LANs and ARP

Networking

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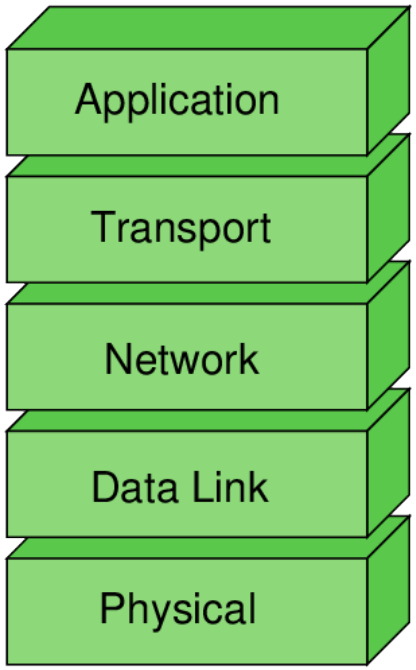
Common/Reports/lans-arp.tex, r723

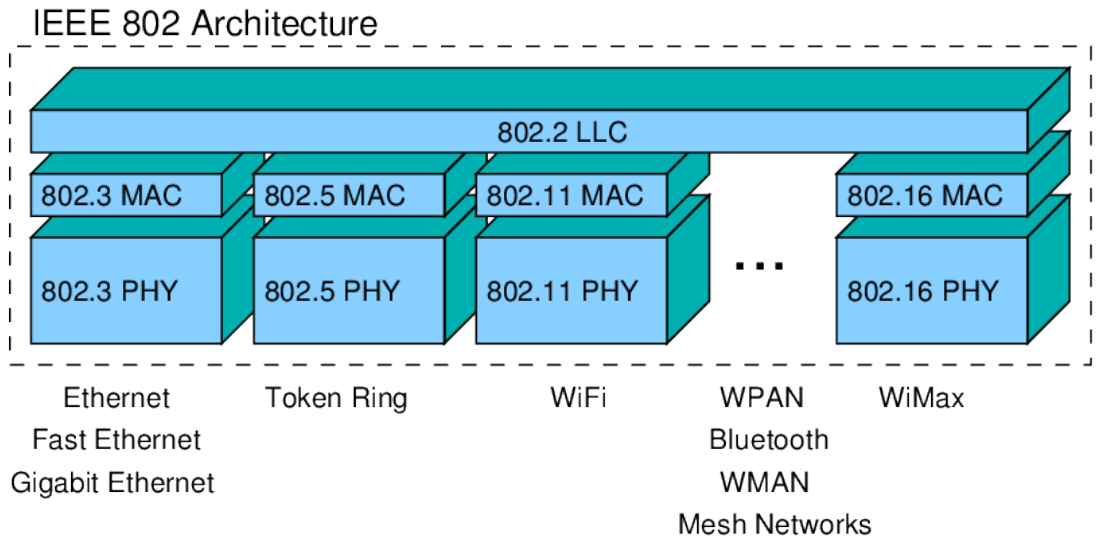
Contents

Ethernet LANs

- Local Area Networks (LANs) connect end-user devices across homes, factories, office buildings, campuses
- Owned and operated by owner of end-user devices
- Many popular LAN technologies are standardised by IEEE in the 802 series
- IEEE 802.3 is most widespread wired LAN technology
- Also called Ethernet

