

Networking

LANs and ARP

Ethernet

Addressing and
Frames

ARP

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Networking

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Common/Reports/lans-arp.tex, r723

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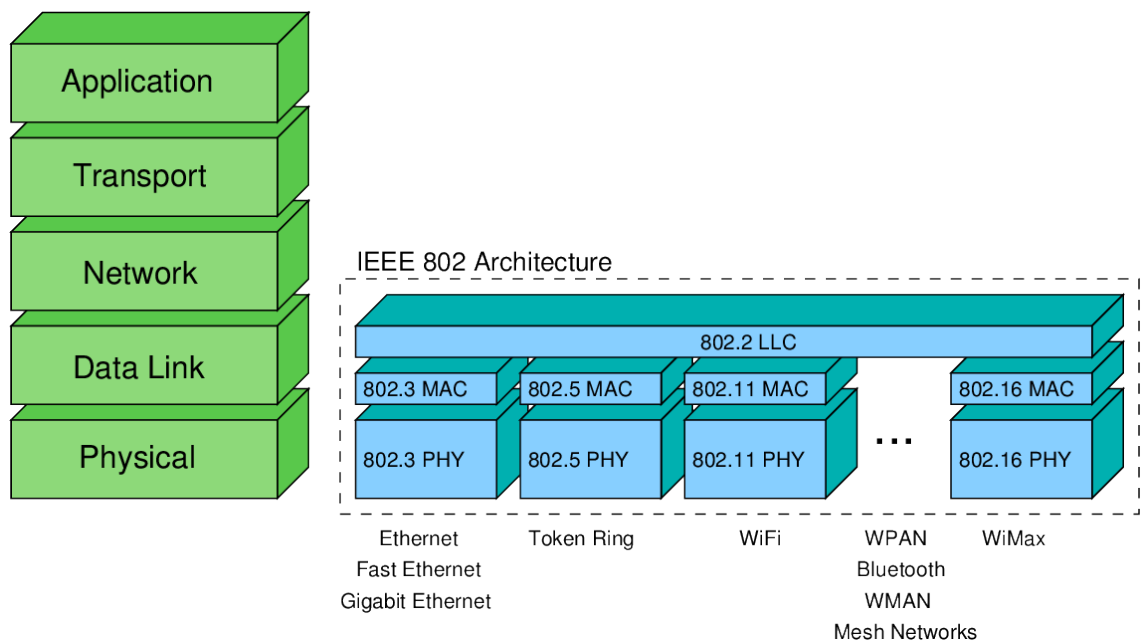
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Ethernet LANs

- ▶ 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

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IEEE 802 Protocol Architecture



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IEEE 802.3 LANs

Physical Layer

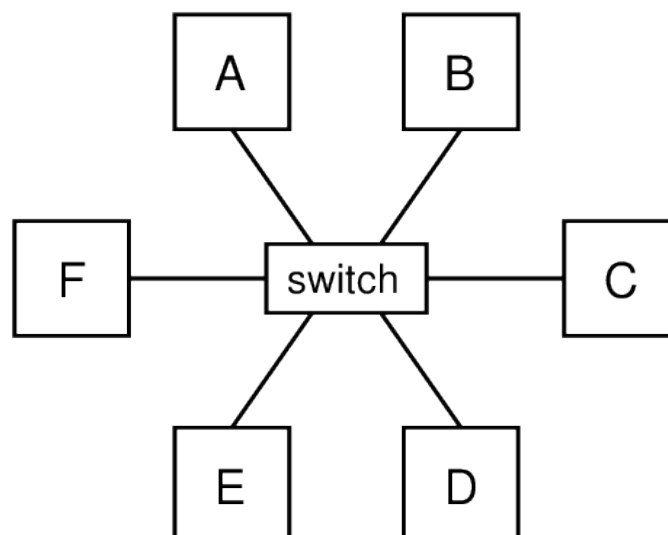
- ▶ Original popular Ethernet: 10 Mb/s, bus topology, coaxial cable, CSMA/CD, half-duplex
- ▶ Fast Ethernet: 100 Mb/s, star (switched) topology, UTP, no MAC, full-duplex
- ▶ Gigabit Ethernet: 1 Gb/s, switched, twisted pair or optical fibre
- ▶ 10-Gigabit Ethernet: between switches, servers
- ▶ 40 Gb/s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

