

Switched Local Area Networks



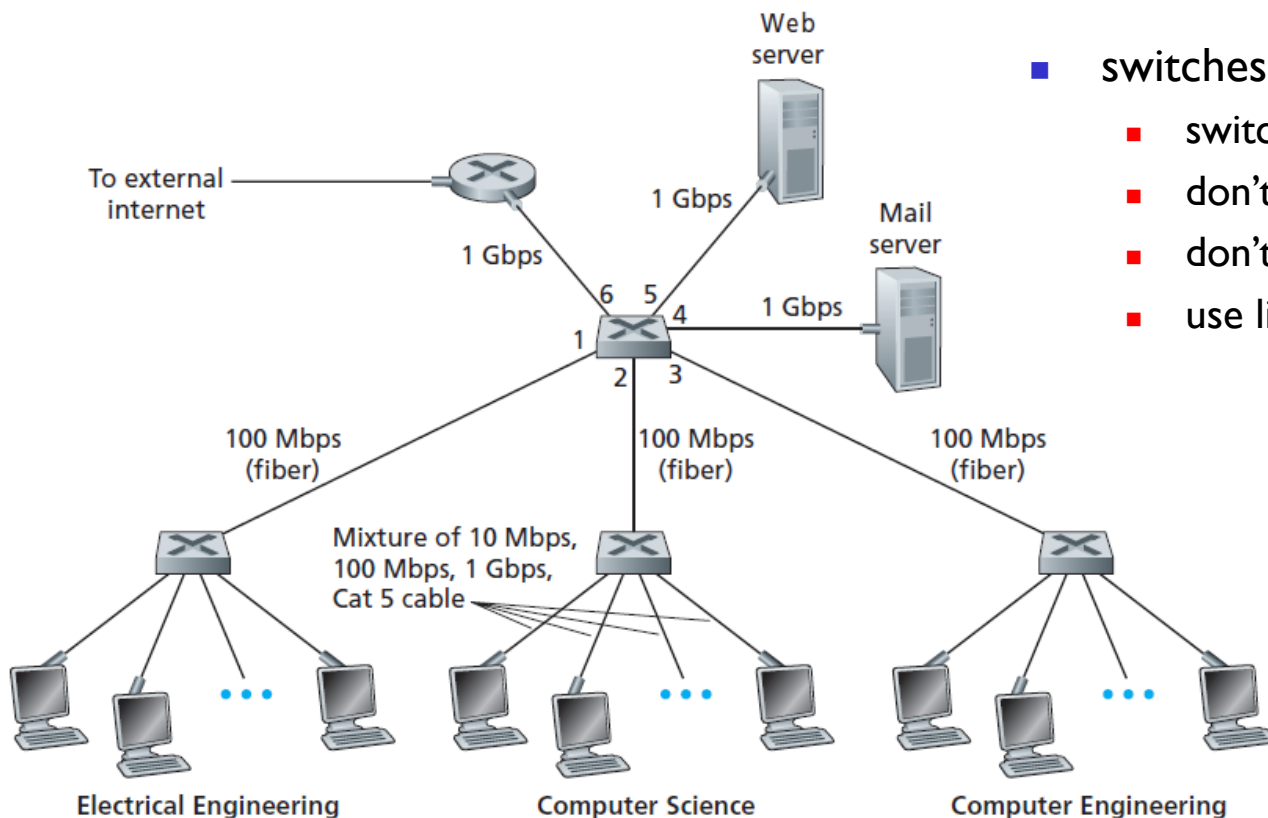
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Lecture 18

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Introduction

- a switched local network connecting three departments, two servers and a router with four switches



- switches operate at the link layer
 - switch link layer frames
 - don't recognize network layer address
 - don't use routing algorithms
 - use link layer address to forward frame



MAC Addresses

- hosts and routers have **link-layer address**
- adapters or network interfaces of hosts and routers have **link-layer addresses**
 - a host or router with multiple network interfaces will have **multiple** link-layer addresses
 - just as having multiple IP addresses
- a link-layer address is called **LAN address, physical address, or MAC address**
- For most LANs, the MAC address is 6 bytes long, giving 2^{48} possible MAC address
 - 6-byte addresses are typically expressed in **hexadecimal** notation
 - each byte of the address expressed as a pair of hexadecimal numbers