IEEE 802 Protocol Architecture





IEEE 802.3 LANs

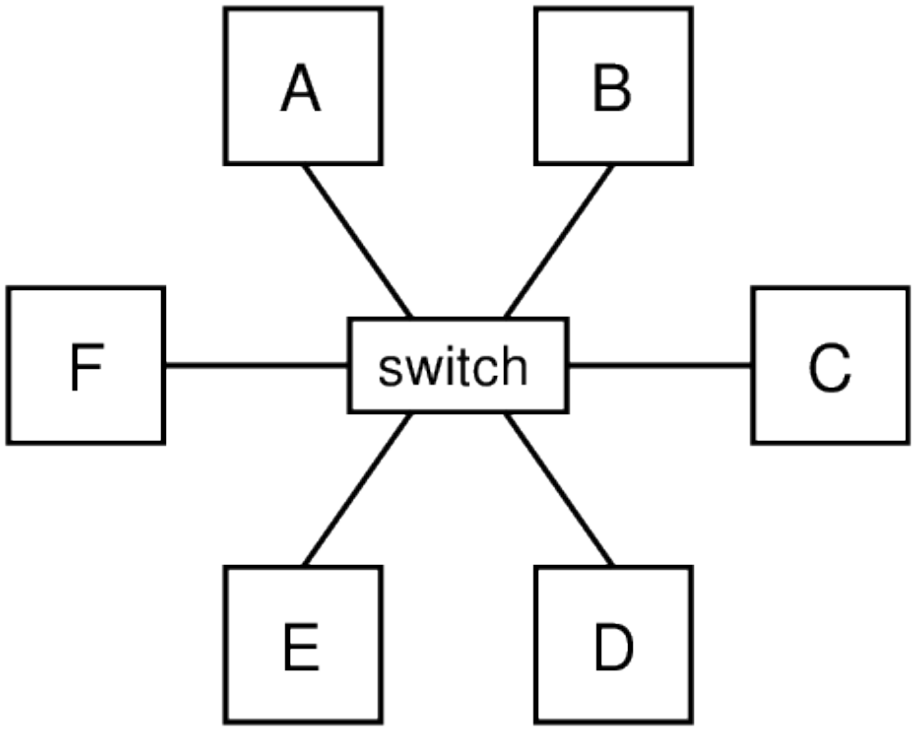
Physical Layer

- Original popular Ethernet: 10 Mb/s, bus topology, coaxial cable, CSMA/CD, half-duplex
- Fast Ethernet: 100 Mb/s, star (switched) topology, UTP, no MAC, full-duplex
- Gigabit Ethernet: 1 Gb/s, switched, twisted pair or optical fibre
- 10-Gigabit Ethernet: between switches, servers
- 40 Gb/s and 100 Gb/s Ethernet is available

Topology

- Bus
- Ring
- Star: commonly used today—switched Ethernet

Switched Ethernet Topology



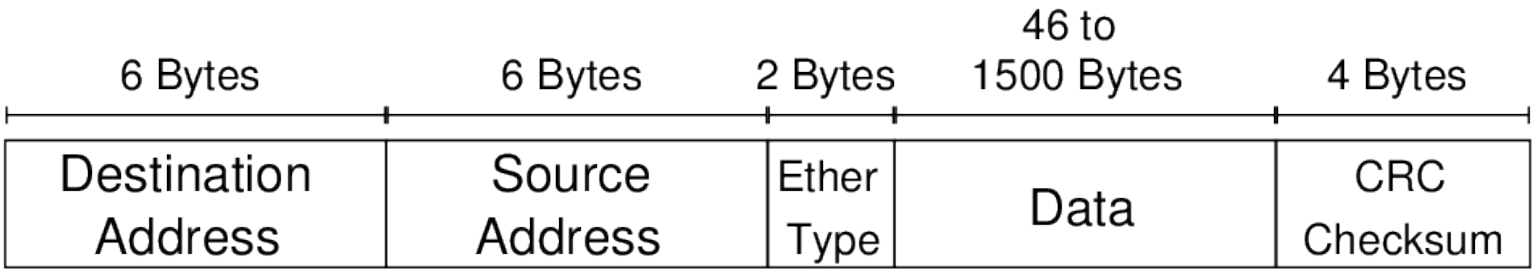
- Stations (hosts, routers) connect via full-duplex twisted pair to switch
- Switch has multiple ports, e.g. 4, 8, 24, 48
- All frames between stations pass via the switch

Contents

IEEE 802 Addresses

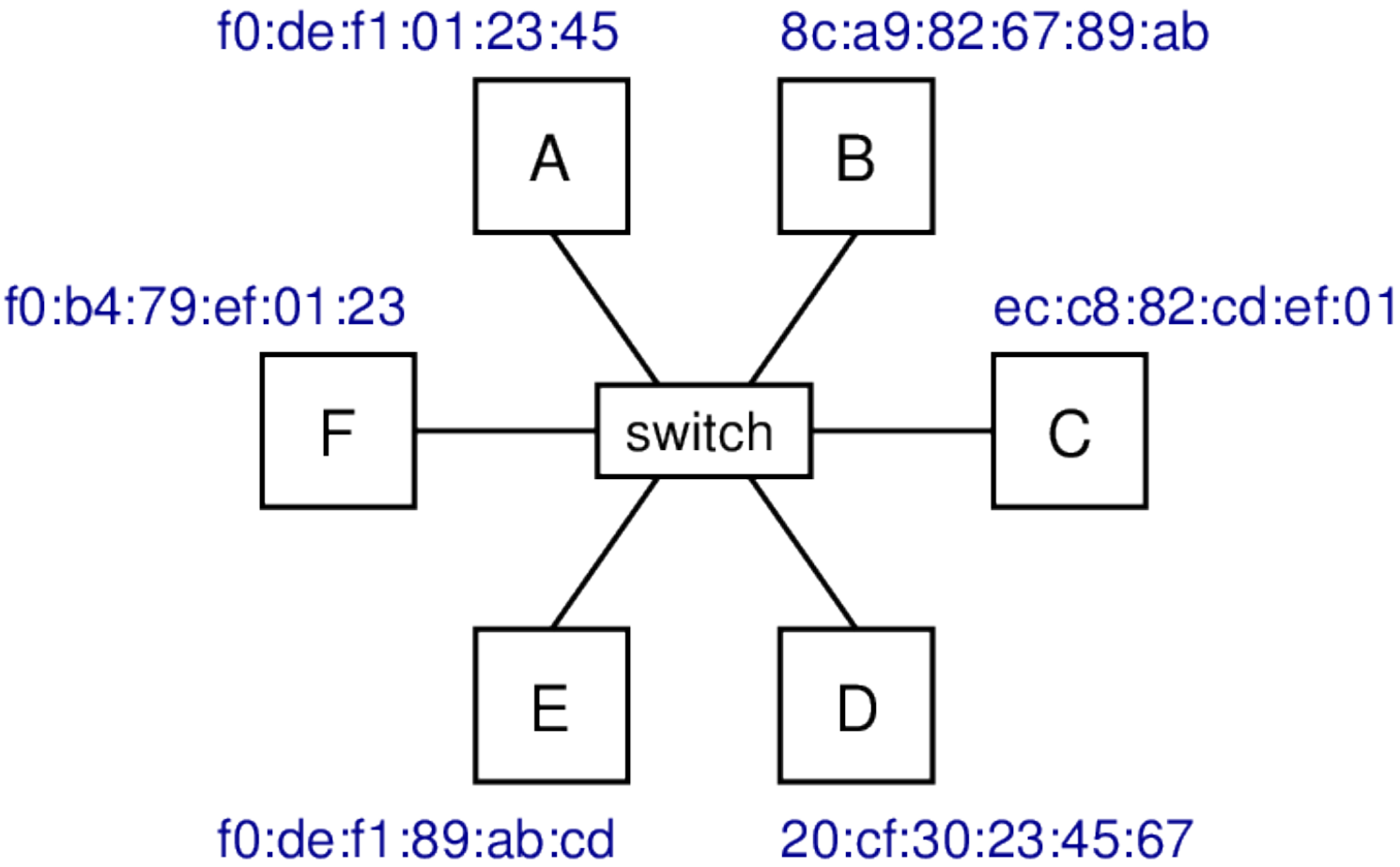
- IEEE 802 standards use common IEEE 48-bit address format
- Commonly called MAC or hardware addresses
- Globally unique (ideally)
  - First 24-bits assigned by IEEE to manufacturer `http://standards.ieee.org/regauth/oui/`
  - Second 24-bits assigned by manufacturer to device
- For simplicity, represented as 6×2 digit hexadecimal numbers, e.g. `90:2b:34:60:dc:2f`
- Special case broadcast address: `ff:ff:ff:ff:ff:ff`
- Common in other standards: Bluetooth, ATM, FDDI, FibreChannel
- IEEE 64-bit address is alternative format: Firewire, ZigBee, IPv6

