

No bags on table,
chair, floor, etc.

All bags on the racks,
please!

COMPUTER NETWORKS LAB (CS315)

Assignment-11

Ethernet and ARP

Date: 21 March 2023



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MAC addresses

- 32-bit IP address:
 - *network-layer* address for interface
 - used for layer 3 (network layer) forwarding
 - e.g.: 128.119.40.136
- MAC (or LAN or physical or Ethernet) address:
 - function: used “locally” to get frame from one interface to another physically-connected interface (same subnet, in IP-addressing sense)
 - 48-bit MAC address (for most LANs) burned in NIC ROM, also sometimes software settable
 - e.g.: 1A-2F-BB-76-09-AD
 - hexadecimal (base 16) notation
(each “numeral” represents 4 bits)

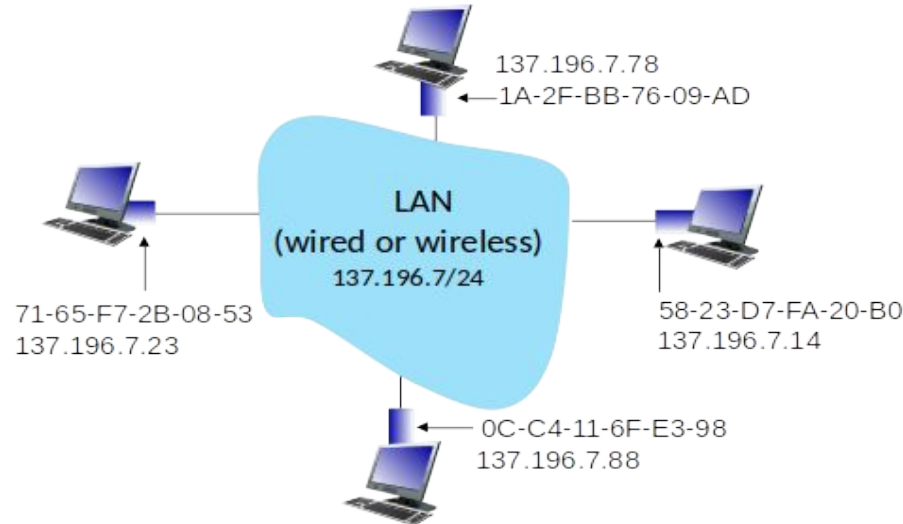
Link Layer: 6-<number>



MAC addresses

each interface on LAN

- has unique 48-bit **MAC** address
- has a locally unique 32-bit IP address (as we've seen)



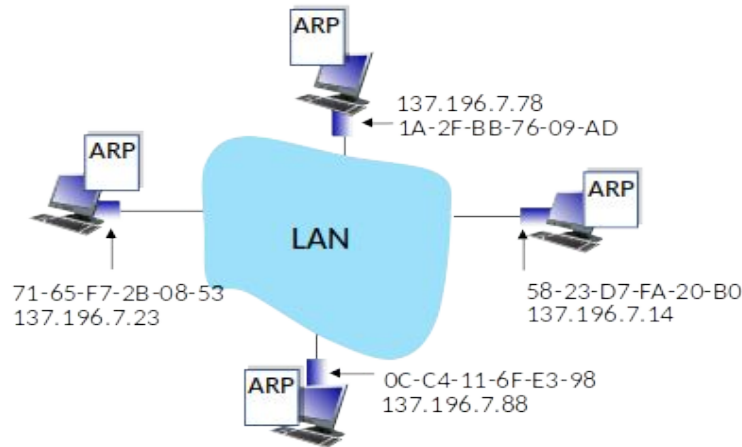
Link Layer: 6-<number>

MAC addresses

- MAC address allocation administered by IEEE
- manufacturer buys portion of MAC address space (to assure uniqueness)
- analogy:
 - MAC address: like Social Security Number
 - IP address: like postal address
- MAC flat address: portability
 - can move interface from one LAN to another
 - recall IP address *not* portable: depends on IP subnet to which node is attached

ARP: address resolution protocol

Question: how to determine interface's MAC address, knowing its IP address?



