# MAC (Physical, or LAN) Addresses

- used to get frames from one interface to another physically-connected interface (same physical network, i.e., p2p or LAN)
- 48 bit MAC address (for most LANs)
  - fixed for each adaptor, burned in the adapter ROM
  - MAC address allocation administered by IEEE
    - 1st bit: 0 unicast, 1 multicast.
    - all 1's : broadcast
- MAC flat address -> portability
  - can move LAN card from one LAN to another
- MAC addressing operations on a LAN:
  - each adaptor on the LAN "sees" all frames
  - accept a frame if dest. MAC address matches its own MAC address
  - accept all broadcast (MAC= all1's) frames
  - accept all frames if set in "promiscuous" mode
  - can configure to accept certain multicast addresses (first bit = 1)

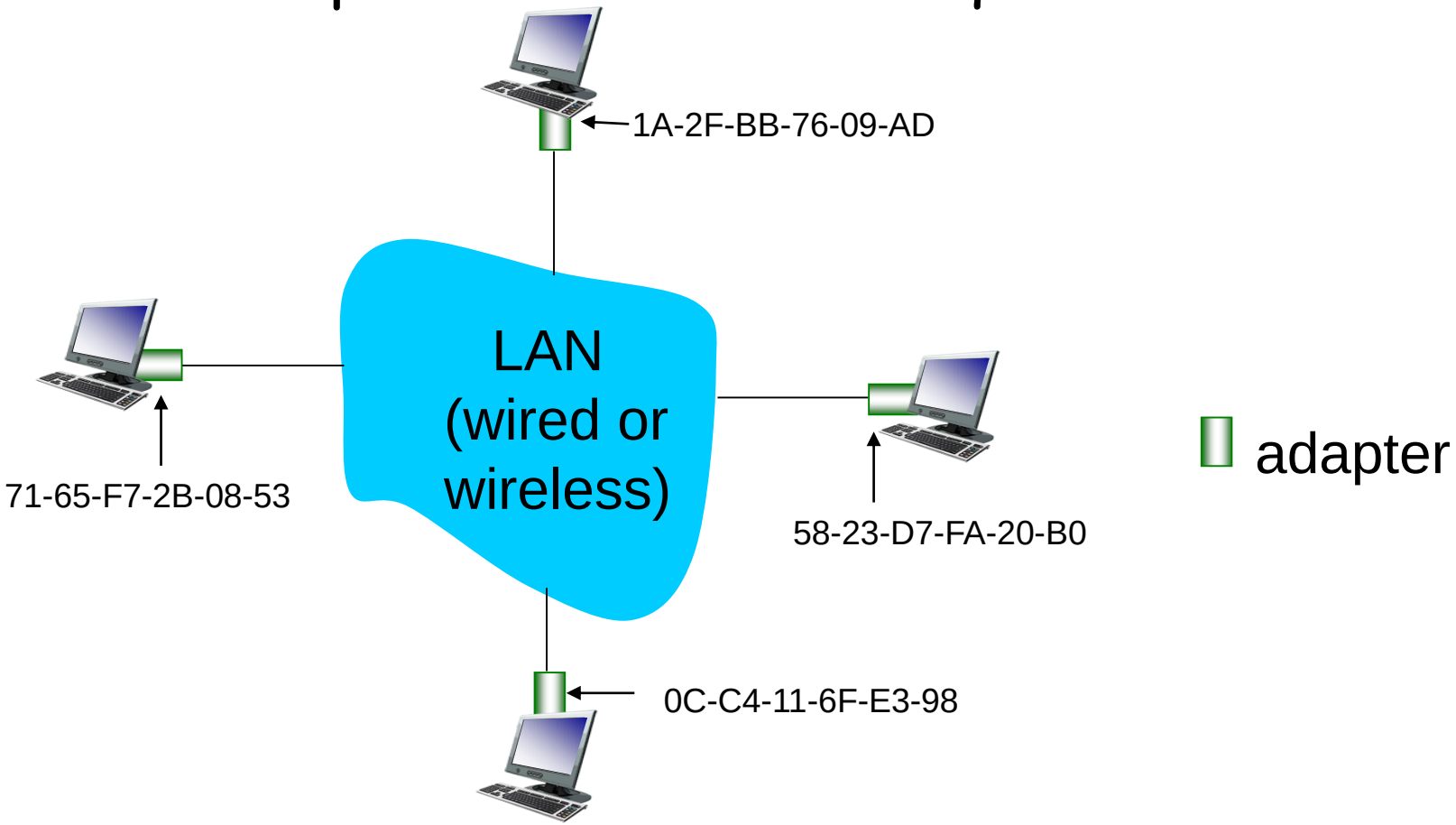
# MAC vs. IP Addresses

32-bit IP address:

- *network-layer* address, logical
  - i.e., not bound to any physical device, can be re-assigned
- IP hierarchical address NOT portable
  - depends on IP network to which an interface is attached
  - when move to another IP network, IP address re-assigned
- used to get IP packets to destination IP network
  - Recall how IP datagram forwarding is performed
- IP network is "virtual," actually packet delivery done by the underlying physical networks
  - from source host to destination host, hop-by-hop via IP routers
  - over each link, different link layer protocol used, with its own frame headers, and source and destination MAC addresses
    - Underlying physical networks do not understand IP protocol and datagram format!

