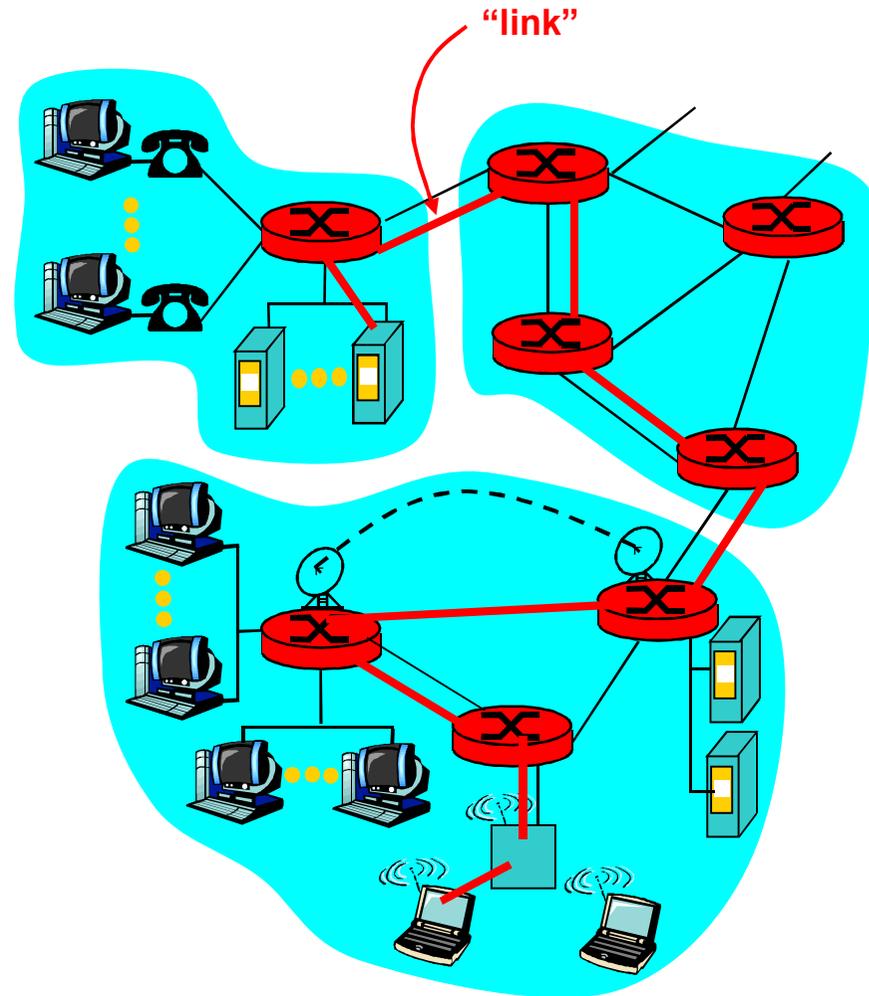


Link Layer: Recall

Some terminology:

- hosts and routers are **nodes** (bridges and switches too)
- communication channels that connect adjacent nodes along communication path are **links**
 - wired links
 - wireless links
 - LANs
- 2-PDU is a **frame**

data-link layer has responsibility of transferring frame from one node to adjacent node over a link



Link layer: context

- frame transferred by different link protocols over different links:
 - e.g., Ethernet on first link, frame relay on intermediate links, 802.11 on last link
- Each link protocol provides different services
 - e.g., may or may not provide rdt(reliable data transfer) over link

transportation analogy

- trip from Princeton(NY) to Lausanne (SWZ)
 - limo: Princeton to JFK
 - plane: JFK to Geneva
 - train: Geneva to Lausanne
- tourist = **frame**
- transport segment = **communication link**
- transportation mode = **link layer protocol**
- travel agent = **routing algorithm**