IEEE 802.3 Frames



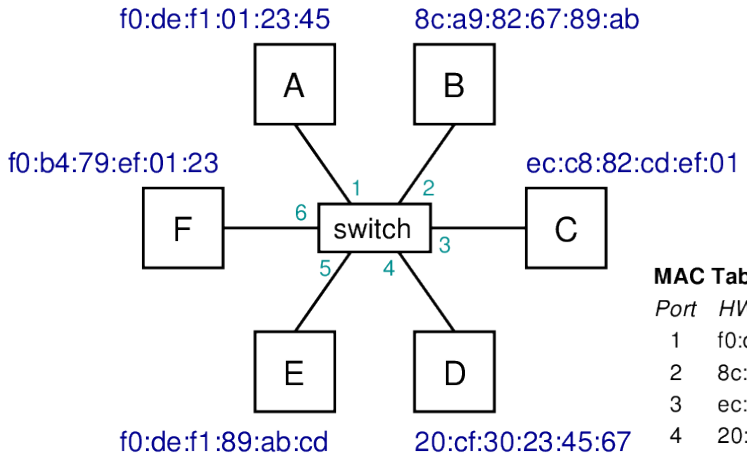
- Typical maximum data size is 1500 Bytes (optional Jumbo frames)
- 1st 8 bytes (preamble, delimiter) sometimes considered part of Physical layer

Example Hardware Addresses



- Hardware (MAC) addresses are assigned to LAN card by manufacturer
- Each station (hosts and routers) have address for each network interface card