MAC Addresses

1A-23-F9-CD-06-9B



5C-66-AB-90-75-B1



49-BD-D2-C7-56-2A



88-B2-2F-54-1A-0F





MAC Addresses

- **no** two adapters have the same address
- IEEE manages the MAC address space
 - when a company wants to manufacture adapters, it purchase a chunk of the address space consisting of 2^{24} addresses for a nominal fee
 - IEEE allocates the chunk of 2^{48} addresses by fixing the first 24 bits of a MAC address and letting the company create unique combinations of the last 24 bits for each adapter
- an adapter's MAC address has a **flat structure**, does not change no matter where the adapter goes
 - an adapter's MAC address is analogous to a person's social security number
 - an IP address is analogous to a person's postal address



MAC Addresses

- when an adapter wants to send a frame to some destination adapter, the sending adapter inserts the destination adapter's **MAC address** into the frame and then sends the frame into the LAN
- a switch occasionally broadcasts an incoming frame onto all of its interfaces
 - an adapter may receive a frame that **isn't** addressed to it
 - when an adapter receives a frame, it will check to see whether the destination MAC address in the frame **matches** its own MAC address
 - if match, accept frame
 - if no match, discard the frame

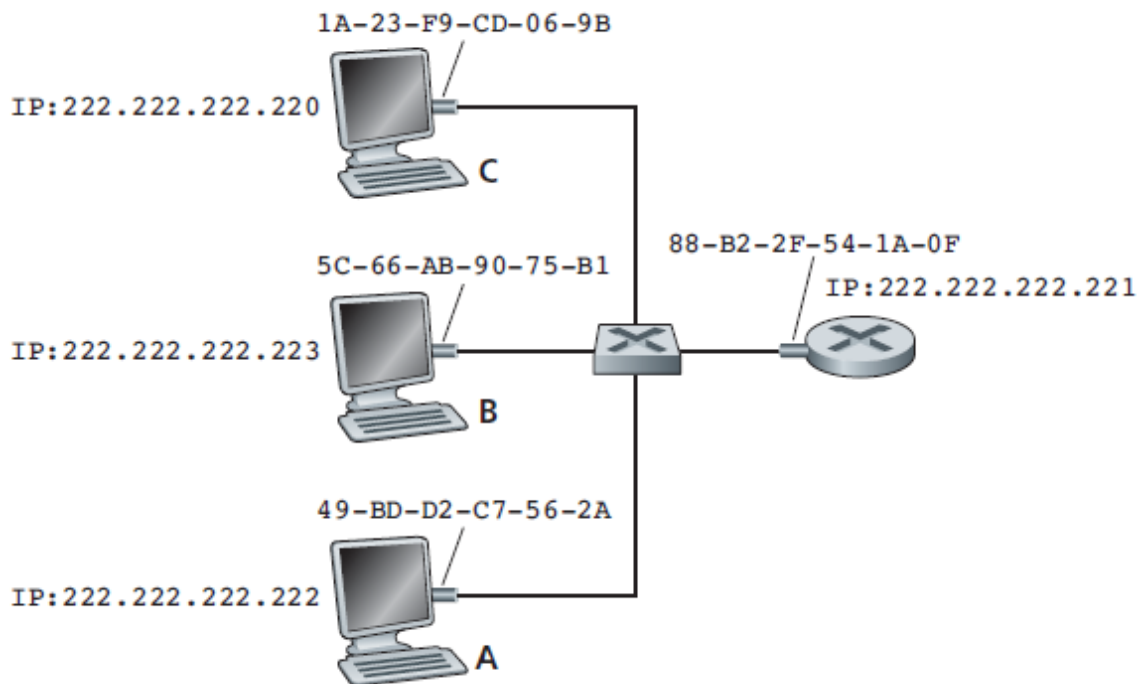


MAC Addresses

- How about a sending adapter wants *all the other adapters* on the LAN to receiver and process the frame it is about to send??
 - the sending adapter inserts a special **MAC broadcast address** into the destination address field of the frame.
 - for LANs that use 6-byte address, the broadcast address is a string of **48 consecutive 1s, FF-FF-FF-FF-FF-FF**

Address Resolution Protocol (ARP)