ARP table: each IP node (host, router) on LAN has table

- IP/MAC address mappings for some LAN nodes:
< IP address; MAC address; TTL >
- TTL (Time To Live): time after which address mapping will be forgotten (typically 20 min)

ARP protocol in action

example: A wants to send datagram to B

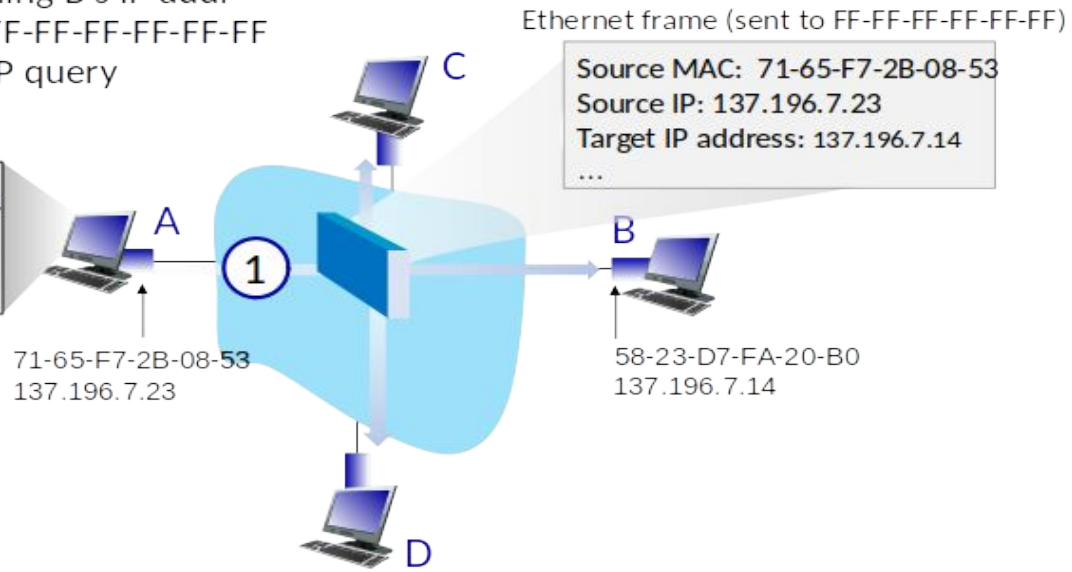
- B's MAC address not in A's ARP table, so A uses ARP to find B's MAC address

A broadcasts ARP query, containing B's IP addr

- ①
- destination MAC address = FF-FF-FF-FF-FF-FF
 - all nodes on LAN receive ARP query