Example MAC Table used by Switch

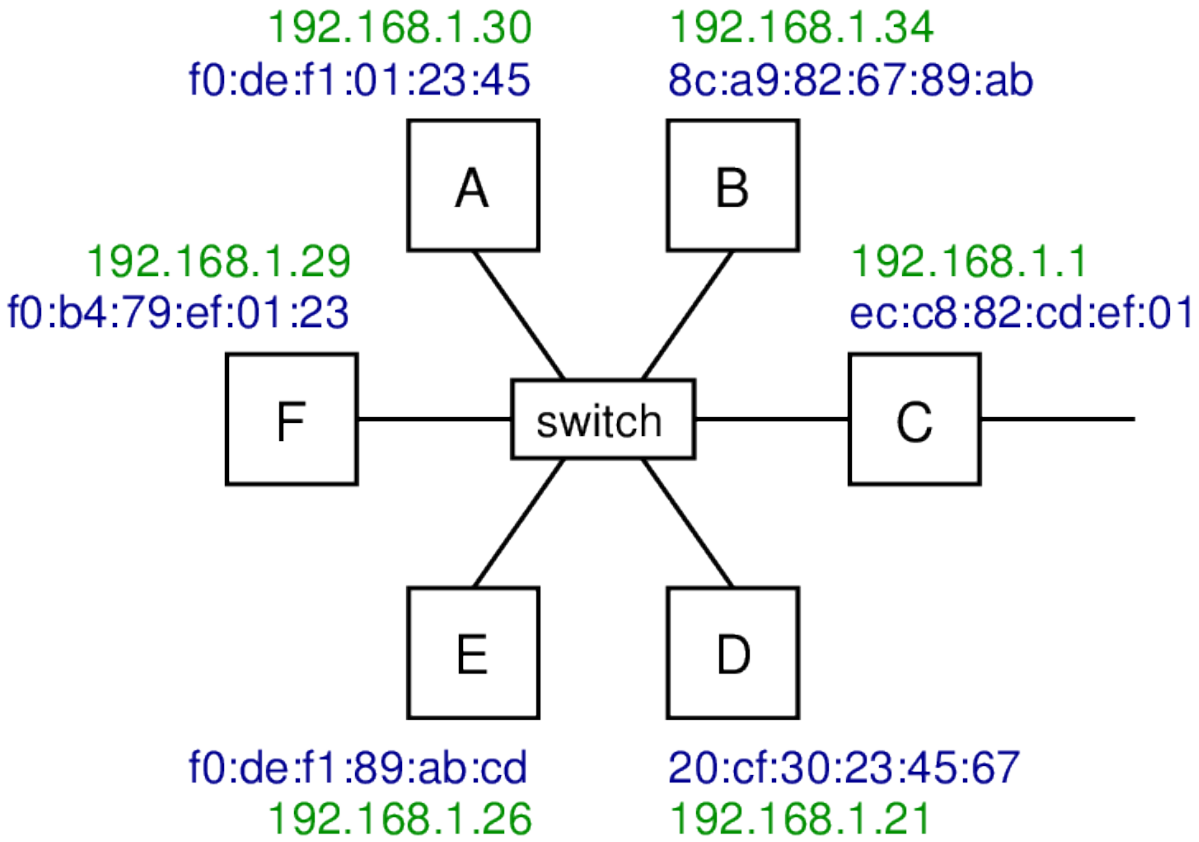


MAC Table of switch

Port	*HWaddress*
1	f0:de:f1:01:23:45
2	8c:a9:82:67:89:ab
3	ec:c8:82:cd:ef:01
4	20:cf:30:23:45:67
5	f0:de:f1:89:ab:cd
6	f0:b4:79:ef:01:23

- Switch learns address of station at other end point of link
- Store address and port in memory; used for forwarding frames

Example IP Addresses



- Interfaces also have IP addresses; assigned manually or dynamically (DHCP)
- All IP addresses in the LAN have same network portion
- Example: subnet mask is /24; network address is 192.168.1.0

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Mapping IP to Hardware Address

- IP-based applications (software) communicate to applications on other computers using logical IP addresses
- Stations inside a LAN communicate to other stations using physical hardware addresses
- Assume source application knows destination computer by IP address
- What is the hardware address of destination computer (or device to reach destination computer)?
- Address Resolution Protocol (ARP) maps IP addresses to hardware addresses