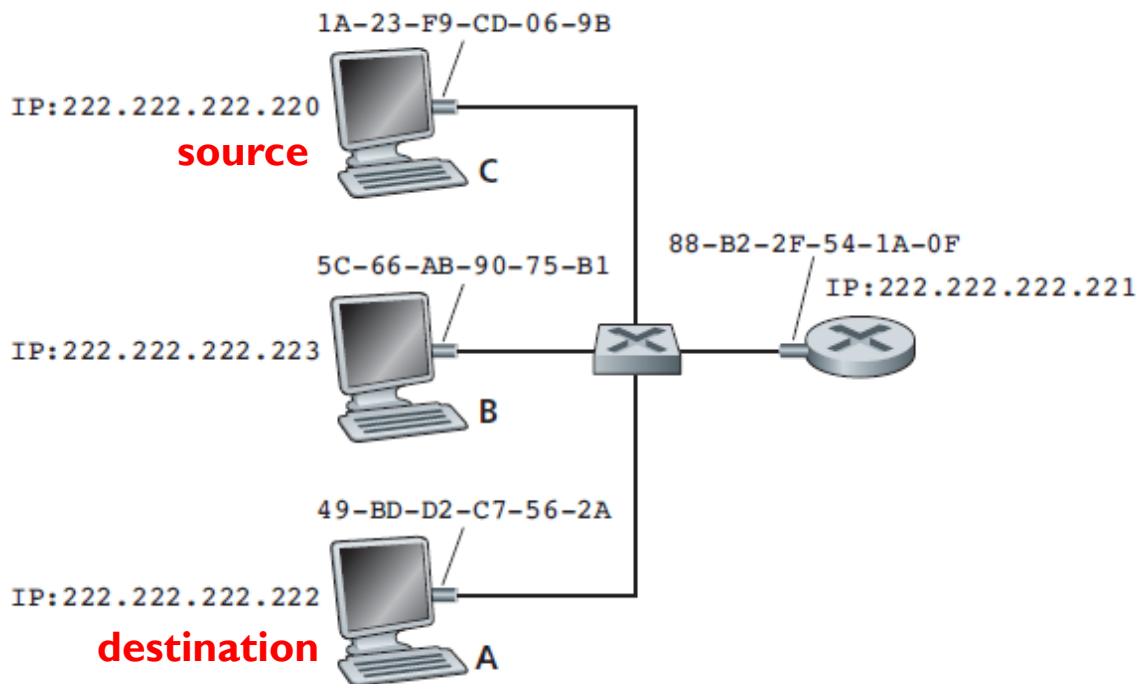
- translation between *link-layer address* and *network-layer address*
- Address Resolution Protocol (ARP)
- Example:



- each host and router has a single IP address and single MAC address
 - IP: dotted-decimal notation
 - MAC: hexadecimal notation
- the switch broadcasts all frames
 - whenever a switch receives a frame on one interface, it forwards the frame on all of its other interfaces

Address Resolution Protocol (ARP)

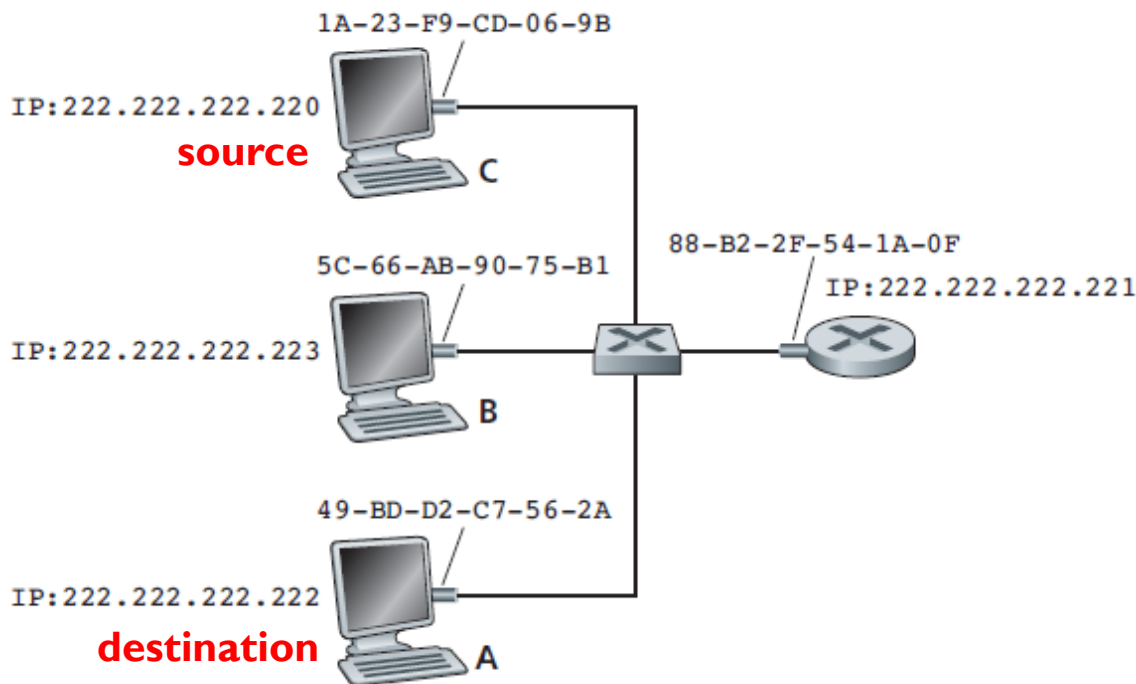
- translation between *link-layer address* and *network-layer address*
- Address Resolution Protocol (ARP)
- Example:



- the host with IP address 222.222.222.220 wants to send an IP datagram to host 222.222.222.222
 - IP datagram and MAC address of destination
 - the sending adapter will construct a link-layer frame containing the destination's MAC address and send the frame into the LAN

Address Resolution Protocol (ARP)

- translation between *link-layer address* and *network-layer address*
- Address Resolution Protocol (ARP)
- Example:



- *how does the sending host determine the MAC address of the destination host with IP address 222.222.222.222??*
- **ARP:** take any IP address on the same LAN as input, and return the corresponding MAC address
 - in the example, ARP returns the MAC address 49-BD-D2-C7-56-2A

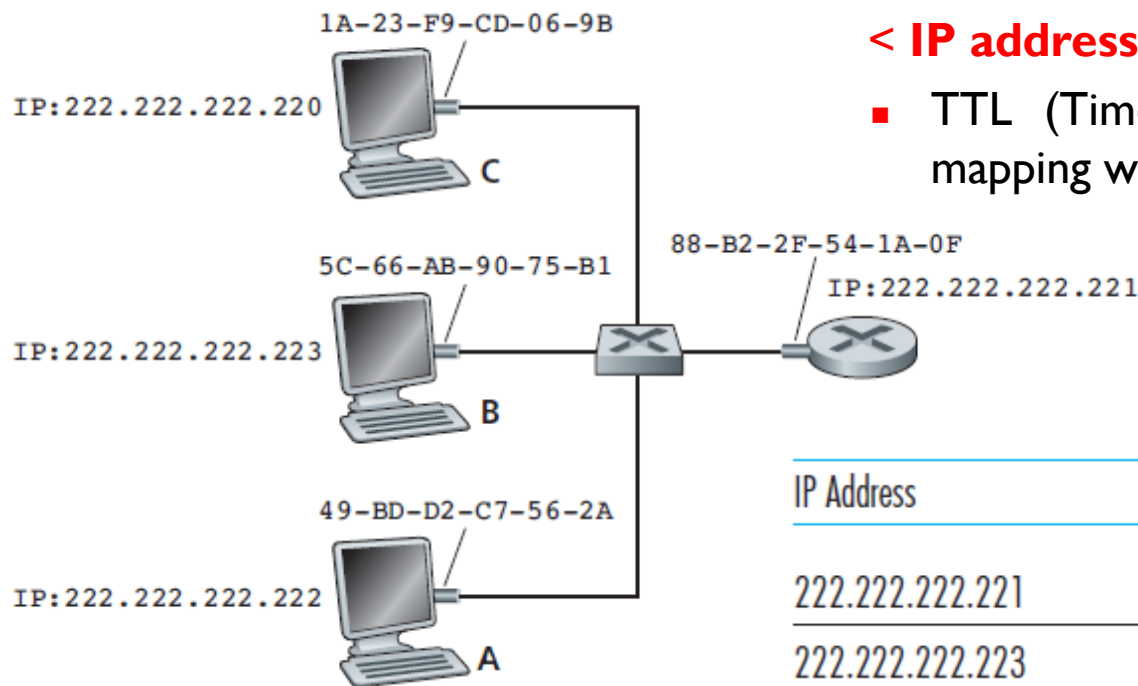
Question: how to determine MAC address of B knowing B's IP address?