# LAN Addresses and ARP

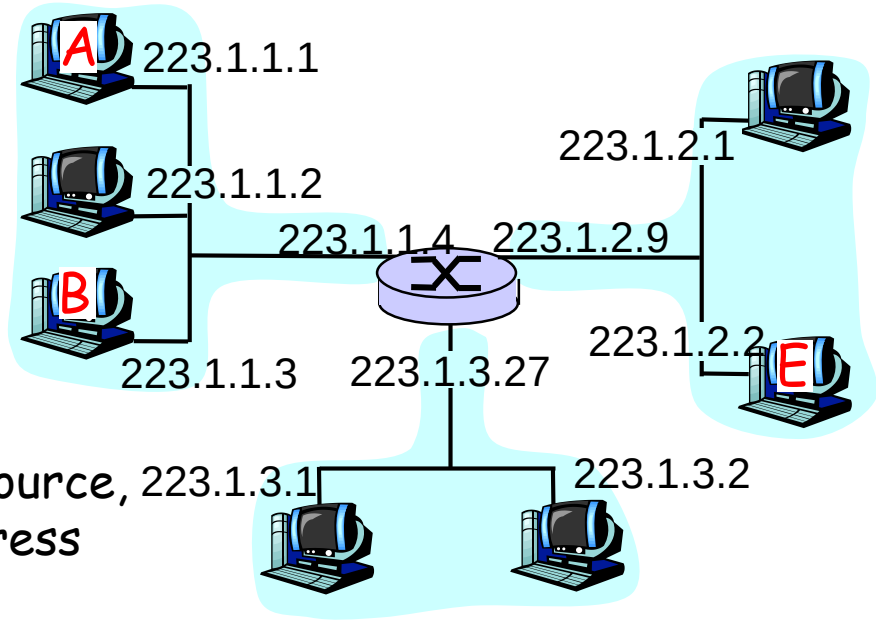
each adapter on LAN has unique *LAN* address

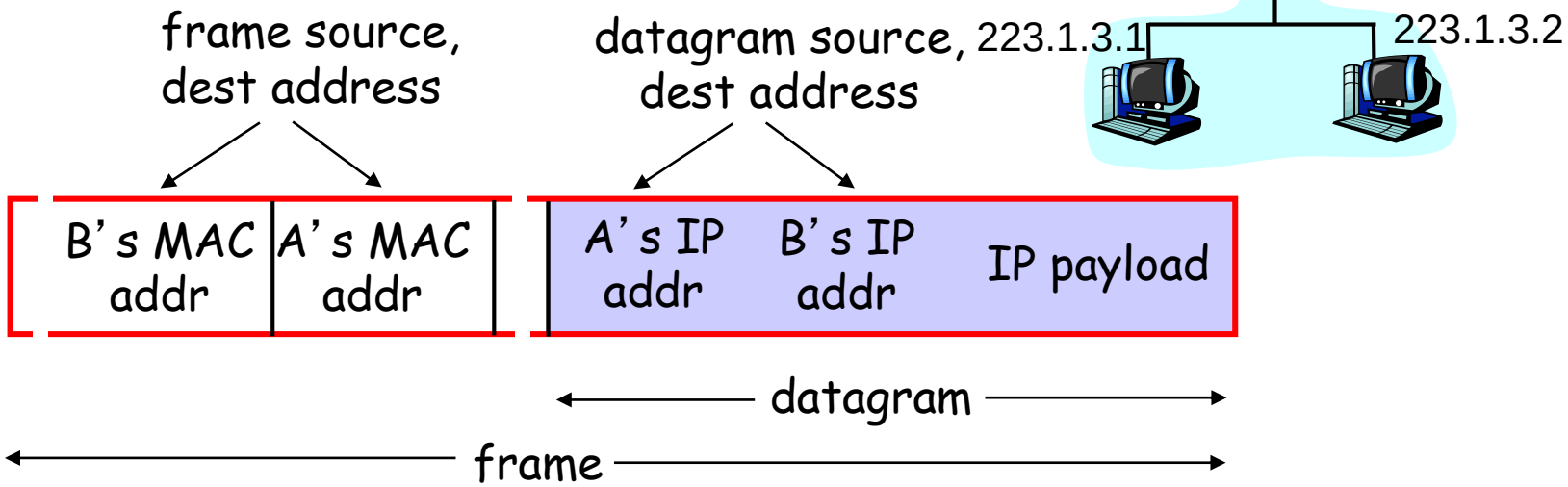


# Recall: IP Datagram Forwarding

Starting at A, given IP datagram addressed to B:

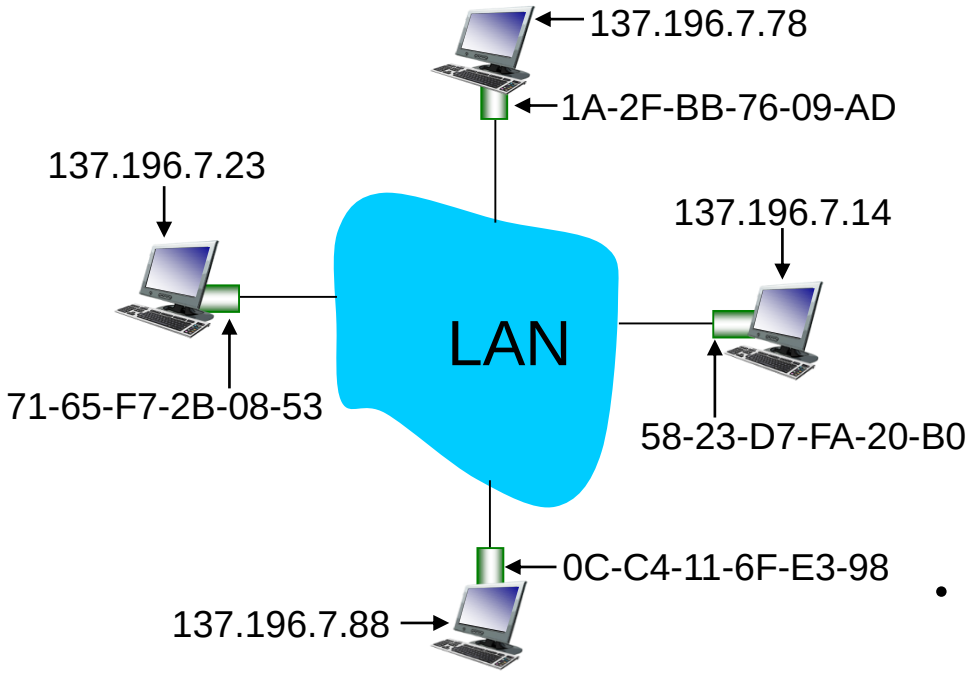
- look up net. address of B, find B on same net. as A
- link layer send datagram to B inside link-layer frame



# ARP: Address Resolution Protocol

Question: how to determine MAC address of B knowing B's IP address?




- Each IP node (host, router) on LAN has ARP table
- ARP Table: IP/MAC address mappings for some LAN nodes

< IP address; MAC address; timer>

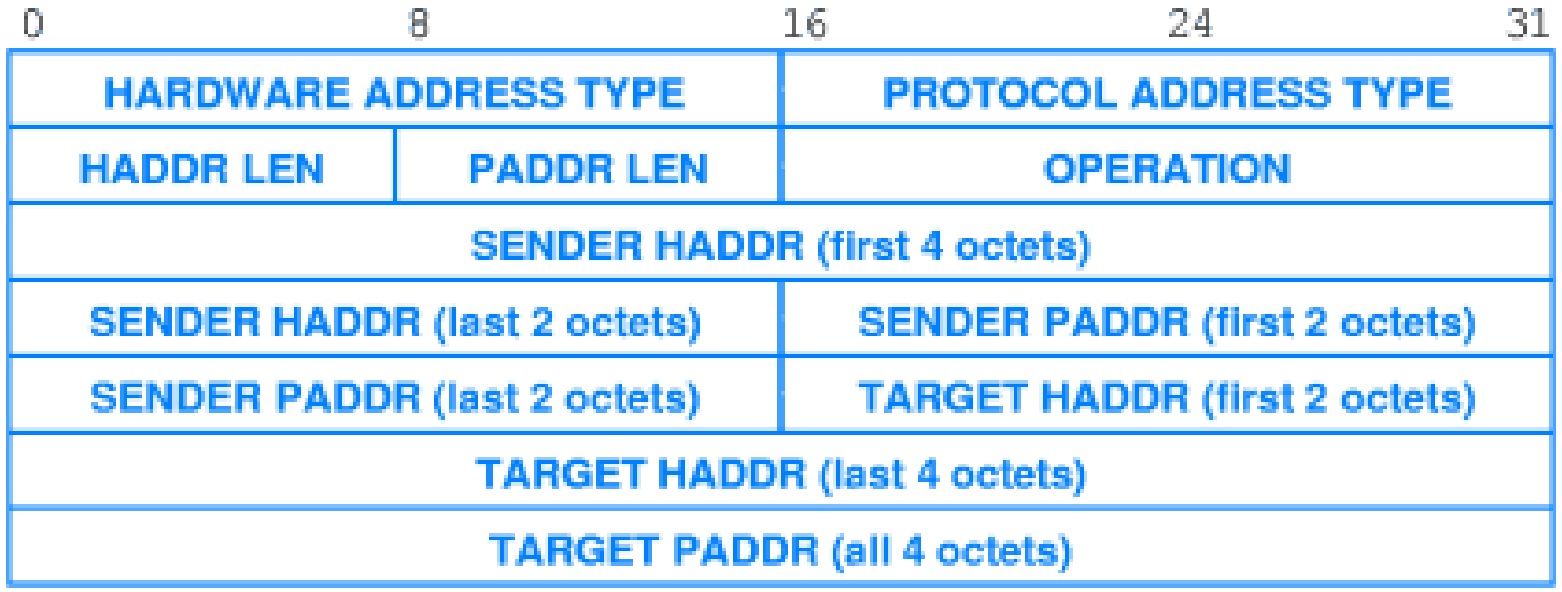
  - timer: time after which address mapping will be forgotten (typically 20 min)

