CSE 333

Lecture 16 -- networks

Hal Perkins

Department of Computer Science & Engineering

University of Washington

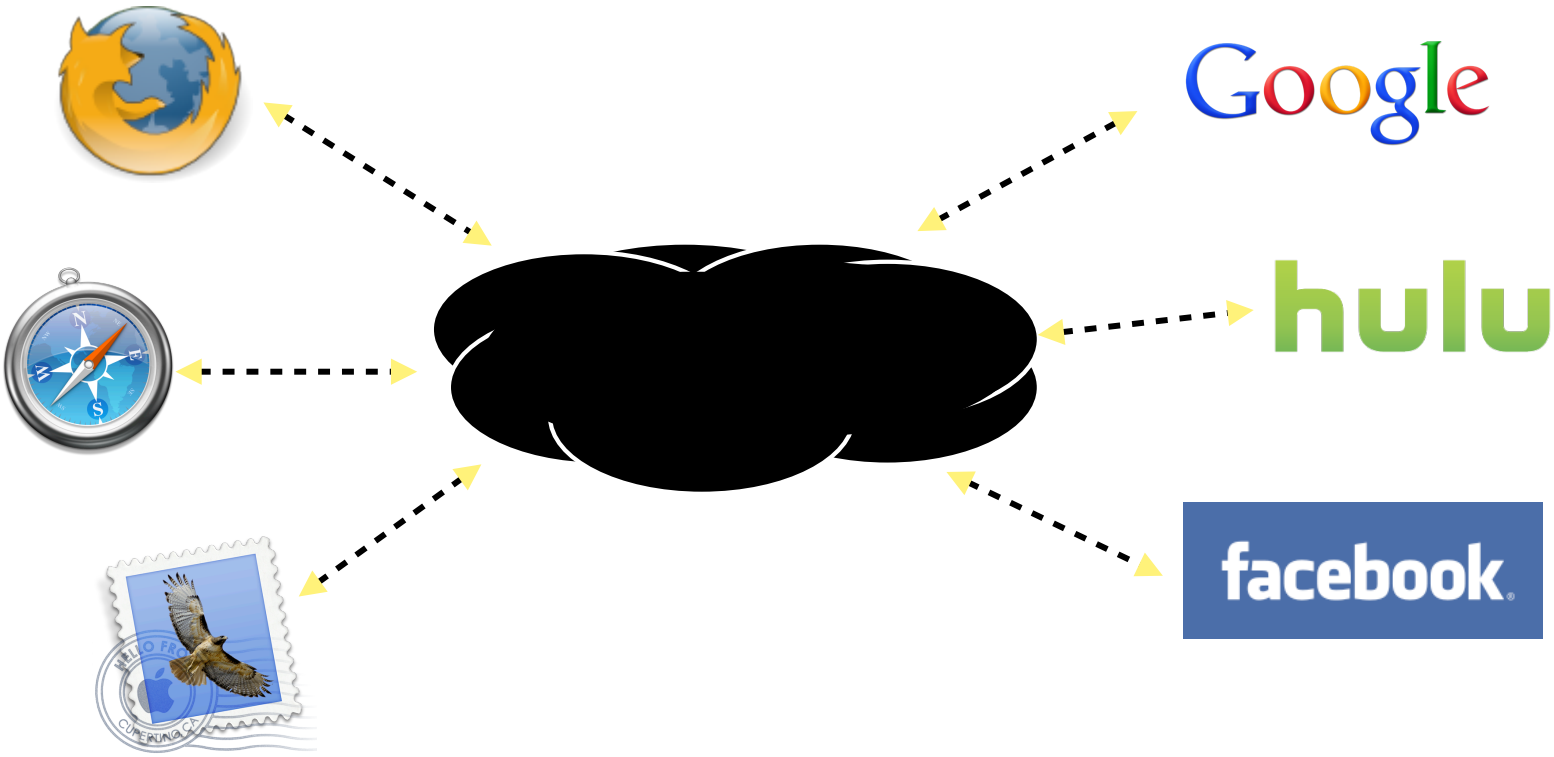
Administrivia

HW3 due Thursday night

- No exercises until after that
- But with the long weekend coming up, maybe two due right afterwards? (Tuesday morning instead of Monday, then Wed.)