ARP table in A

IP addr	MAC addr	TTL

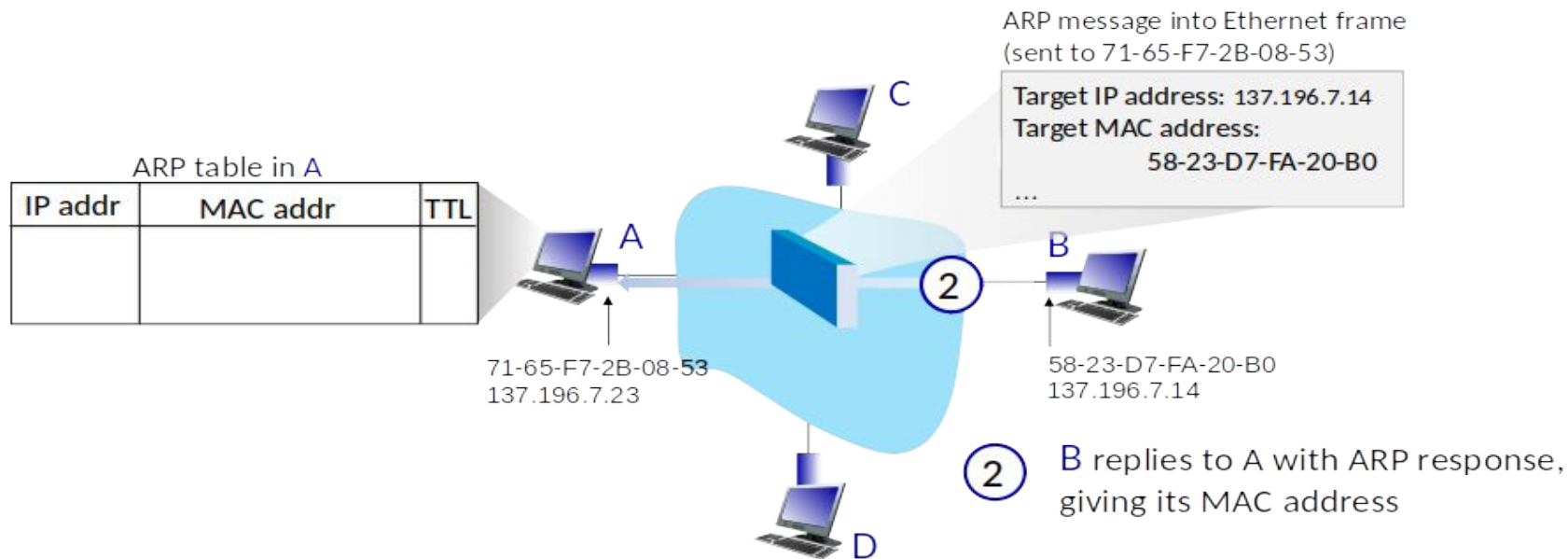


Link Layer: 6-<number>

ARP protocol in action

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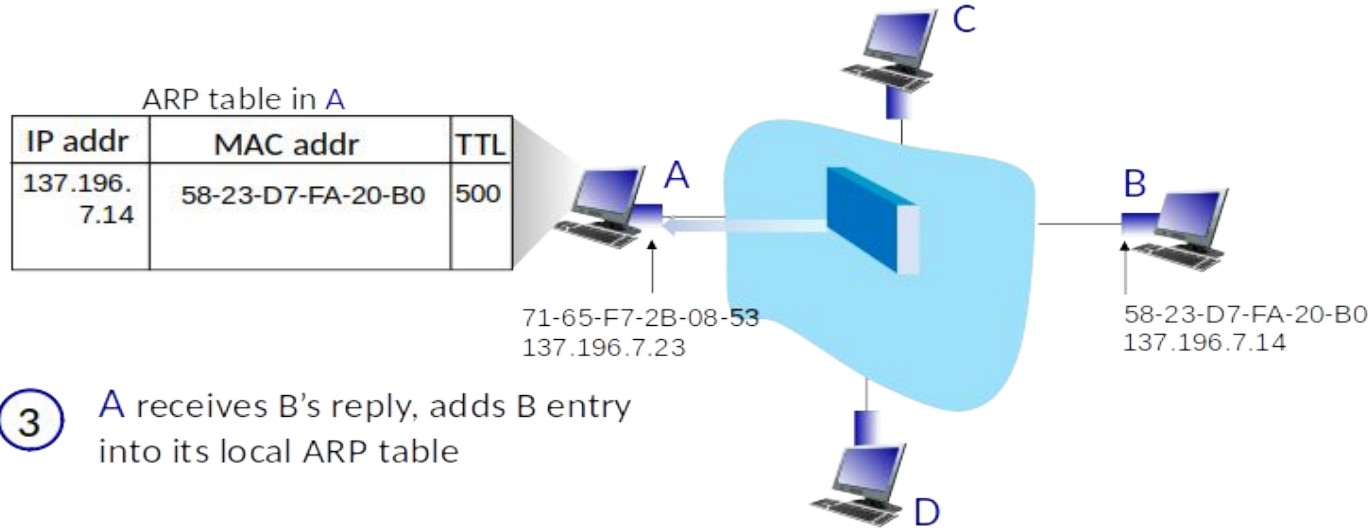