- try out "arp -a" command

# ARP Protocol

- A wants to send datagram to B, and A knows B's IP address.
- A looks up B's MAC address in its ARP table
- Suppose B's MAC address is not in A's ARP table.
- A broadcasts (why?) ARP query packet, containing B's IP address
  - destination MAC address = FF-FF-FF-FF-FF-FF
  - all machines on LAN receive ARP query
- B receives ARP packet, replies to A with its (B's) MAC address
  - frame sent to A's MAC address (unicast)
- A caches (saves) IP-to-MAC address pair in its ARP table until information becomes old (times out)
  - soft state: information that times out (goes away) unless refreshed
- ARP is "plug-and-play":
  - nodes create their ARP tables without intervention from net administrator

# ARP Messages

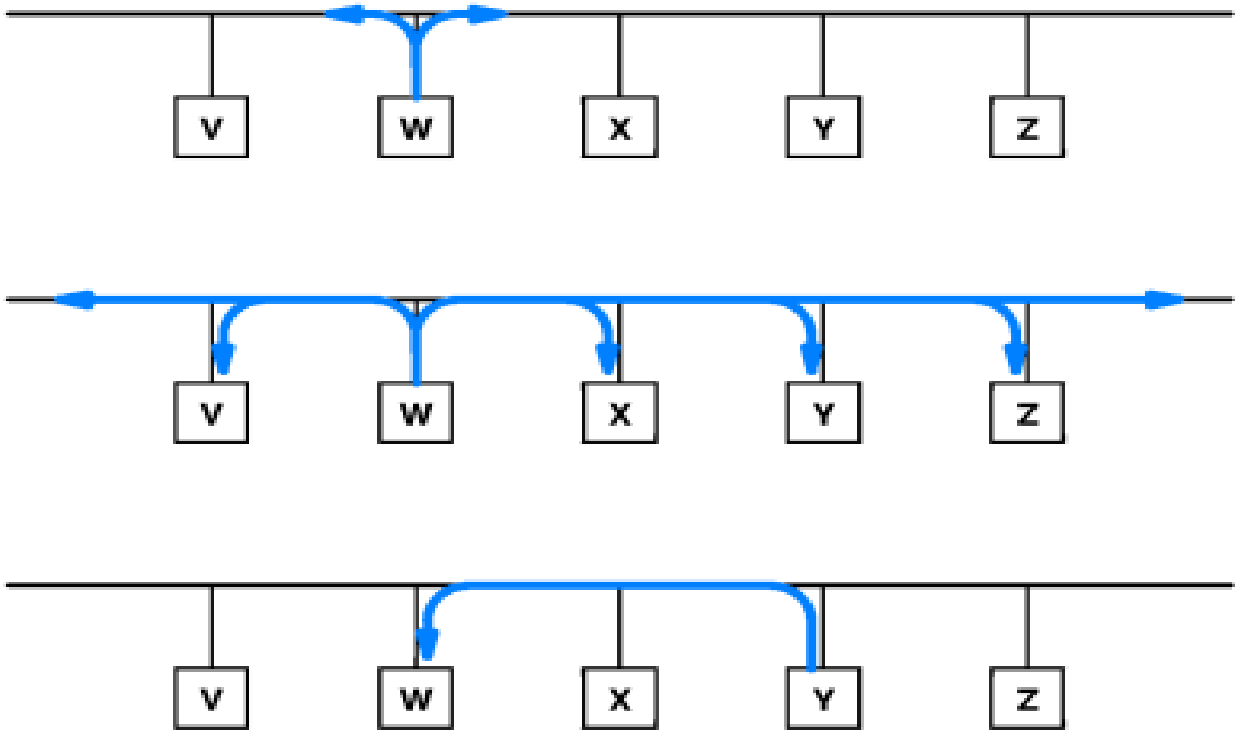



Hardware Address Type: e.g., Ethernet
Protocol address Type: e.g., IP
Operation: ARP request or ARP response