Topology

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

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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

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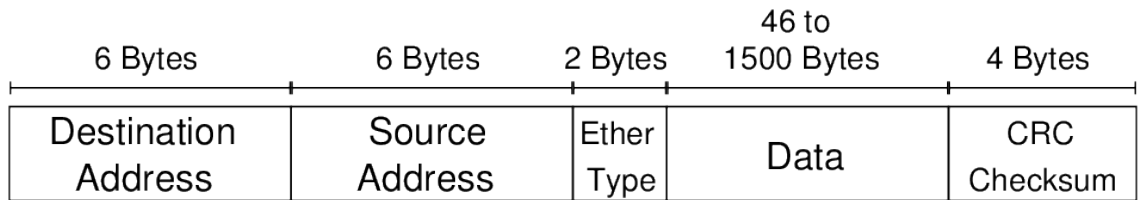
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IEEE 802 Addresses

- ▶ 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

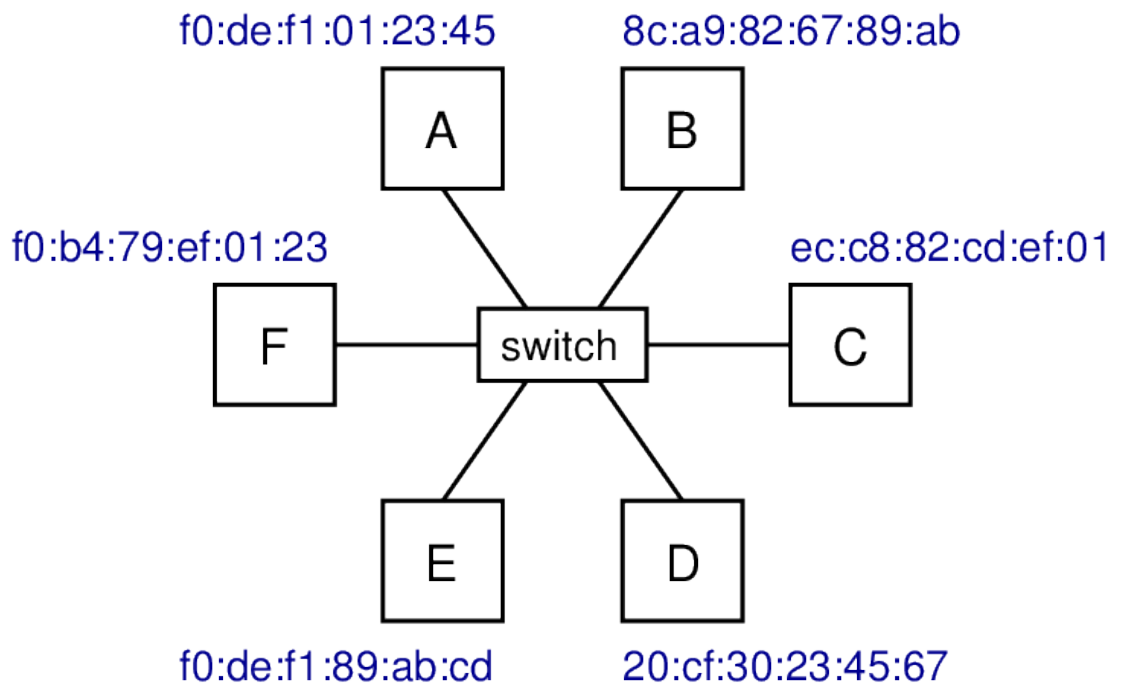
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IEEE 802.3 Frames