HW4 out by end of the week

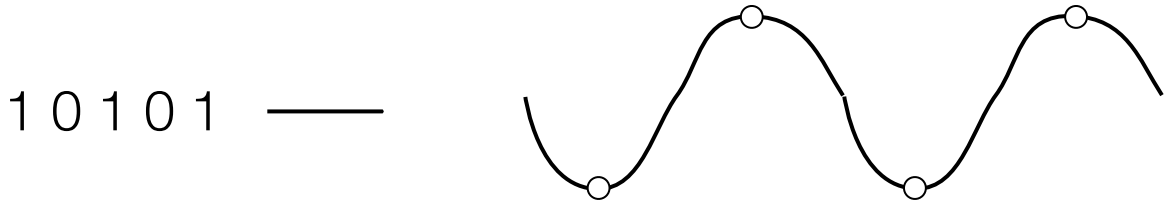
Networks from 10,000ft

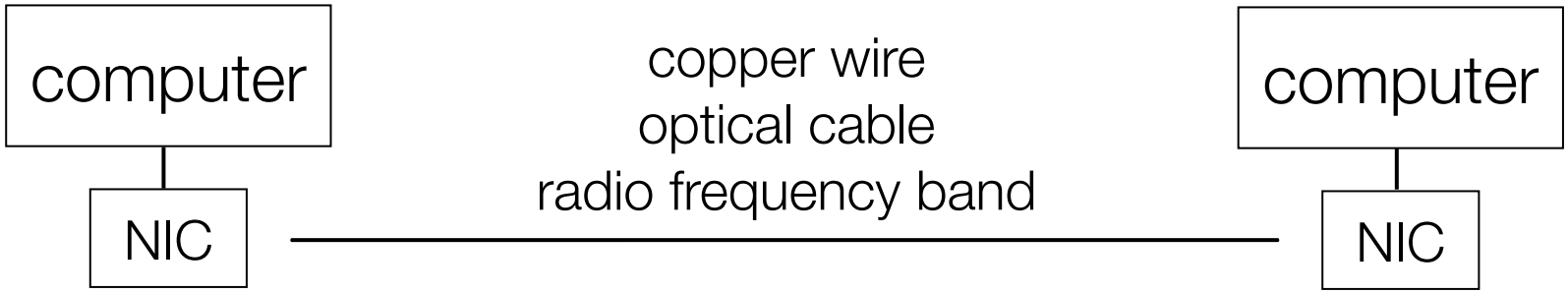


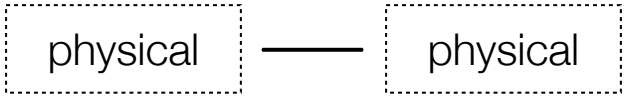
The “physical” layer

Individual bits are modulated onto a wire or transmitted over radio

- physical layer specifies how bits are encoded at a signal level
- e.g., a simple spec would encode “1” as +1V, “0” as -1V