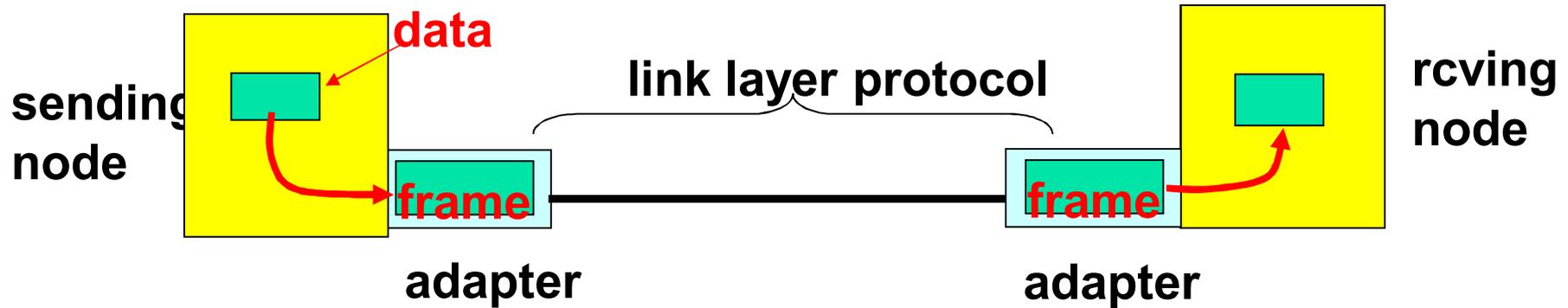
Link Layer Services

- Framing, link access:
 - encapsulate data into frame, adding **header, trailer**
 - **channel access** if shared medium
 - **'physical addresses'** used in frame headers to identify **source, dest**
 - different from IP address!
- Reliable delivery between adjacent nodes

Link Layer Services (more)

- *Flow Control:*
 - pacing between adjacent sending and receiving nodes
- *Error Detection:*
 - errors caused by signal attenuation, noise.
 - receiver detects presence of errors:
 - signals sender for retransmission or drops frame
- *Error Correction:*
 - receiver identifies *and corrects* bit error(s) without resorting to retransmission
- *Half-duplex and full-duplex*
 - with half duplex, nodes at both ends of link can transmit, but not at same time

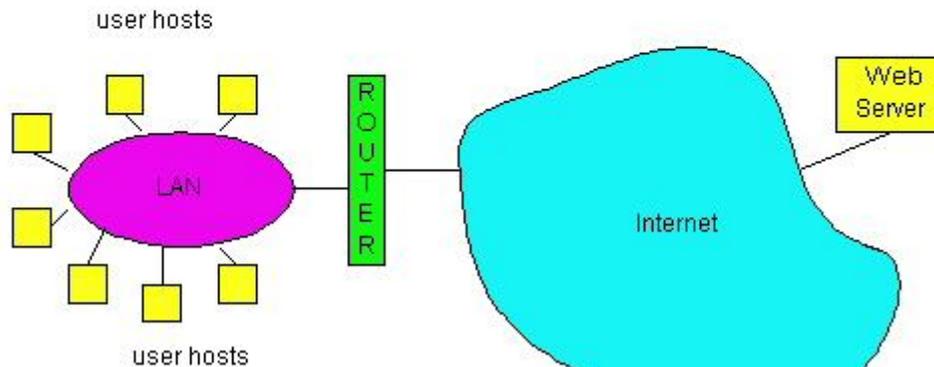
Adaptors Communicating



- link layer implemented in "adaptor" (aka NIC)
 - Ethernet card, PCMCIA card, 802.11 card
- sending side:
 - encapsulates data in a frame
 - adds error checking bits, rdt, flow control, etc.
- receiving side
 - looks for errors, rdt, flow control, etc
 - extracts data, passes to rcving node
- adapter is semi-autonomous
- link & physical layers

LAN technologies

- addressing
- Ethernet
- hubs, bridges, switches
- 802.11
- PPP
- ATM



LAN Addresses and ARP

32-bit IP(Internet Protocol) address:

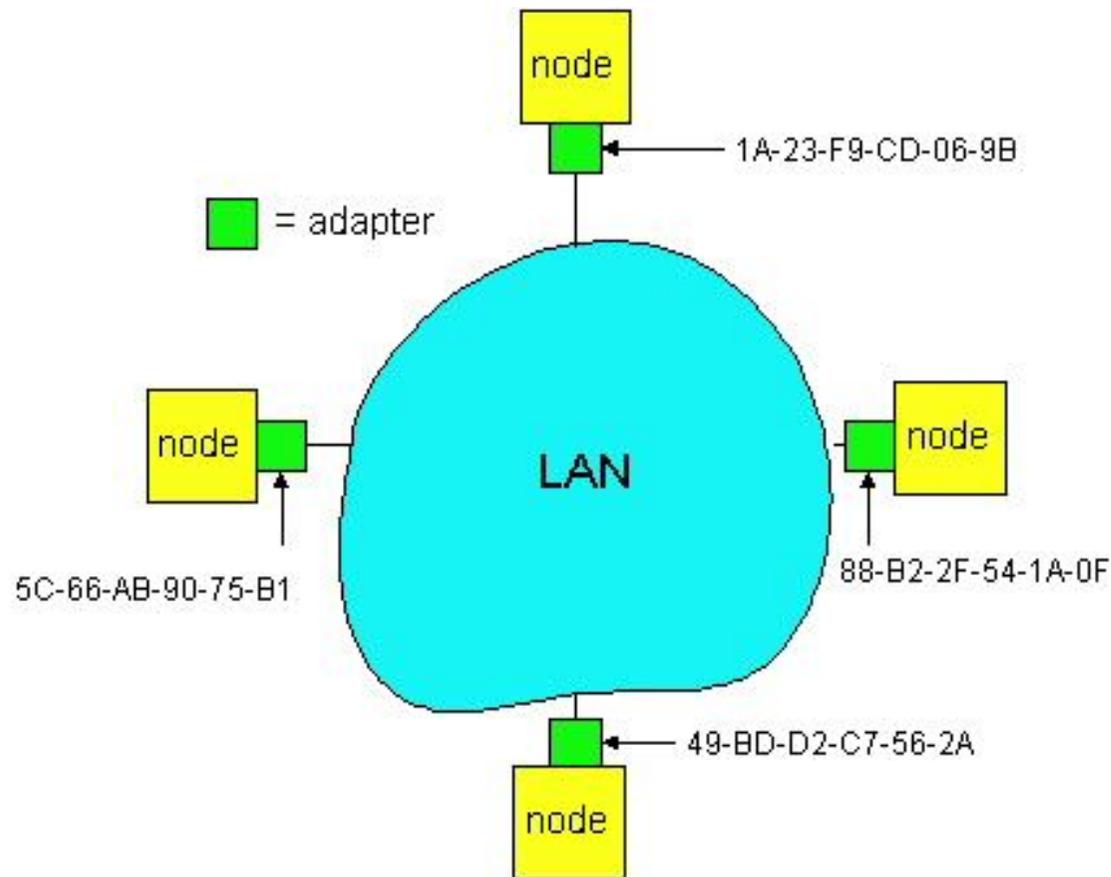
- *network-layer* address
- used to get datagram to destination IP network (network layer)

LAN (or MAC or physical or Ethernet) address:

- used to get data from one interface to another physically-connected interface (same network)
- 48 bit MAC address (for most LANs)
burned in the adapter ROM

LAN Addresses and ARP

Each adapter on LAN has unique LAN address



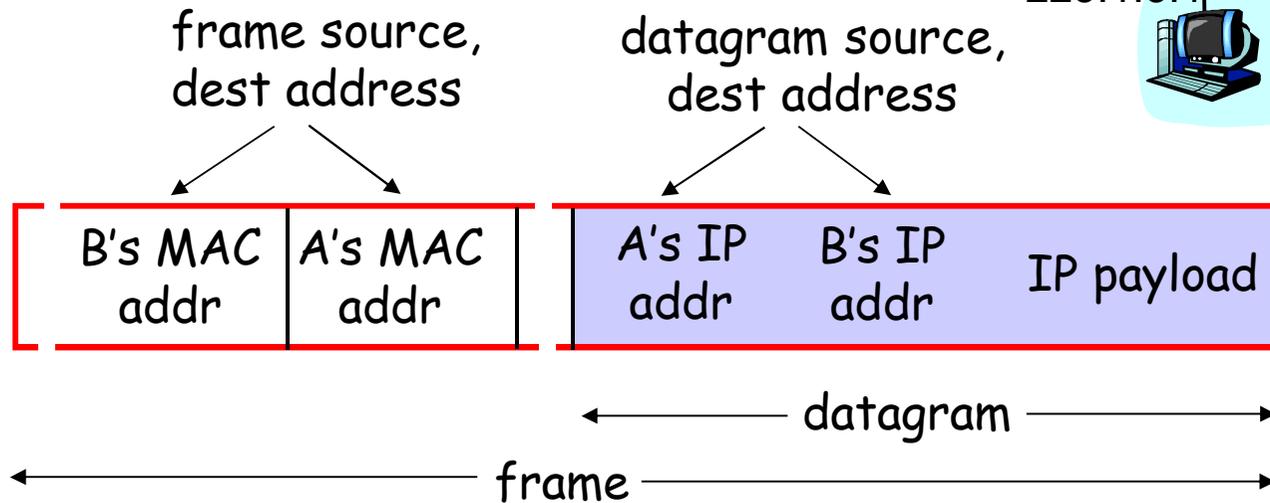
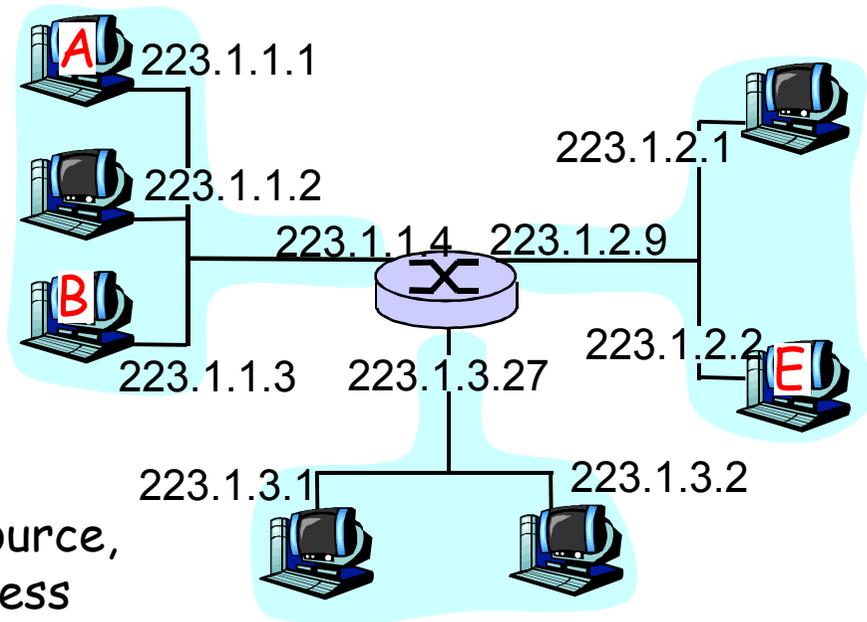
LAN Address (more)