Link Layer: 6-<number>

ARP protocol in action

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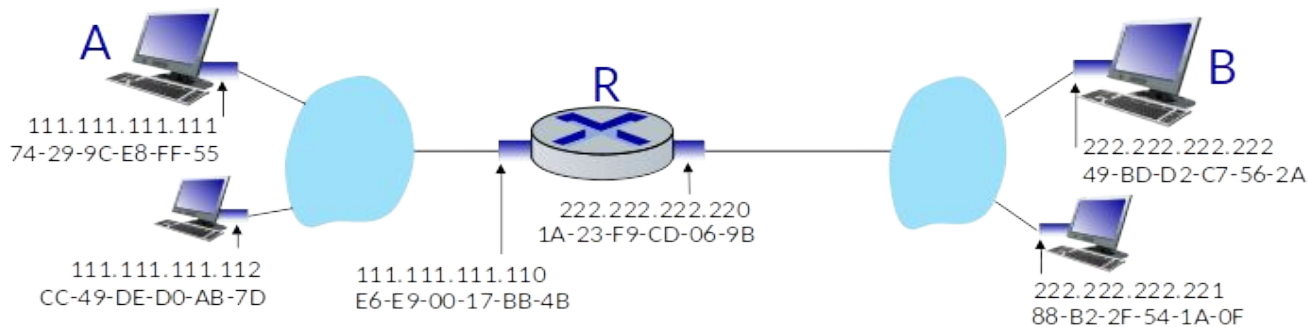


Link Layer: 6-<number>

Routing to another subnet: addressing

walkthrough: sending a datagram from A to B via R

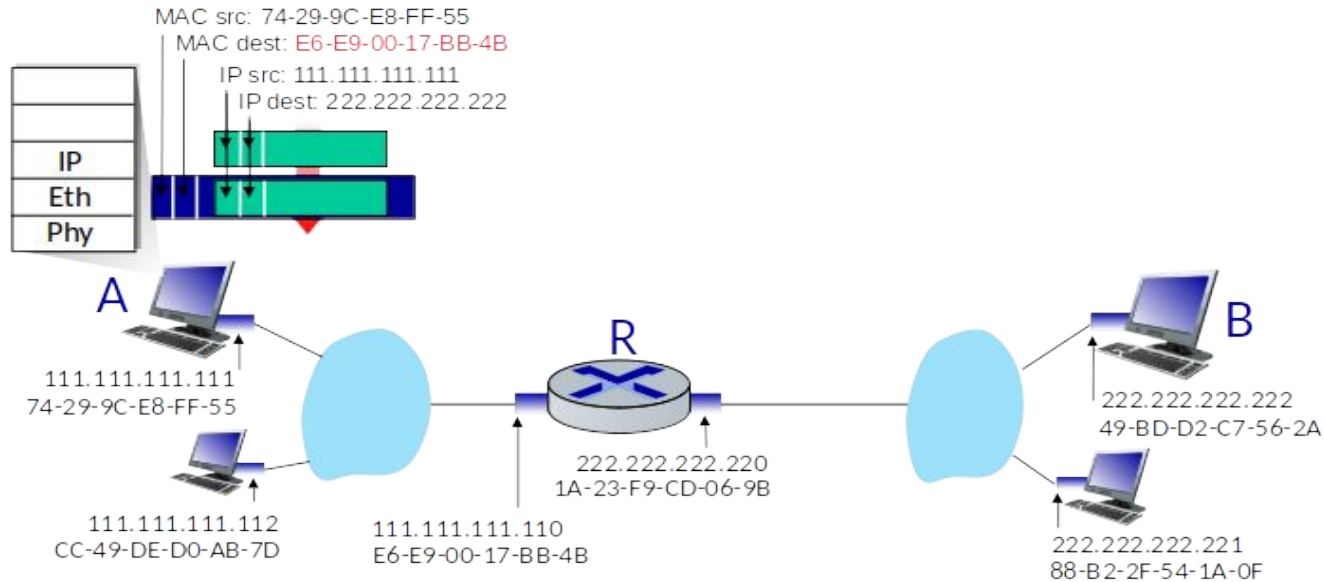
- focus on addressing – at IP (datagram) and MAC layer (frame) levels
- assume that:
 - A knows B's IP address
 - A knows IP address of first hop router, R (how?)
 - A knows R's MAC address (how?)