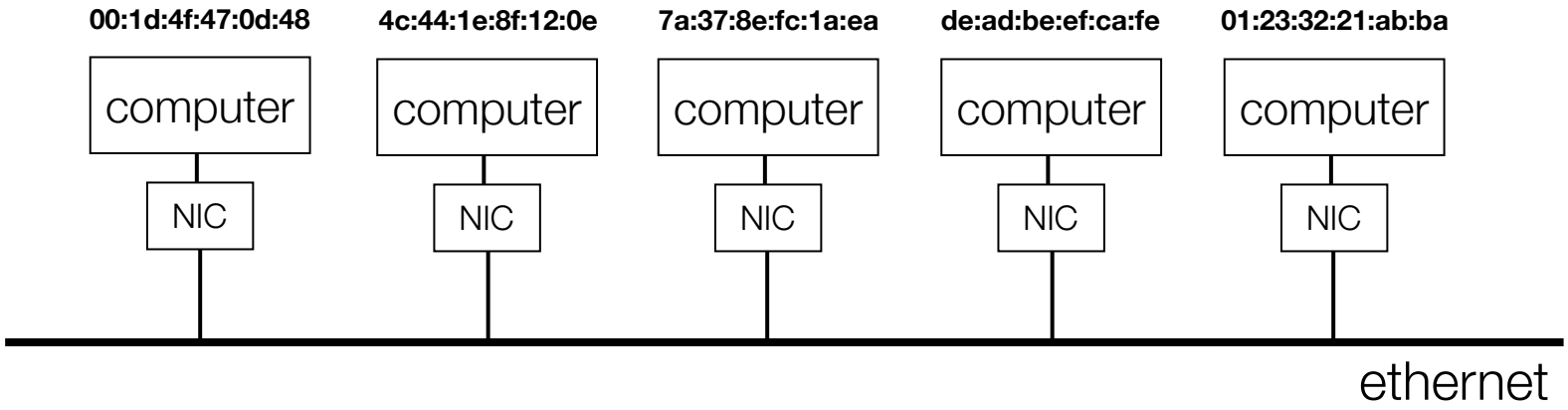


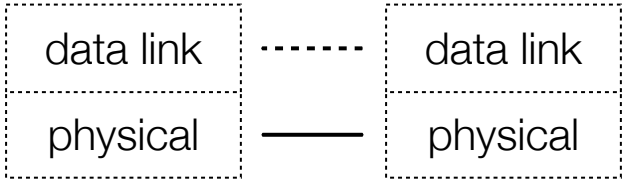


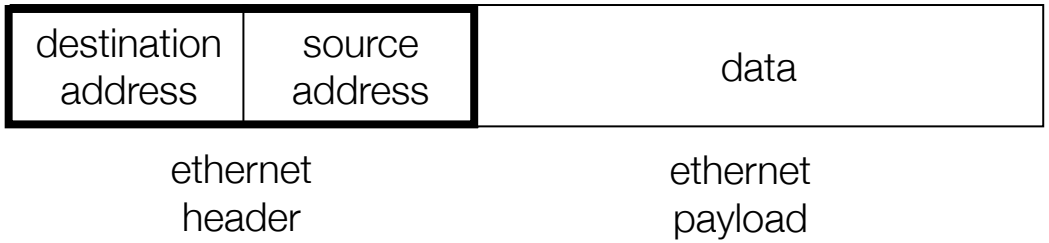
The “data link” layer

Multiple computers on a LAN contend for the network medium

- media access control (MAC) specifies how computers cooperate
- link layer also specifies how bits are packetized and NICs are addressed



