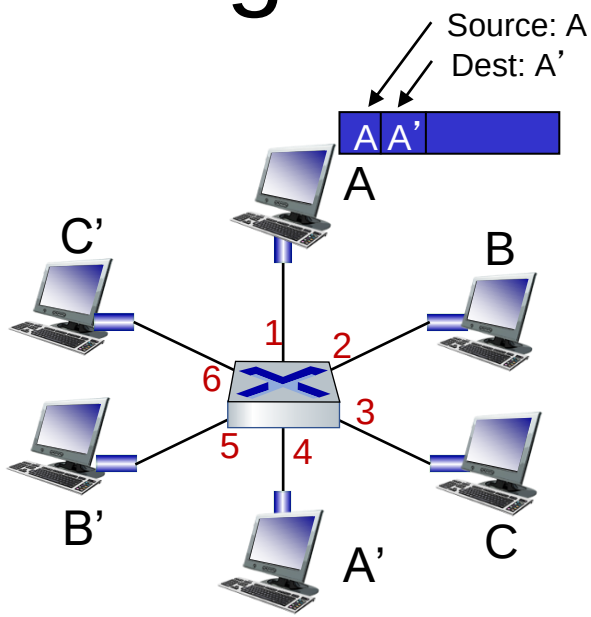
- (MAC address of host, interface to reach host, time stamp)



Q: How are entries created, maintained in forwarding table?

Switch: self-learning

- 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

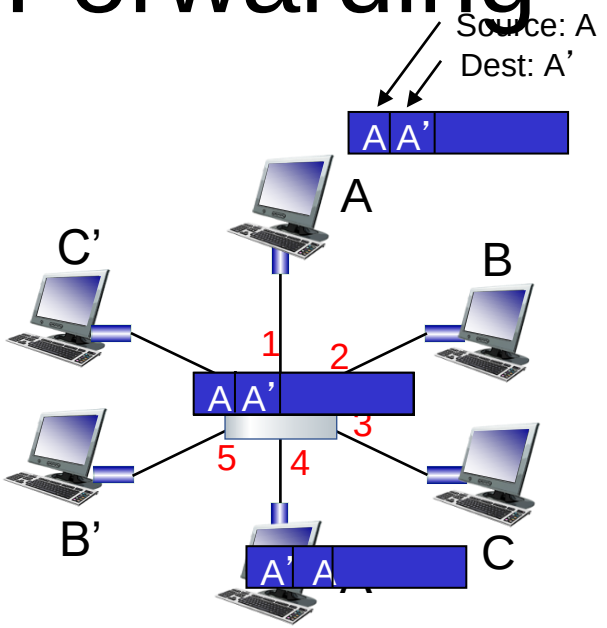


MAC addr	interface	TTL
A	1	60

Forwarding table (initially empty)

Self-learning and Forwarding

- Frame destination, A’, location unknown: flood
- Destination A location known: selectively send on just one link

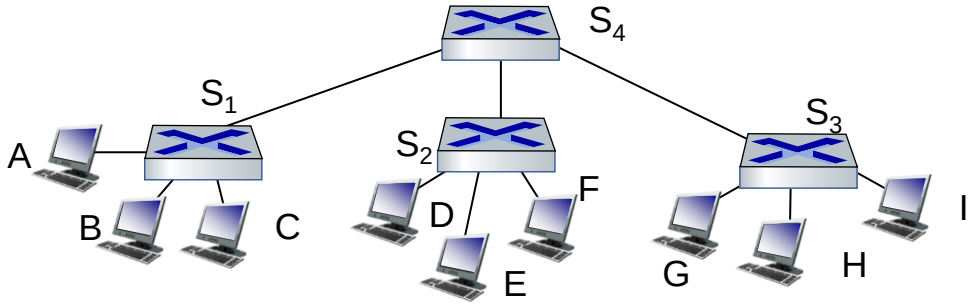


MAC addr	interface	TTL
A	1	60
A’	4	60

switch table (initially empty)

Interconnecting switches

Self-learning switches can be connected together:



Q: Sending from A to G - how does S_1 know to forward frame destined to G via S_4 and S_3?

- A: Self learning! (works exactly the same as in single-switch case!)

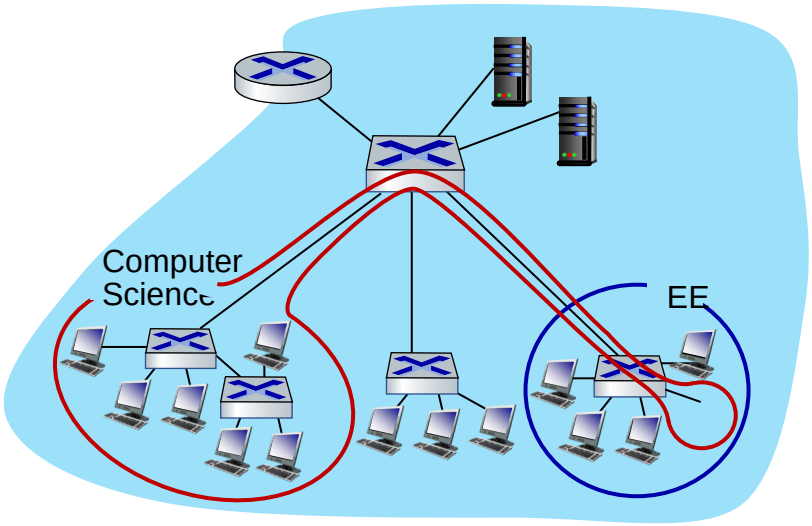
Switch: frame filtering/forwarding

When frame received at switch:

1. Record incoming link, MAC address of sending host
2. Index forwarding table using MAC destination address
3. If entry found for destination
   then {
   if destination on segment from which frame arrived
   then drop frame
   else forward frame on interface indicated by entry
   }
   else flood /* forward on all interfaces except arriving interface
   */

Virtual LAN

Virtual LANs (VLANs)



Single broadcast domain:

- Scaling: all layer-2 broadcast traffic (i.e. unknown MAC) must cross entire LAN
- Efficiency, security, privacy issues

Administrative issues:

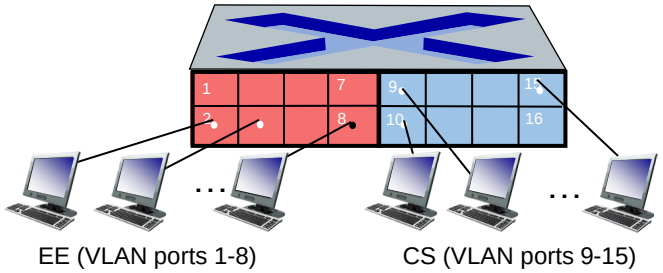
- CS user moves office to EE - physically attached to EE switch, but wants to remain logically attached to CS switch

Port-based VLANs

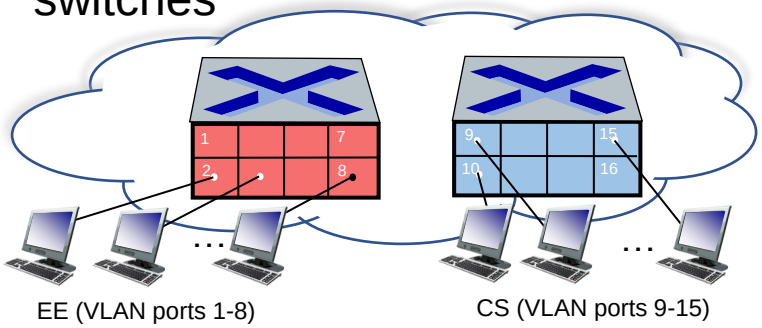
Virtual Local Area Network (VLAN)

Switch(es) supporting VLAN capabilities can be configured to define multiple virtual LANS over single physical LAN infrastructure

Port-based VLAN: switch ports grouped (by switch management software) so that single physical switch ……

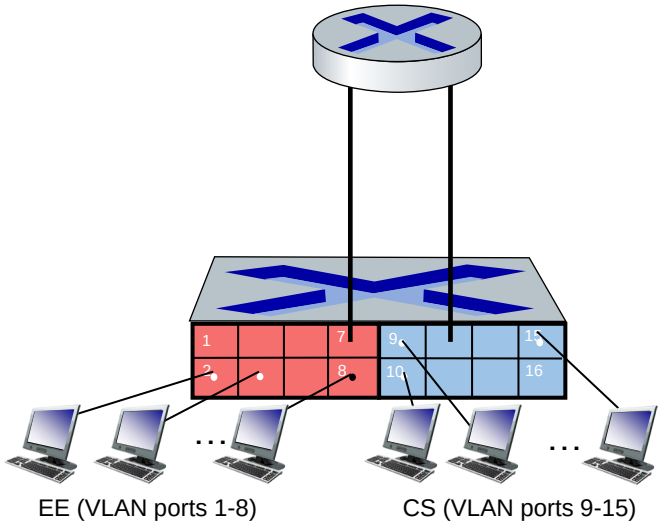


… operates as multiple virtual switches

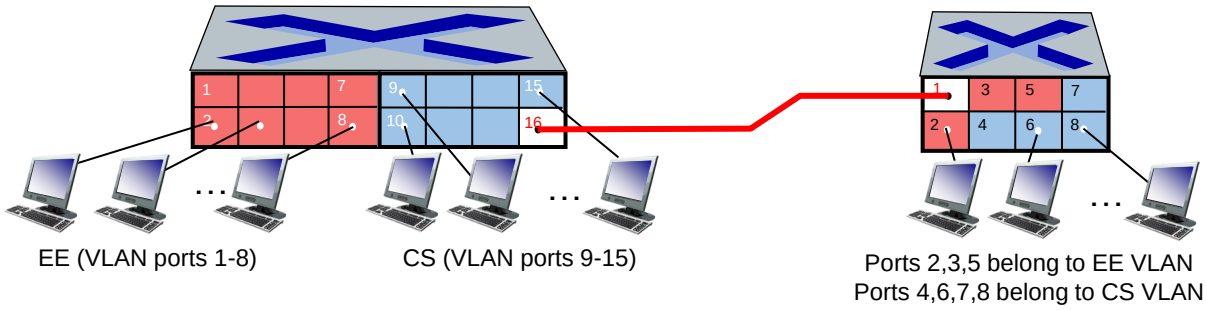


Port-based VLANs

- Traffic isolation: frames to/from ports 1-8 can only reach ports 1-8
  - can also define VLAN based on MAC addresses of endpoints, rather than switch port
- Dynamic membership: ports can be dynamically assigned among VLANs
- Forwarding between VLANS: done via routing (just as with separate switches)
  - in practice vendors sell combined switches plus routers



VLANS spanning multiple switches



Trunk port: carries frames between VLANS defined over multiple physical switches

- frames forwarded within VLAN between switches must carry VLAN ID info
- 802.1q protocol adds/removed additional header fields for frames forwarded between trunk ports

Summary

- Local area networks:
  - MAC addresses and framing
  - Ethernet switch and self learning
  - Virtual LANs