Link Layer: 6-<number>

Routing to another subnet: addressing

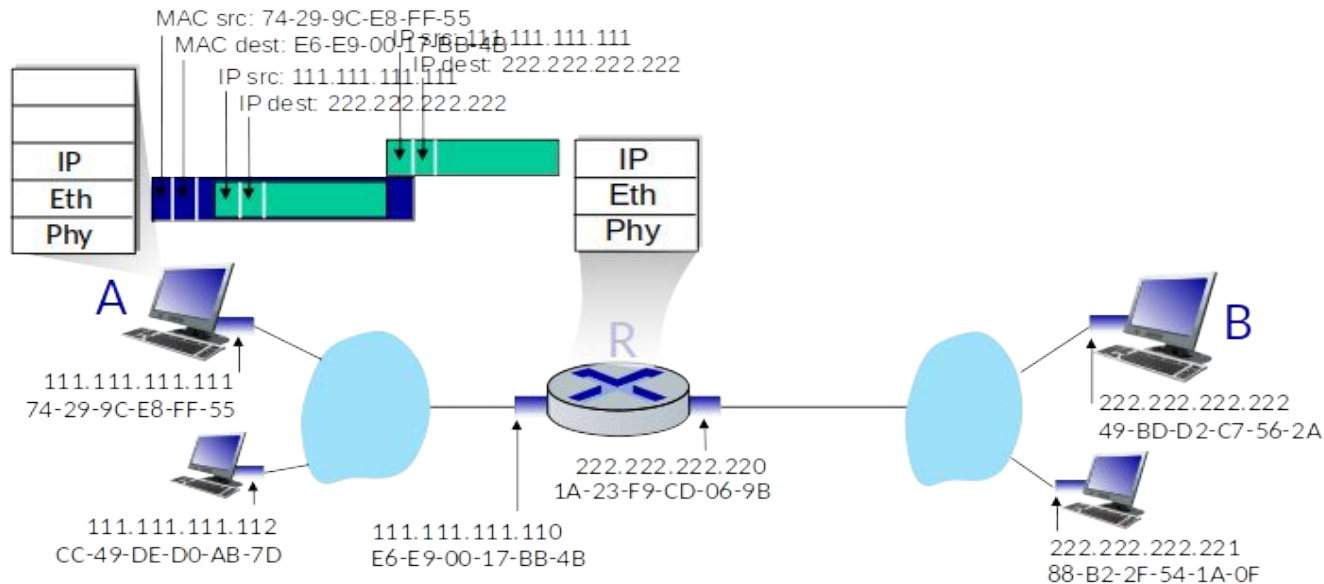
- A creates IP datagram with IP source A, destination B
- A creates link-layer frame containing A-to-B IP datagram
 - R's MAC address is frame's destination