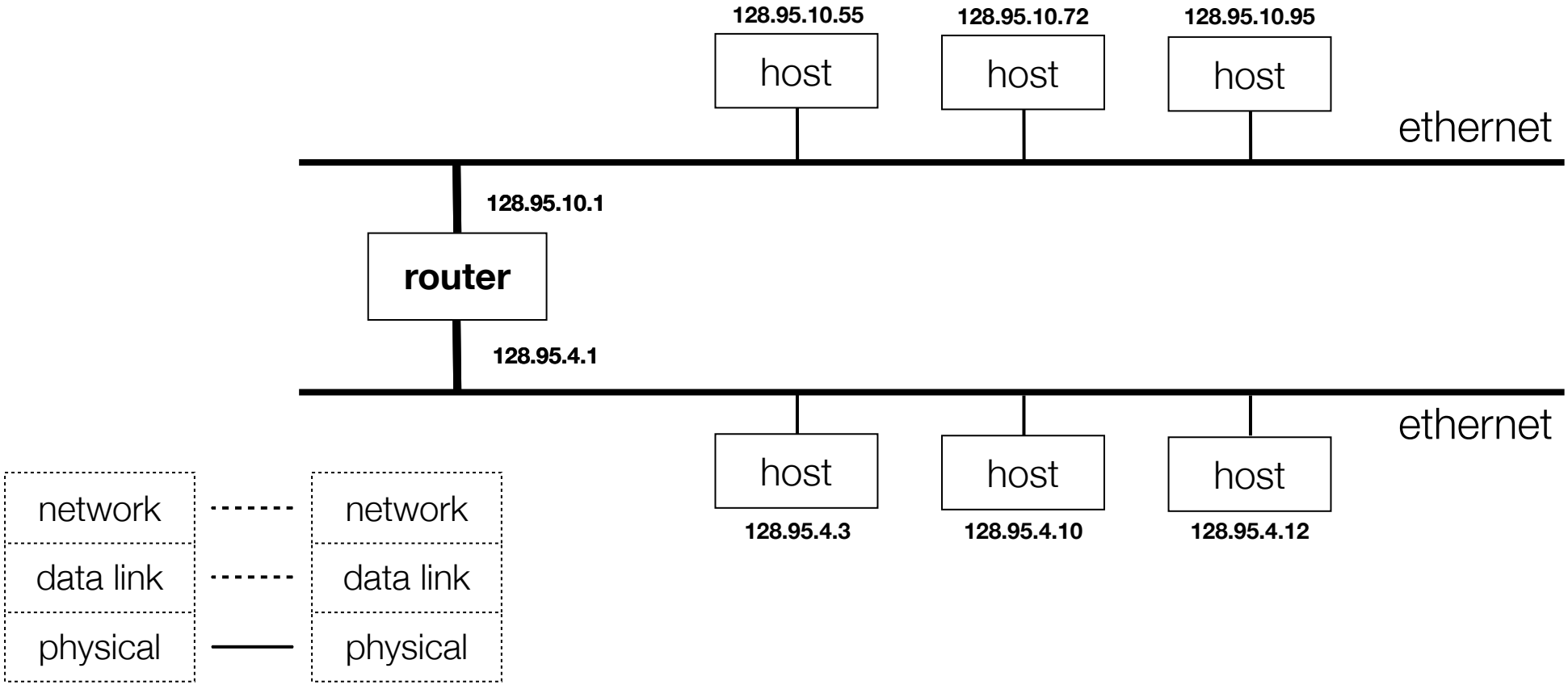




The “network” layer (IP)