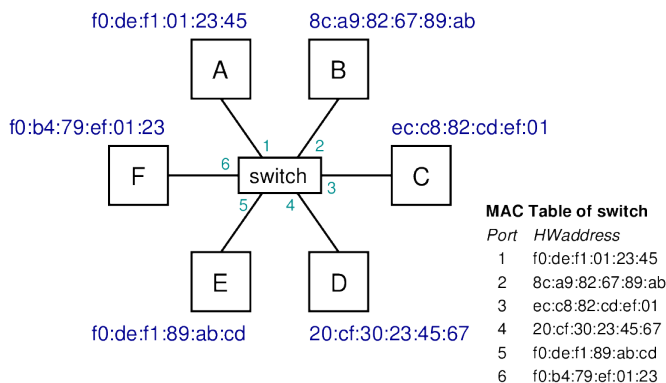
- ▶ Typical maximum data size is 1500 Bytes (optional Jumbo frames)
- ▶ 1st 8 bytes (preamble, delimiter) sometimes considered part of Physical layer

Example Hardware Addresses



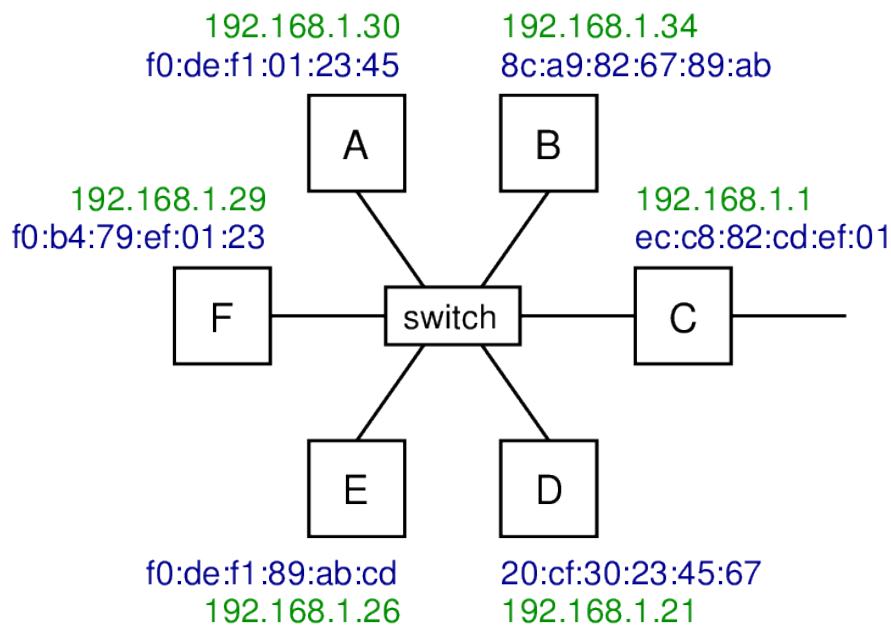
- ▶ Hardware (MAC) addresses are assigned to LAN card by manufacturer
- ▶ Each station (hosts and routers) have address for each network interface card