Address Resolution Protocol (ARP)

- each host and router on LAN has **ARP table**
- **ARP 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 mins)



IP Address	MAC Address	TTL
222.222.222.221	88-B2-2F-54-1A-0F	13:45:00
222.222.222.223	5C-66-AB-90-75-B1	13:52:00

A possible ARP table in 222.222.222.220

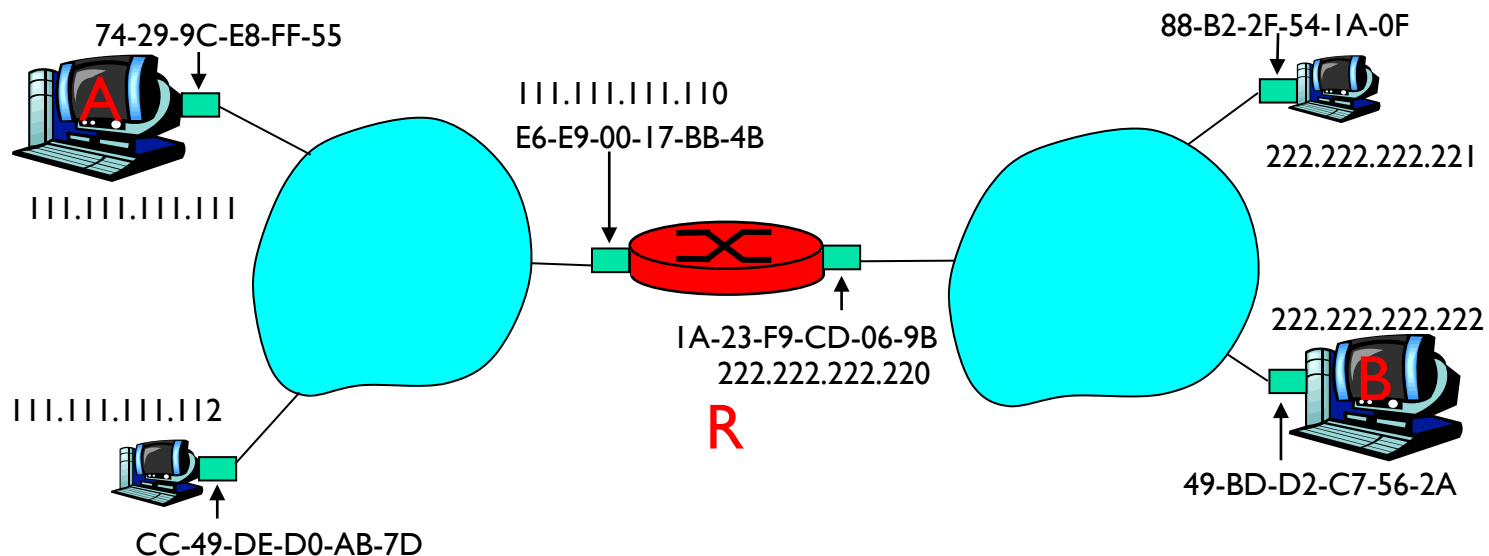


Address Resolution Protocol (ARP)

- A wants to send datagram to B, and B's MAC address **not** in A's ARP table
 - A uses ARP to resolve the MAC of B
- A **broadcasts** ARP query packet, containing B's IP address
 - dest 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

Sending a Datagram off the Subnet

- when a host wants to send a datagram to another host on the same subnet: ARP
- complicated situation: when a host on a subnet wants to send a network-layer datagram to a host off the subnet?