Link Layer: 6-<number>

Routing to another subnet: addressing

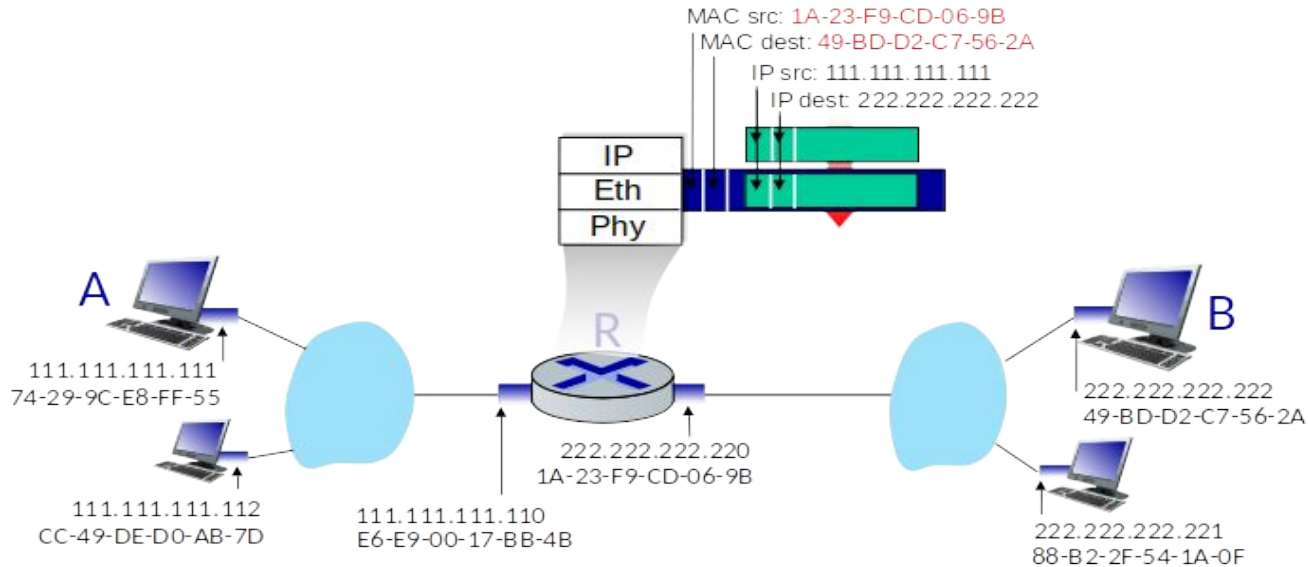
- frame sent from A to R
- frame received at R, datagram removed, passed up to IP



Link Layer: 6-<number>

Routing to another subnet: addressing

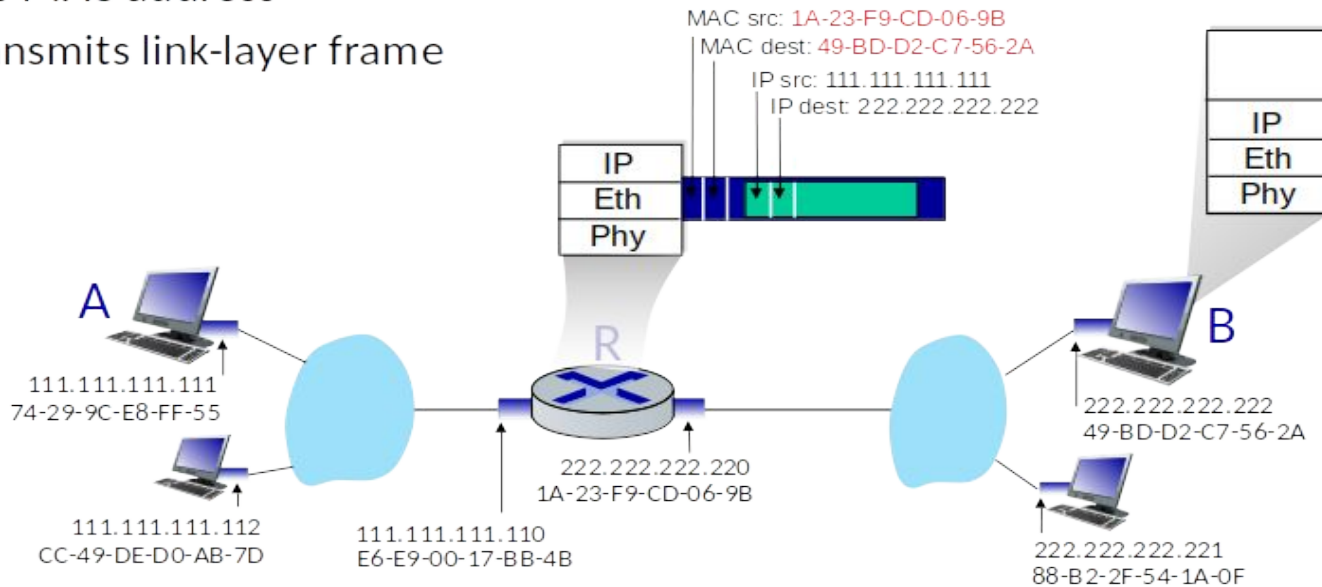
- R determines outgoing interface, passes datagram with IP source A, destination B to link layer
- R creates link-layer frame containing A-to-B IP datagram. Frame destination address: B's MAC address