Example MAC Table used by Switch



- ▶ 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

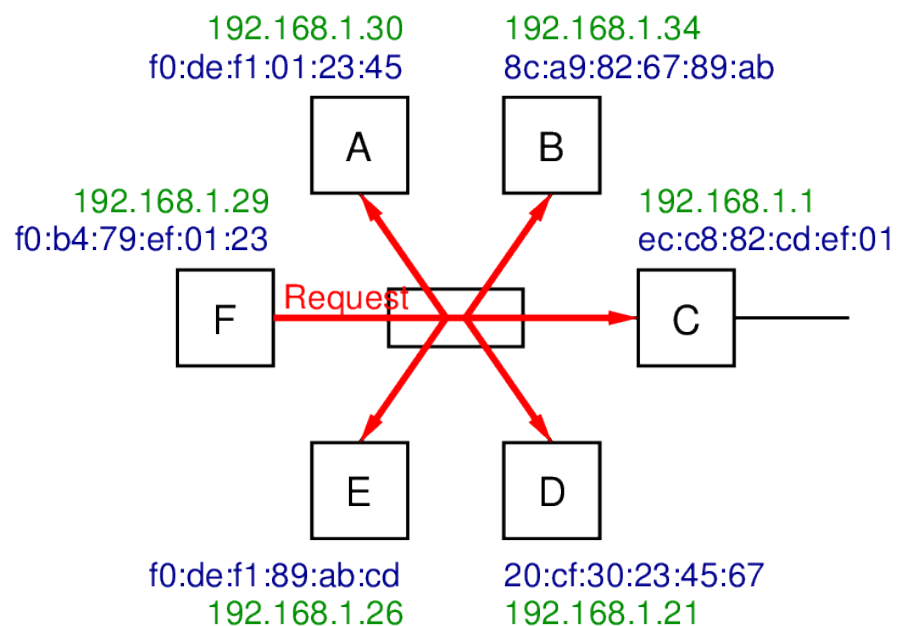
- ▶ Source S needs to send data to destination IP_{dst}
- ▶ Therefore, S needs to know hardware address of destination, i.e. HW_{dst}

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

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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)

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Example ARP Request from Station F

SenderHW=f0:b4:79:ef:01:23
 SenderIP=192.168.1.29
 TargetHW=00:00:00:00:00:00
 TargetIP=192.168.1.1

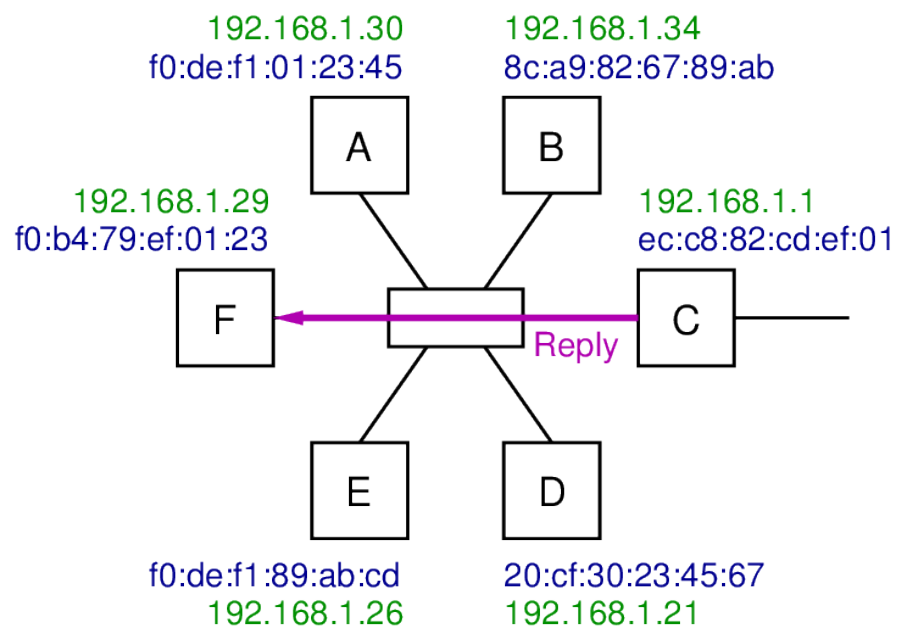


Src=f0:b4:79:ef:01:23
 Dst=ff:ff:ff:ff:ff:ff

- ▶ 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

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Example ARP Reply to Station F



- ▶ Reply sent only by station that “knows” the request IP address

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Example ARP Reply to Station F

SenderHW=ec:c8:82:cd:ef:01
 SenderIP=192.168.1.1
 TargetHW=f0:b4:79:ef:01:23
 TargetIP=192.168.1.29