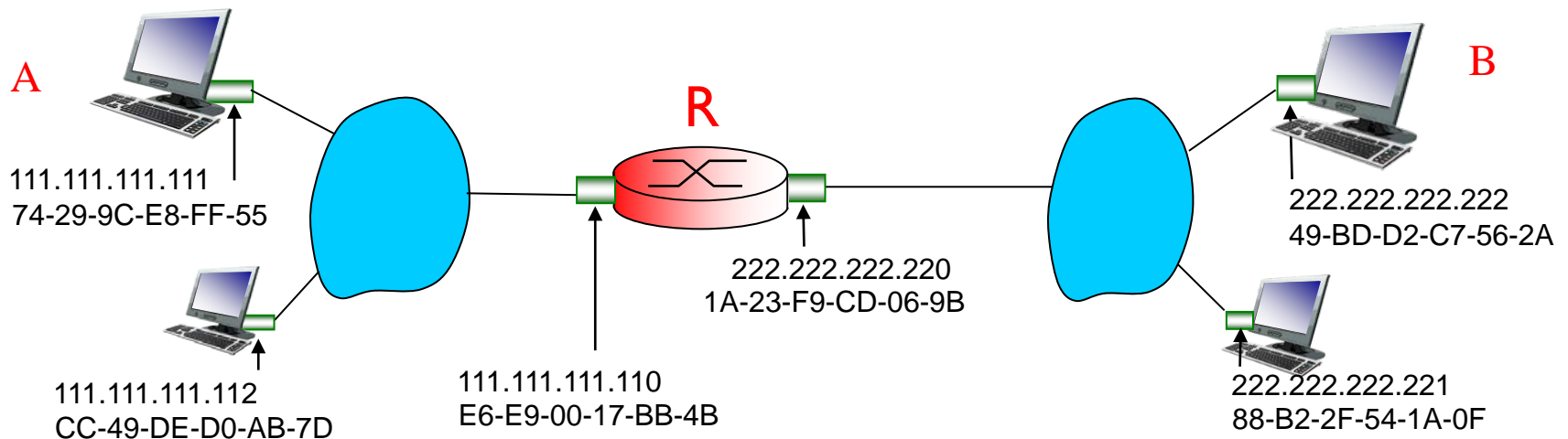


- a host has exactly one IP address and one adapter
- a router has an IP address for each of its interface
 - for each router interface, there is also an ARP module and an adapter

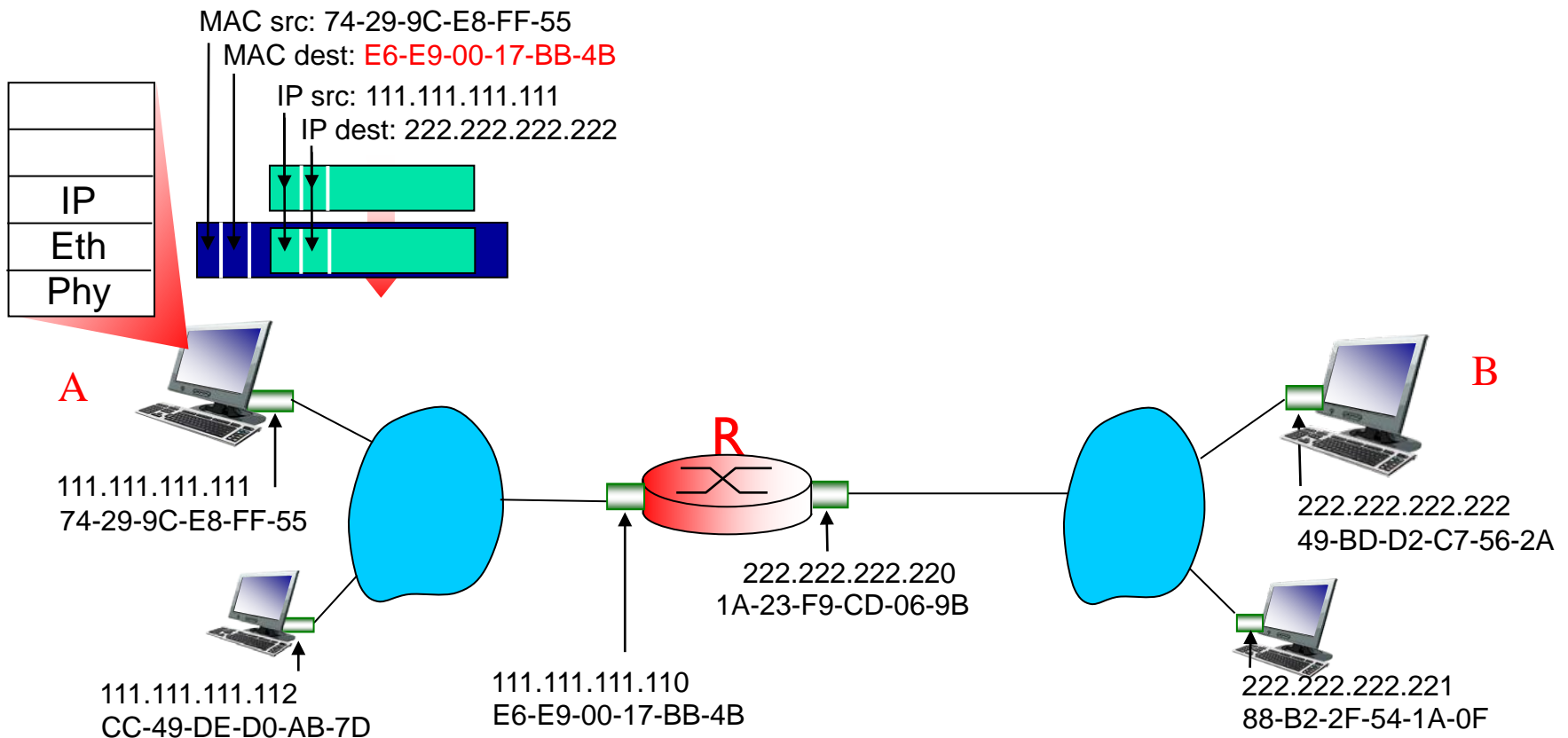
Addressing: Routing to another LAN (cont.)