The Internet Protocol (IP) routes packets across multiple networks

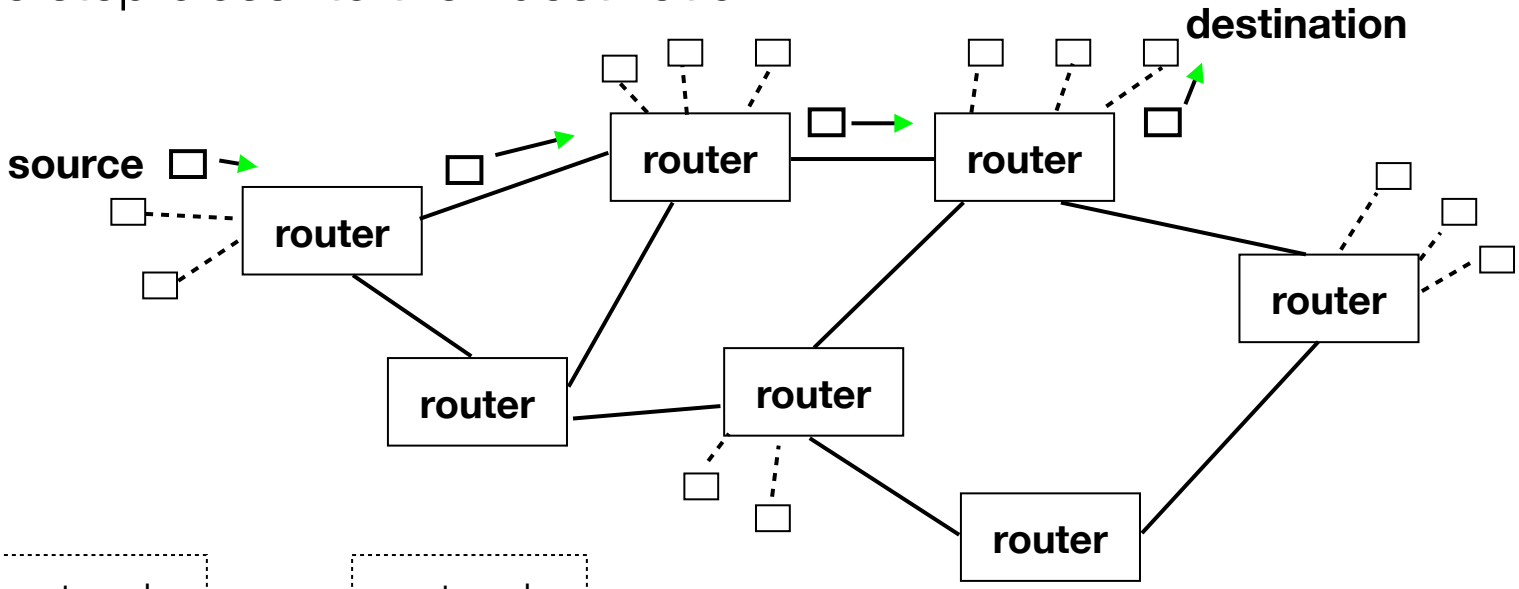
- every computer has a unique Internet address (IP address)
- individual networks are connected by routers that span networks

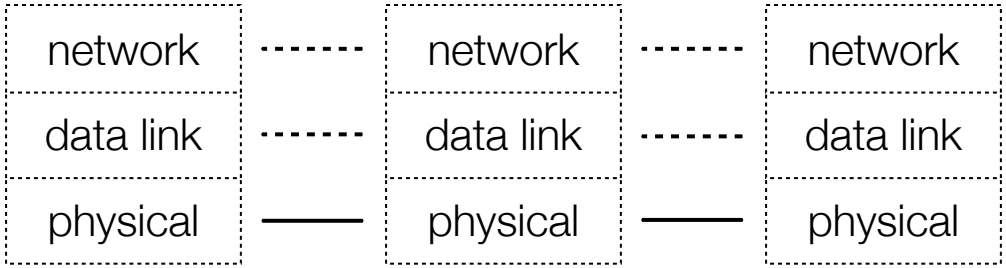


The “network” layer (IP)

Protocols to:

- let a host find the MAC address of an IP address on the same network
- let a router learn about other routers and figure out how to get IP packets one step closer to their destination