# ARP Request & Response Processing

- The requester *broadcasts* ARP request
- The target node *unicasts* (why?) ARP reply to requester
  - With its physical address
  - Adds the requester into its ARP table (why?)
- On receiving the response, requester
  - updates its table, sets timer
- Other nodes upon receiving the ARP request
  - Refresh the requester entry if already there
  - No action otherwise
- Some questions to think about:
  - Shall requester buffer IP datagram while performing ARP?
  - What shall requester do if never receive any ARP response?

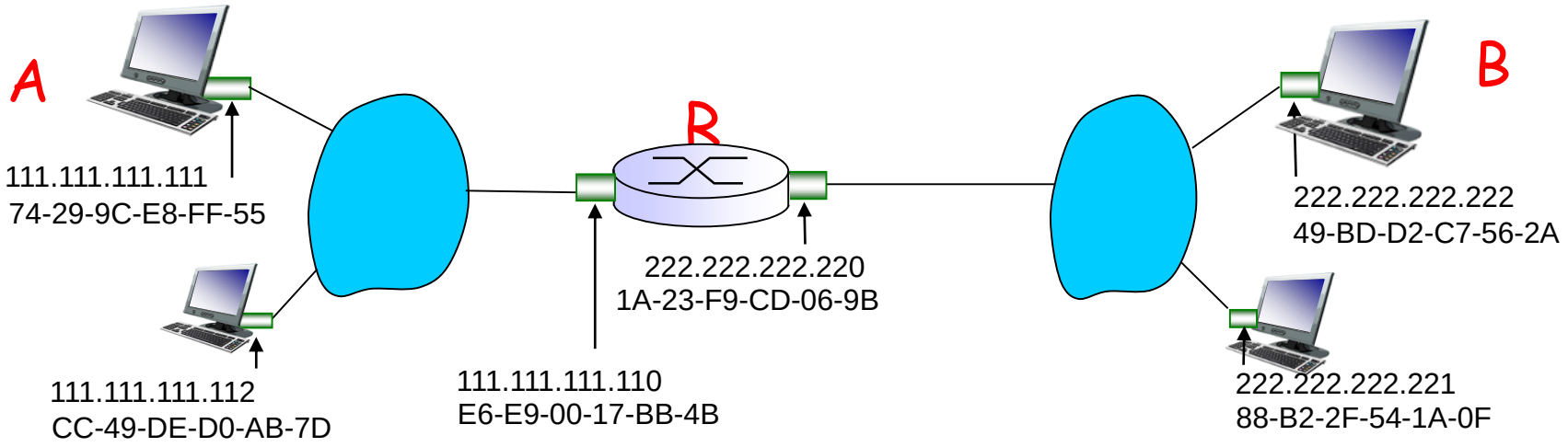
# ARP Operation Illustration



# Forwarding to Another LAN

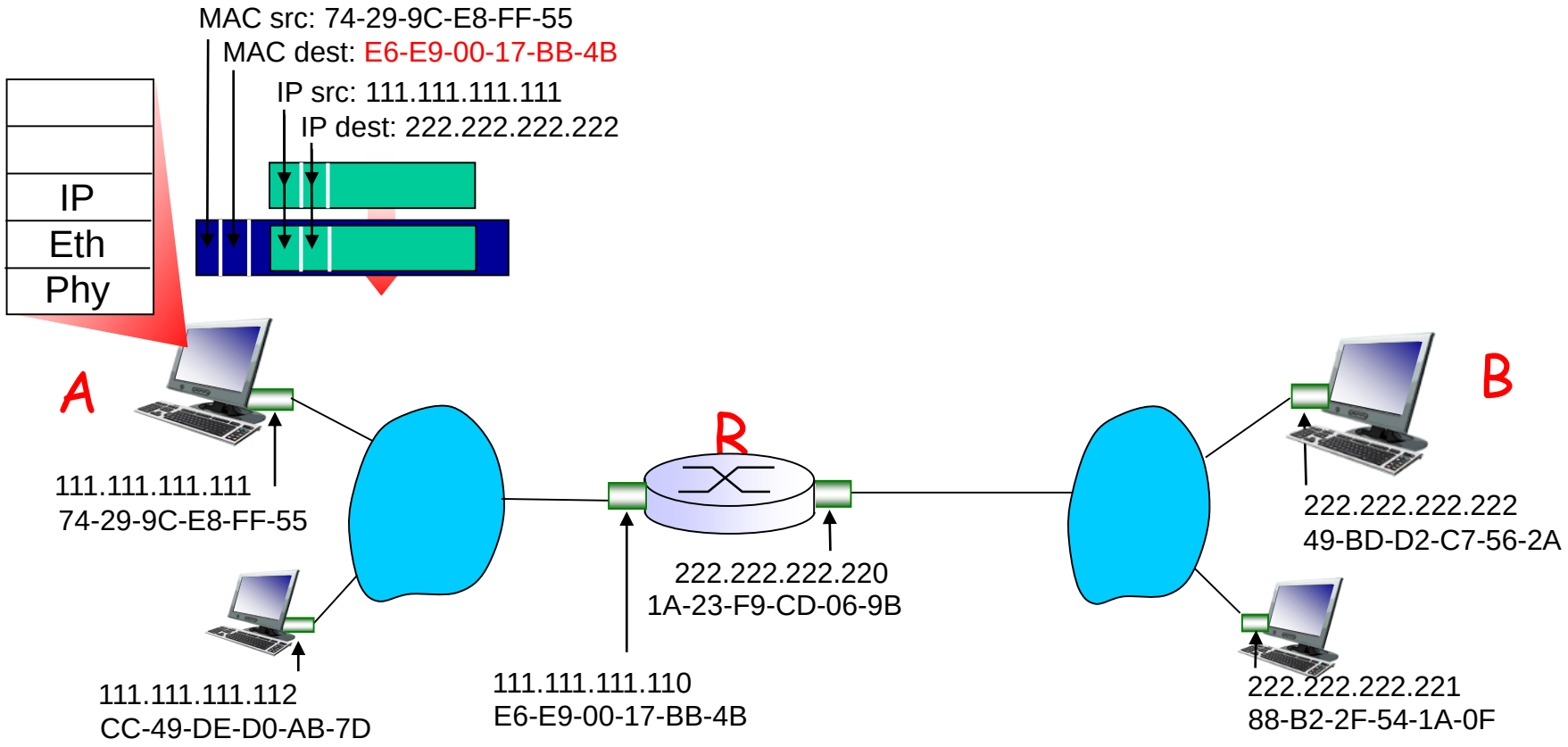
walkthrough: send datagram from A to B via R