Src=ec:c8:82:cd:ef:01
 Dst=f0:b4:79:ef:01:23

- ▶ 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

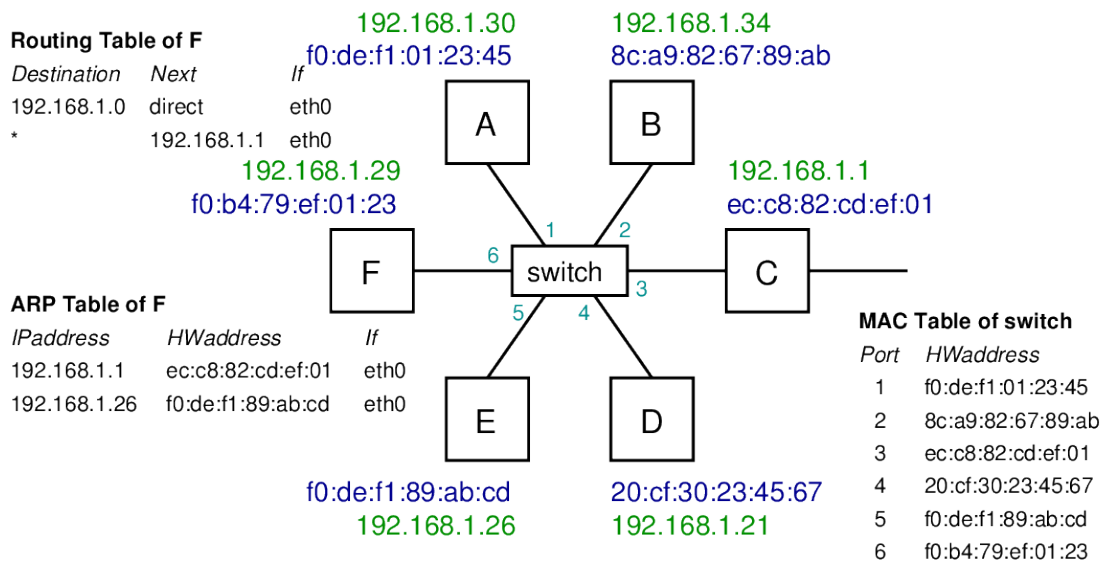
Example Routing Table of Station F

Destination	Next	If
192.168.1.0	direct	eth0
*	192.168.1.1	eth0

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

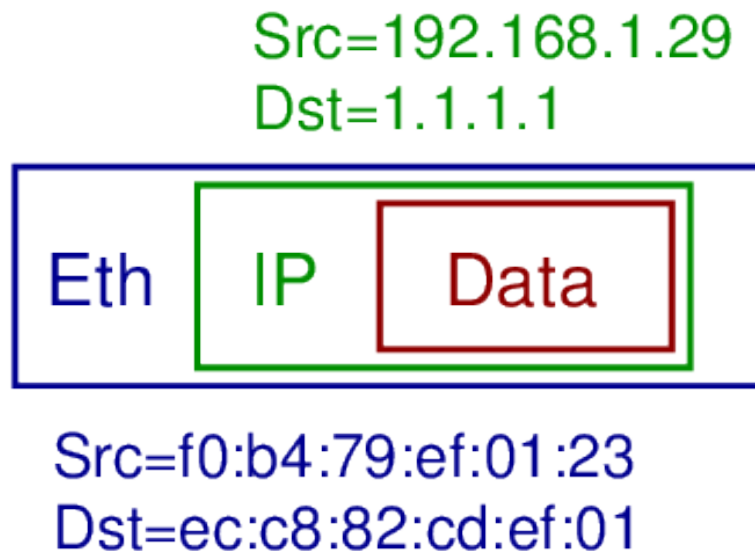
Example Addressing in LAN



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

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Example IP Datagram from Station F



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

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