Address Resolution Protocol

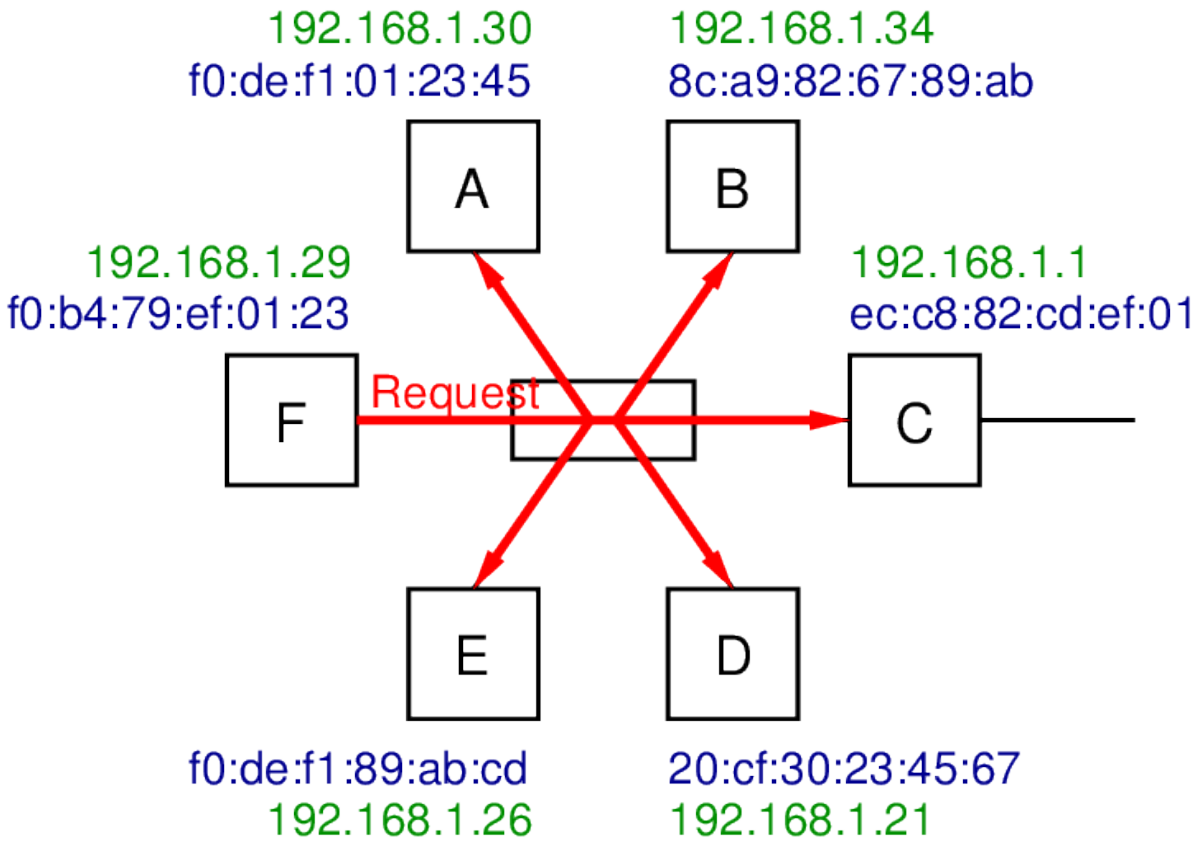
Motivation

- Source S needs to send data to destination IP_{dst}
- Therefore, S needs to know hardware address of destination, i.e. HW_{dst}

Approach

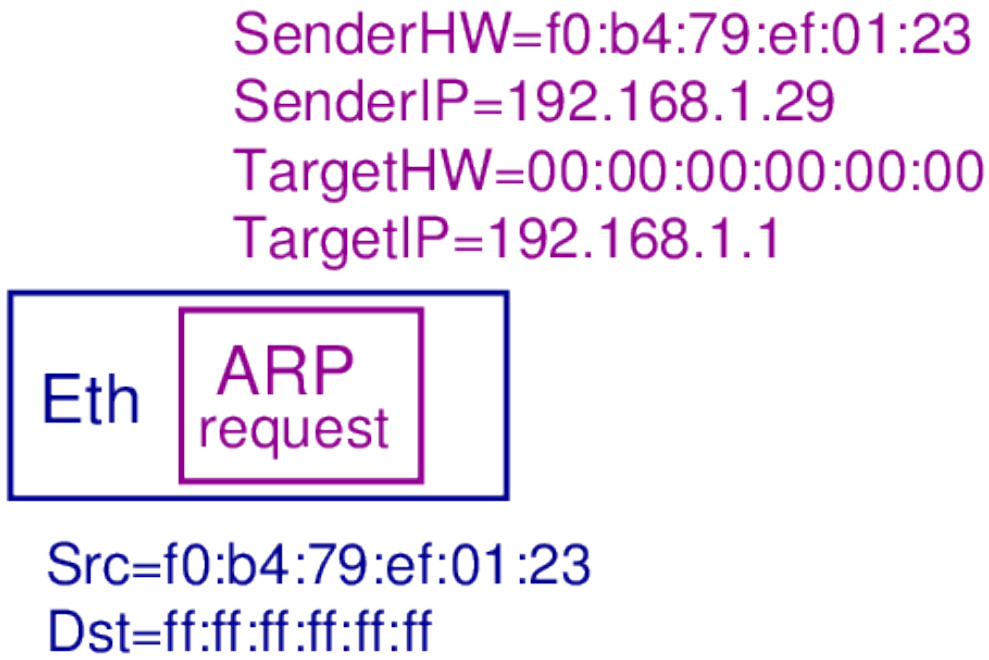
1. S asks all stations on LAN: "*Who has address IP_{dst}?*"
   - Broadcast ARP request packet
   - Sent on-demand
2. Station with address IP_{dst} replies: "*I have IP_{dst} (and my hardware address is HW_{dst})*"
   - Unicast ARP reply packet
   - Cache recent replies in table