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



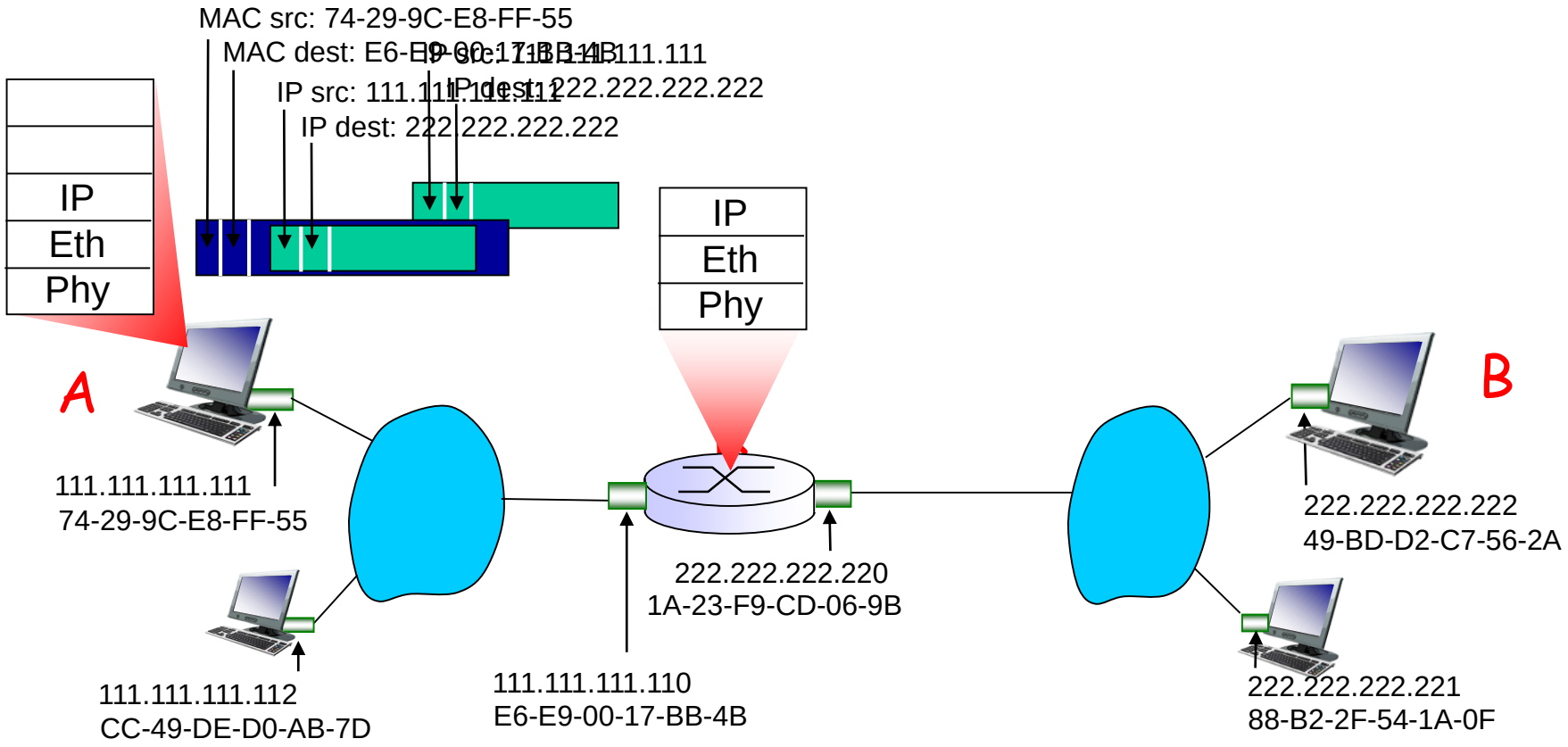
# Forwarding to Another LAN

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



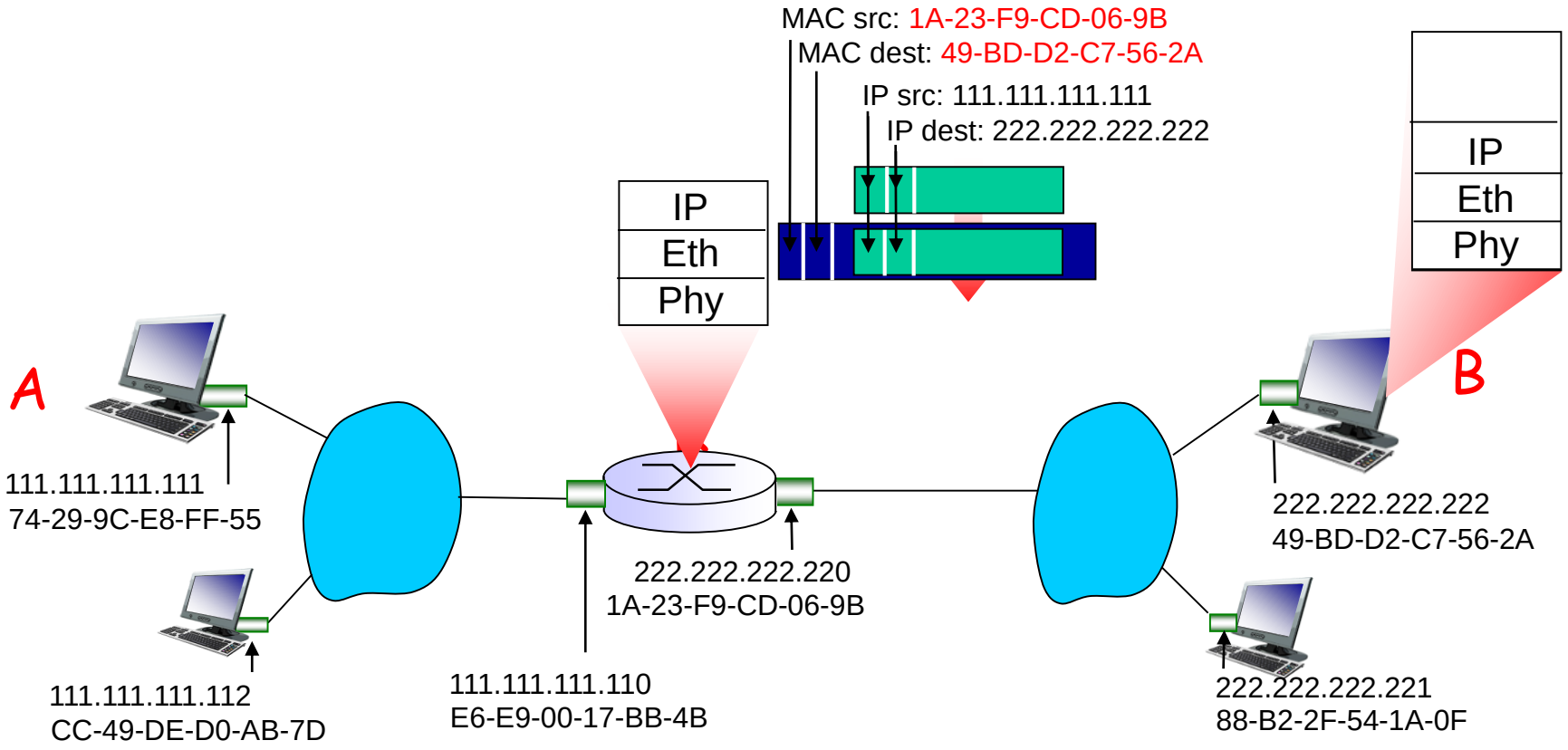
# Forwarding to Another LAN

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



