Data link layer: Ethernet

- Broadcast network
  ![broadcast_network_diagram]
  - CSMA-CD: Carrier Sense Multiple Access with Collision Detection
    - recall the "standing in a circle, drinking beer and telling stories" analogy
  - Packetized - fixed
  - Every computer has a unique physical address
    - 00-08-74-C9-C8-7E

Network layer: IP

- Internet Protocol (IP)
  - routes packets across multiple networks, from source to destination
  - Every computer has a unique Internet address
    - 172.30.192.251
  - Individual networks are connected by routers that have physical addresses (and interfaces) on each network
  - A really hairy protocol lets any node on a network find the physical address on that network of a router that can get a packet one step closer to its destination
- Packet format
  ![packet_format_diagram]
• A separate really hairy protocol, DNS (the Domain Name Service), maps from intelligible names (lazowska.org) to IP addresses (209.180.207.60)
• So to send a packet to a destination
  – use DNS to convert domain name to IP address
  – prepare IP packet, with payload prefixed by IP address
  – determine physical address of appropriate router
  – encapsulate IP packet in Ethernet packet with appropriate physical address
  – blast away!
• Detail: port number gets you to a specific address space on a system

Transport layer: TCP

• TCP: Transmission Control Protocol
  – manages to fabricate reliable multi-packet messages out of unreliable single-packet datagrams
  – analogy: sending a book via postcards – what’s required?

Summary

• Using TCP/IP and lower layers, we can get multi-packet messages delivered reliably from address space A on machine B to address space C on machine D, where machines B and D are many heterogeneous network hops apart, without knowing any of the underlying details
• Higher protocol layers facilitate specific services
  – email: smtp
  – web: http
  – file transfer: ftp
  – remote login: telnet