- MAC address allocation administered by IEEE
- manufacturer buys portion of MAC address space (to assure uniqueness)
- Analogy:
 - (a) MAC address: like Social Security Number
 - (b) IP address: like postal address
- MAC flat address => portability
 - can move LAN card from one LAN to another
- IP hierarchical address NOT portable
 - depends on IP network to which node is attached

Addressing

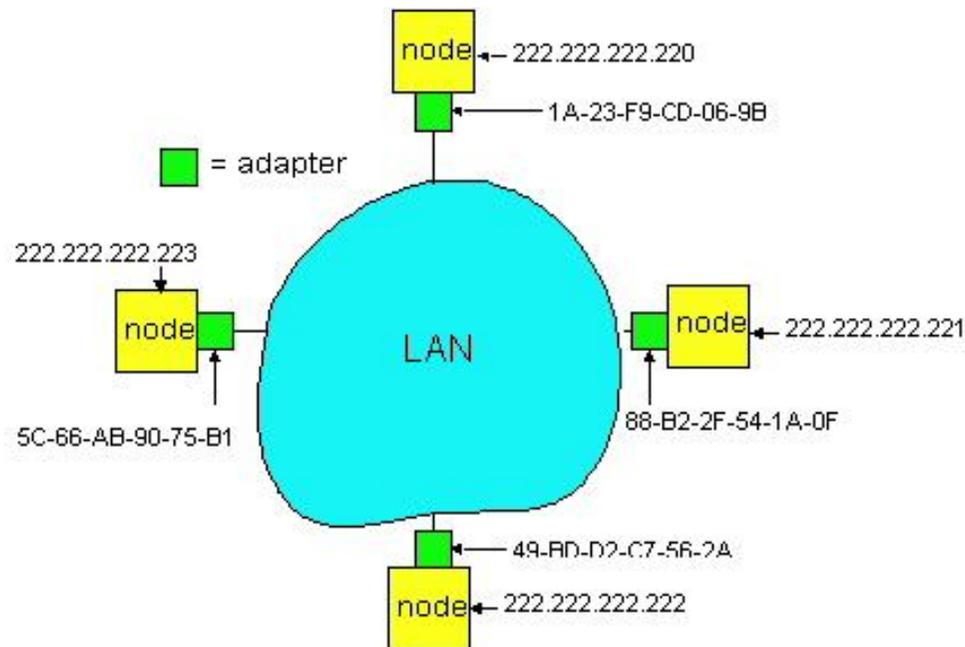
Starting at A, given IP datagram addressed to B:

- look up net. address of B, find B on same net. as A
- link layer send data 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; TTL >
 - TTL (Time To Live): time after which address mapping will be forgotten (typically 20 min)

Multiple Access protocols

- ❑ single shared broadcast channel
- ❑ two or more simultaneous transmissions by nodes:
interference
 - only one node can send **successfully** at a time