Example ARP Request from Station F



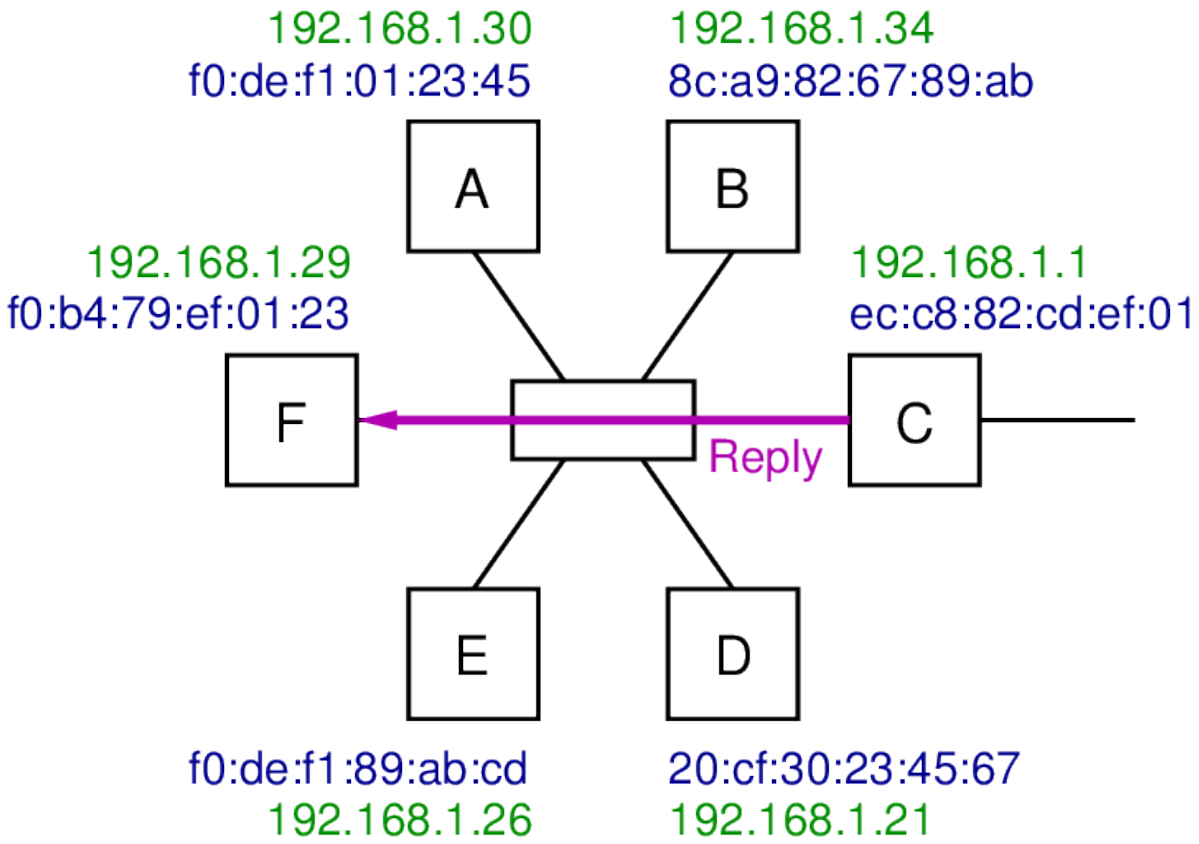
- F knows destination IP 192.168.1.1
- ARP Request broadcast to LAN (switch sends to all other ports)

Example ARP Request from Station F



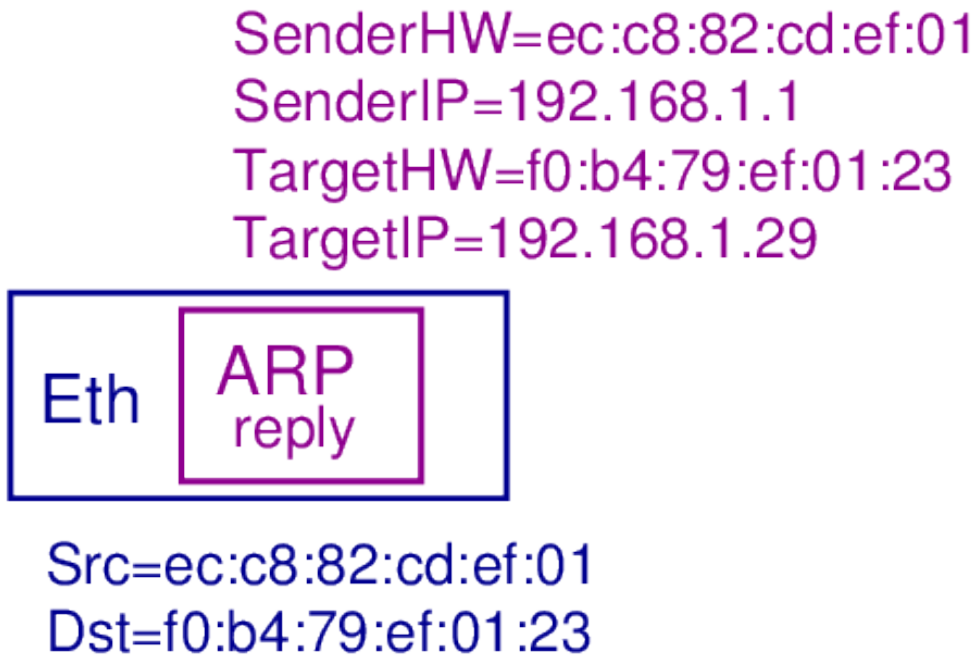
- ff:ff:ff:ff:ff:ff (all binary 1's) is special LAN broadcast address
- 00:00:00:00:00:00 (all binary 0's) is special when address unknown

Example ARP Reply to Station F



- Reply sent only by station that "knows" the request IP address

Example ARP Reply to Station F



- F learns hardware address of 192.168.1.1: ec:c8:82:cd:ef:01
- F can cache the value to avoid ARP Request/Reply in future
- C may also cache hardware address for F