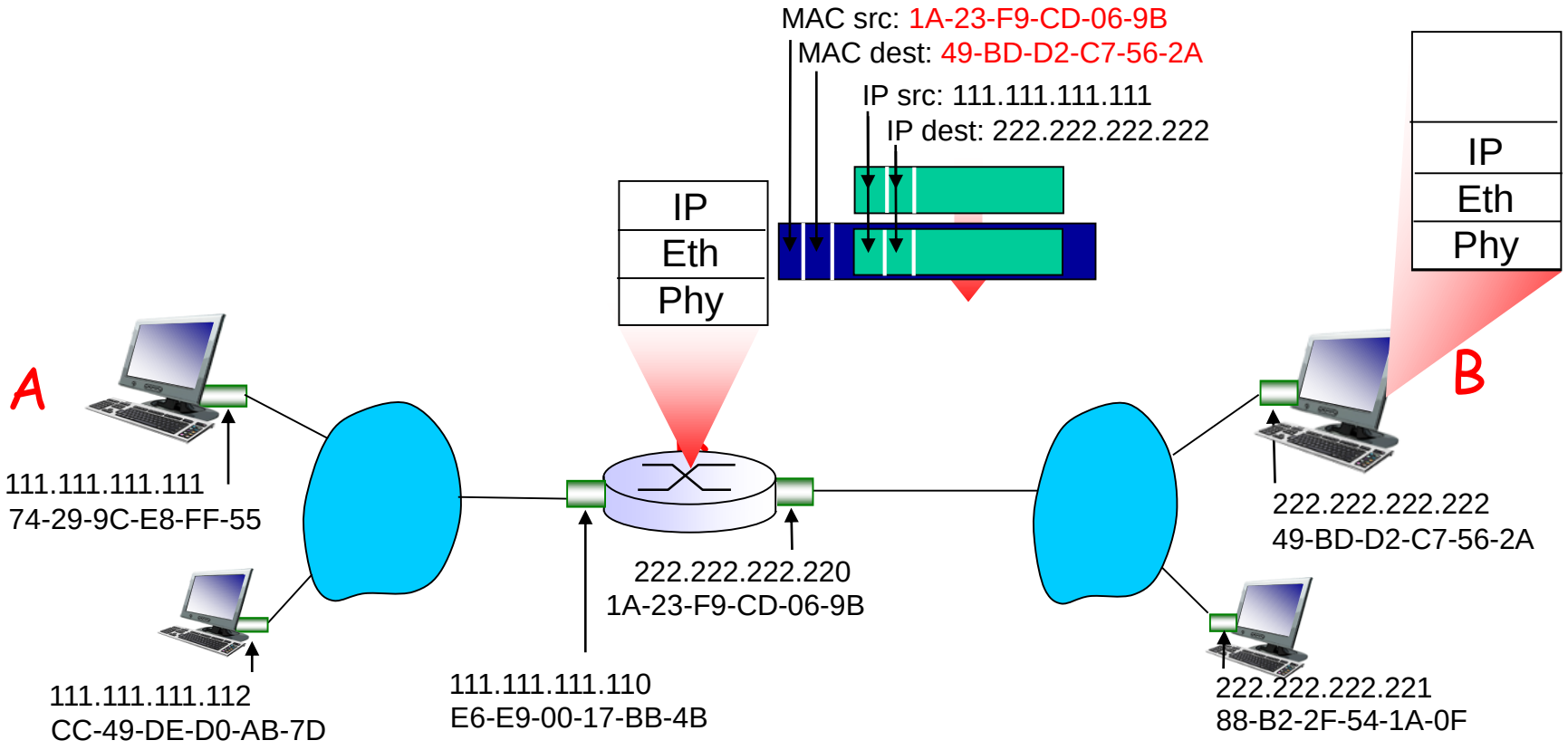
# Forwarding to Another LAN

- R forwards datagram with IP source A, destination B
- R creates link-layer frame with B's MAC address as destination address, frame contains A-to-B IP datagram



# Forwarding to Another LAN

- R forwards datagram with IP source A, destination B
- R creates link-layer frame with B's MAC address as destination address, frame contains A-to-B IP datagram



# Forwarding to Another LAN

- R forwards datagram with IP source A, destination B
- R creates link-layer frame with B's MAC address as dest, frame contains A-to-B IP datagram