Link Layer: 6-<number>

Routing to another subnet: addressing

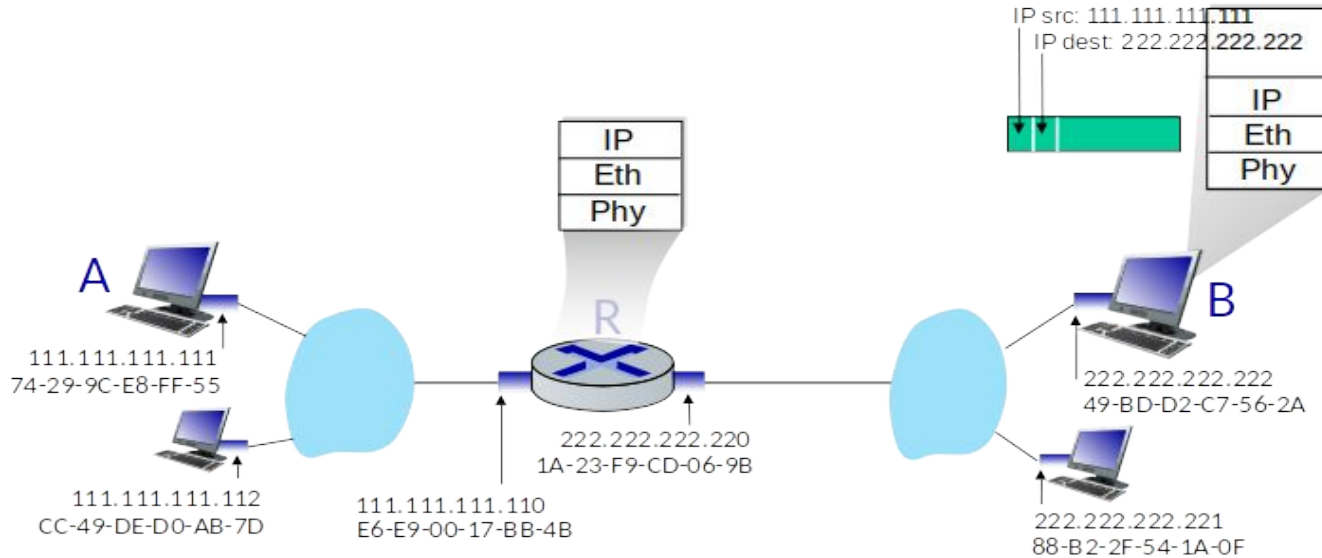
- R determines outgoing interface, passes datagram with IP source A, destination B to link layer
- R creates link-layer frame containing A-to-B IP datagram. Frame destination address: B's MAC address
- transmits link-layer frame



Link Layer: 6-<number>

Routing to another subnet: addressing

- B receives frame, extracts IP datagram destination B
- B passes datagram up protocol stack to IP

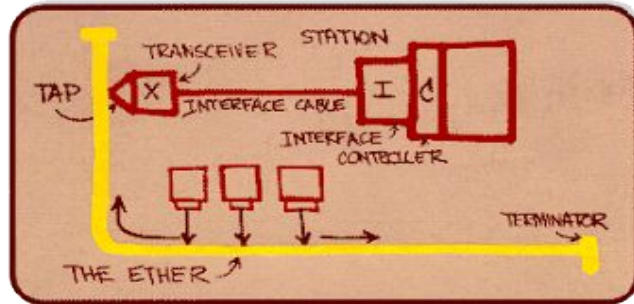


Link Layer: 6-<number>

Ethernet

“dominant” wired LAN technology:

- first widely used LAN technology
- simpler, cheap
- kept up with speed race: 10 Mbps – 400 Gbps
- single chip, multiple speeds (e.g., Broadcom BCM5761)