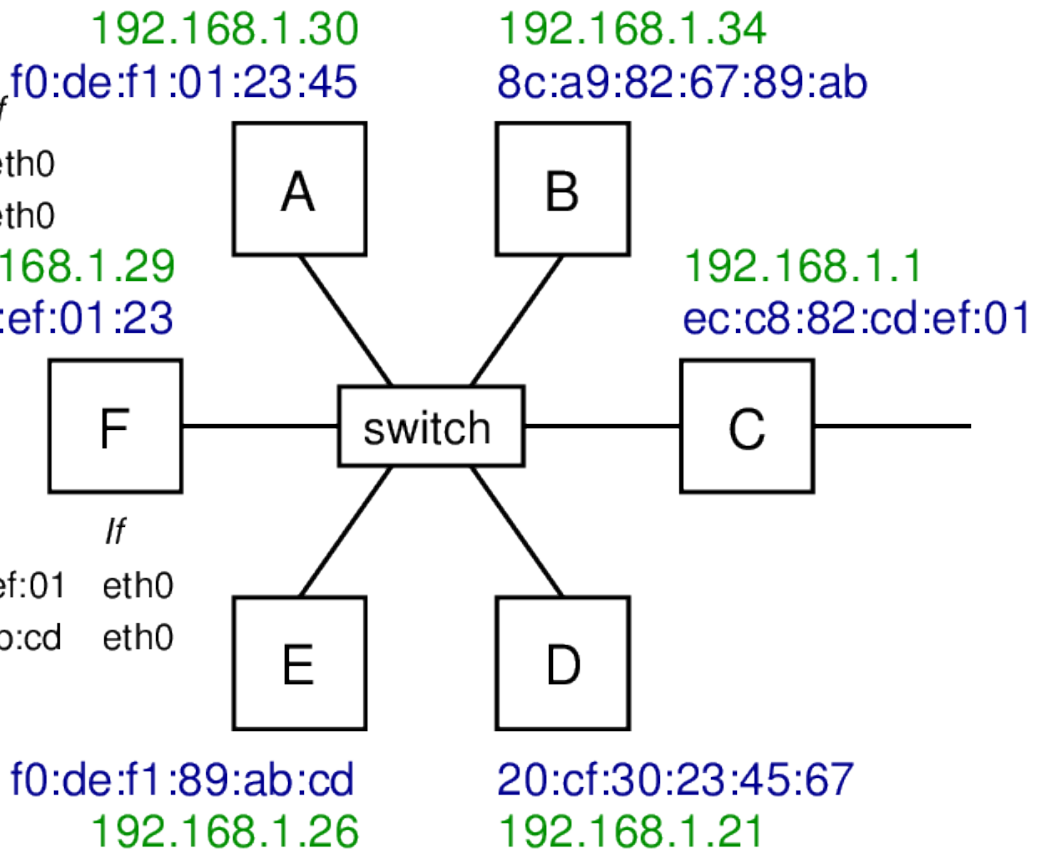
Example Routing Table of Station F

Routing Table of F

Destination	*Next*	*If*
192.168.1.0	direct	eth0
*	192.168.1.1	eth0

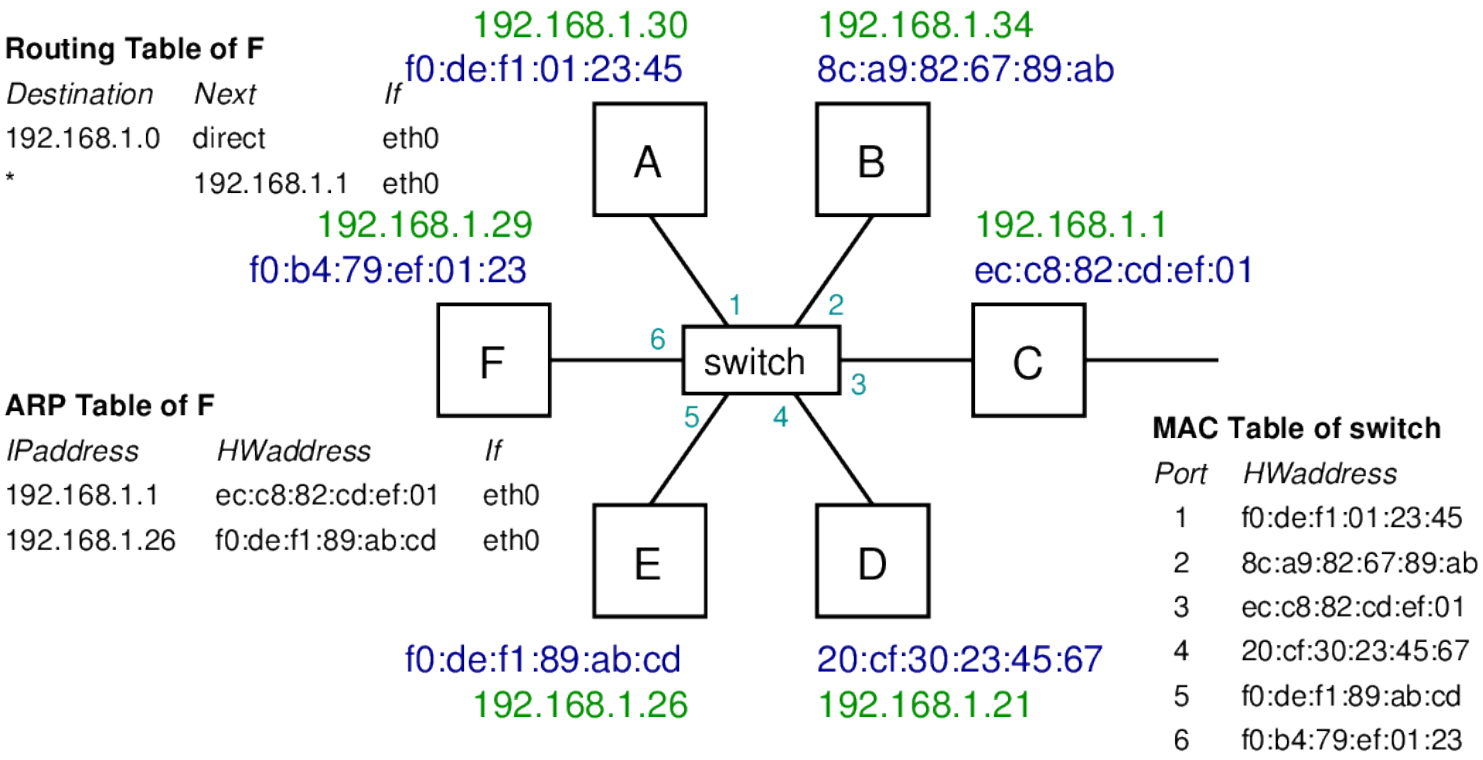
ARP Table of F

IPaddress	*HWaddress*	*If*
192.168.1.1	ec:c8:82:cd:ef:01	eth0
192.168.1.26	f0:de:f1:89:ab:cd	eth0



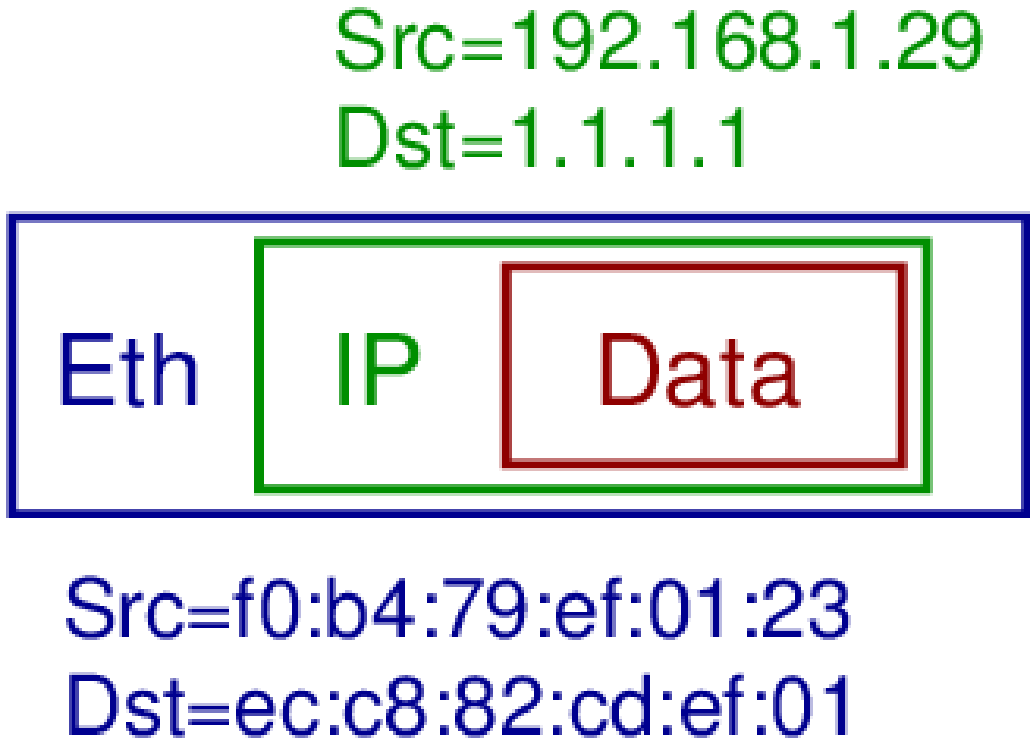
- Stations also have routing table
- Indicates next IP device to send in order to reach some destination

Example Addressing in LAN



1. F: IP datagram with destination 1.1.1.1
2. F: Lookup routing table $\rightarrow$ send to 192.168.1.1
3. F: Lookup ARP table $\rightarrow$ send to ec:c8:82:cd:ef:01
4. Switch: Lookup MAC table $\rightarrow$ send on port 3
5. C: Lookup routing table $\rightarrow$ send on next hop (not shown)

Example IP Datagram from Station F



- F sends the datagram to the router
- Router C will send on next hop (not shown)