walkthrough: **send datagram from A to B via R**

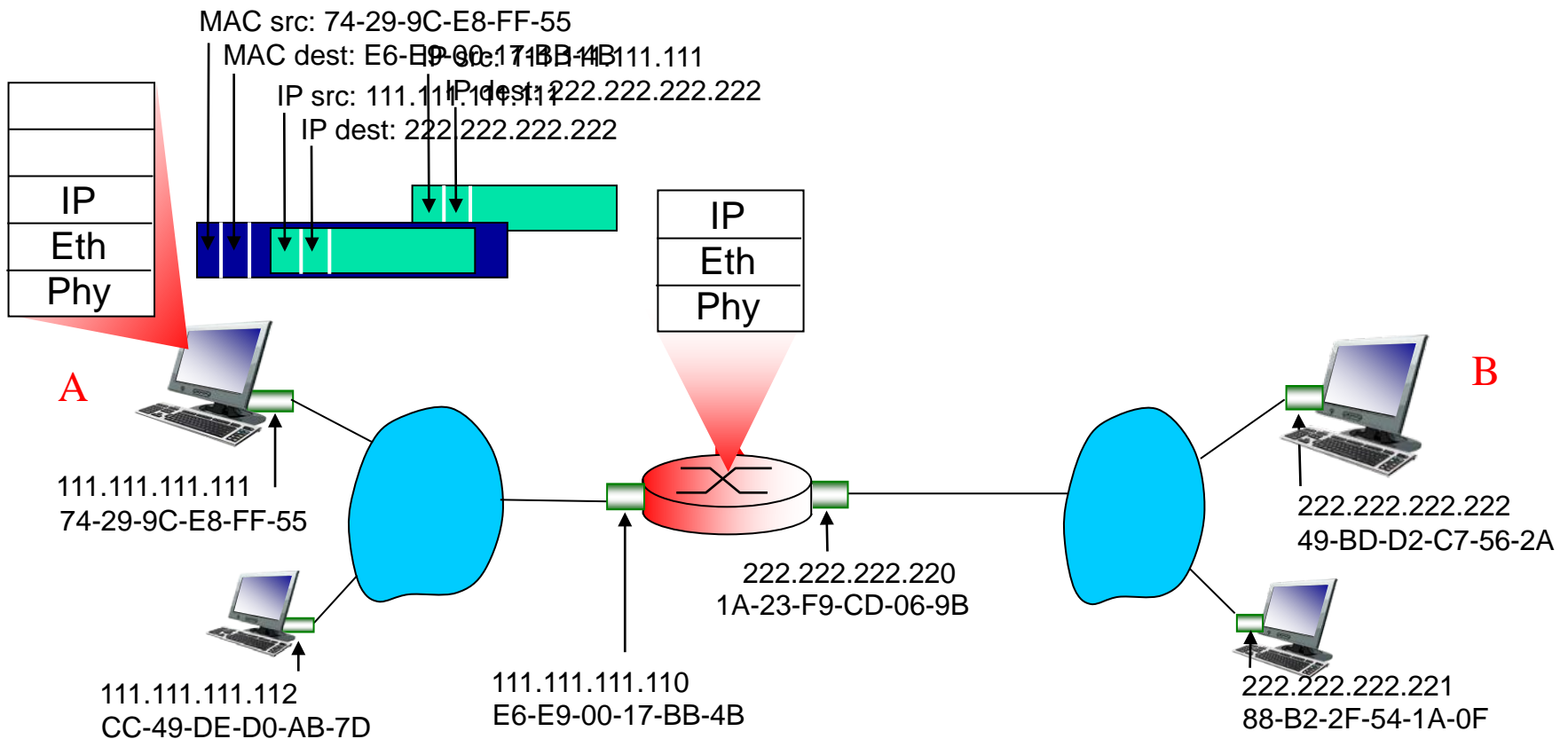
- focus on addressing – at IP (datagram) and MAC layer (frame)
- assume A knows B's IP address
- assume A knows IP address of first hop router, R
- assume A knows R's MAC address