Metcalfe's Ethernet sketch

<https://www.uspto.gov/learning-and-resources/journeys-innovation/audio-stories/defying-doubters>

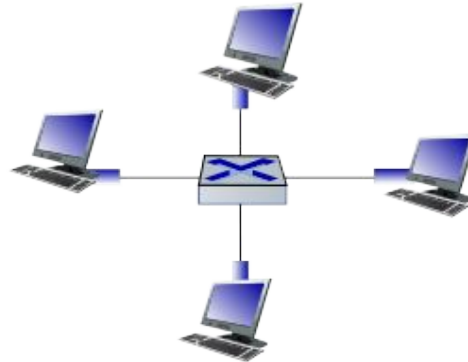
Link Layer: 6-<number>



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: coaxial cable



switched

Link Layer: 6-<number>

Ethernet frame structure

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

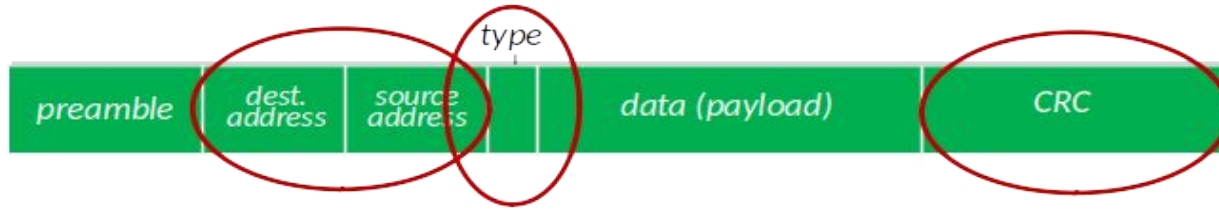


preamble:

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

Link Layer: 6-<number>

Ethernet frame structure (more)



- **addresses:** 6 byte source, destination MAC addresses
 - if adapter receives frame with matching destination address, or with broadcast address (e.g., ARP packet), 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

Link Layer: 6-<number>

Ethernet: unreliable, connectionless

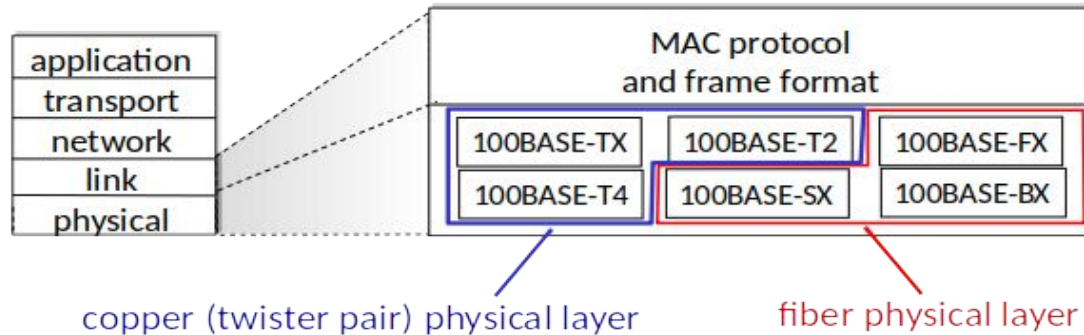
- **connectionless**: no handshaking between sending and receiving NICs
- **unreliable**: receiving NIC doesn't send ACKs or NAKs to sending NIC
 - data in dropped frames recovered only if initial sender uses higher layer rdt (e.g., TCP), otherwise dropped data lost
- Ethernet's MAC protocol: unslotted **CSMA/CD with binary backoff**

Link Layer: 6-<number>



802.3 Ethernet standards: link & physical layers

- *many* different Ethernet standards
 - common MAC protocol and frame format
 - different speeds: 2 Mbps, 10 Mbps, 100 Mbps, 1Gbps, 10 Gbps, 40 Gbps
 - different physical layer media: fiber, cable



Link Layer: 6-<number>

Thank you