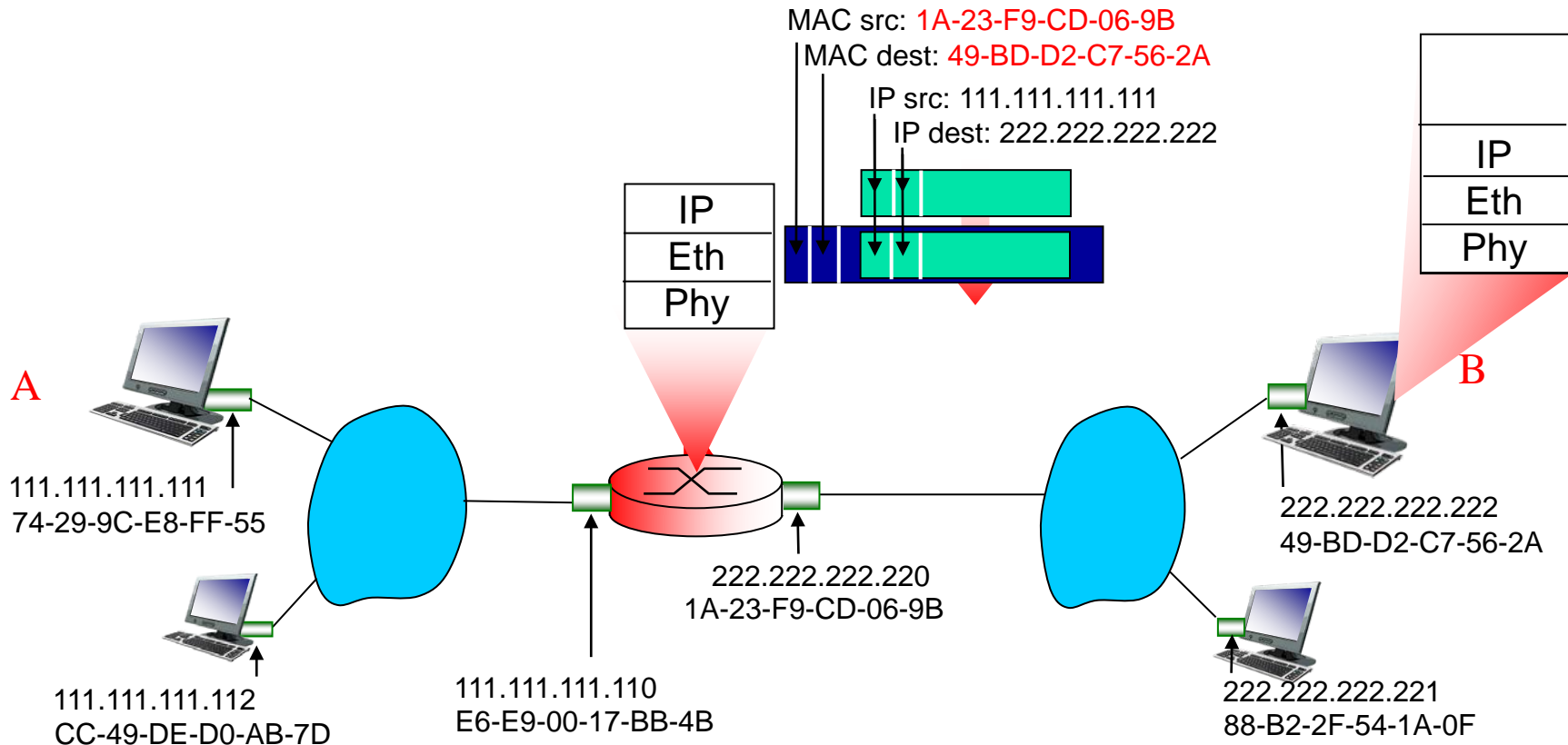
- ❖ A creates IP datagram with IP source A, destination B
- ❖ A creates link-layer frame with **R's MAC address** as dest, frame contains A-to-B IP datagram



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



- ❖ 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



- ❖ 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