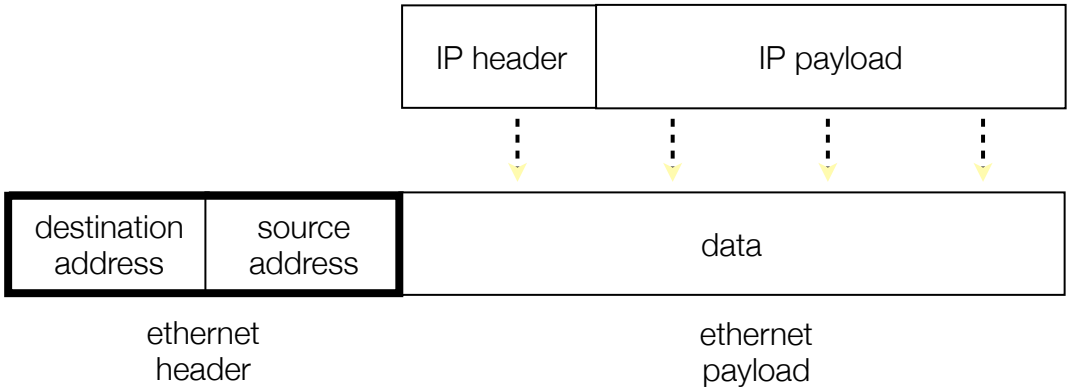


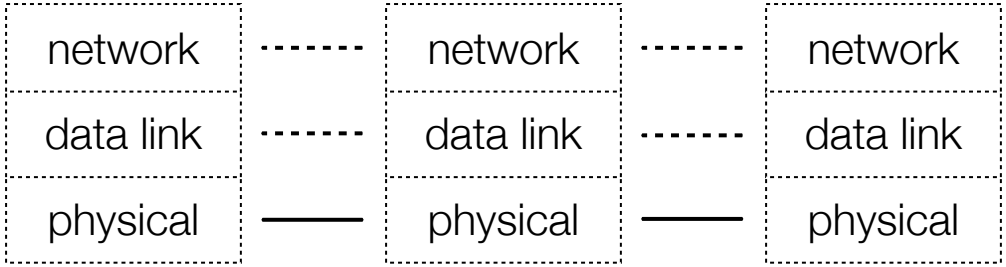


The “network” layer (IP)

Packet encapsulation

- an IP packet is encapsulated as the payload of an Ethernet frame
- as IP packets traverse networks, routers pull out the IP packet from an ethernet frame and plunk it into a new one on the next network

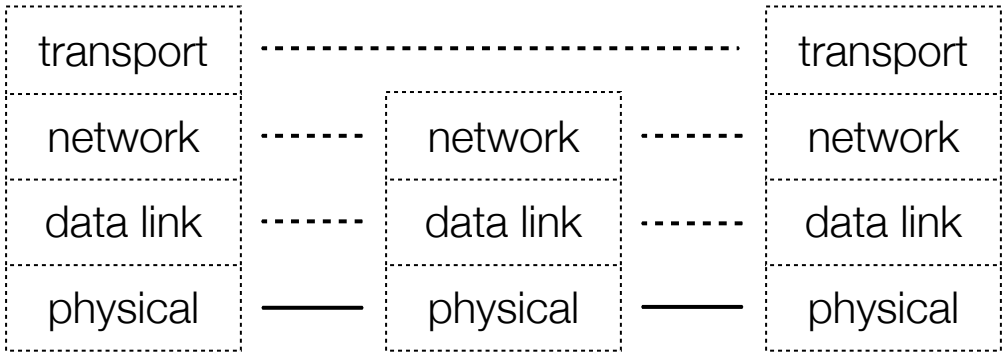




The “transport” layer (TCP, UDP)

TCP

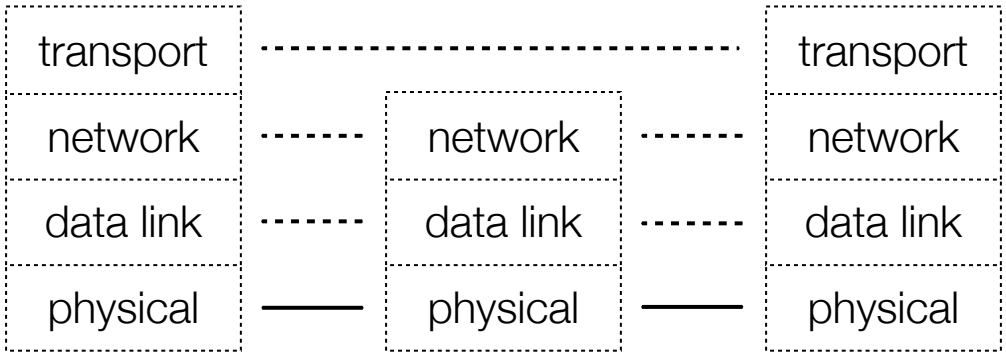
- the “transmission control protocol”
- provides apps with reliable, ordered, congestion-controlled byte streams
- fabricates them by sending multiple IP packets, using sequence numbers to detect missing packets, and retransmitting them
- a single host (IP address) can have up to 65,535 “ports”
  - kind of like an apartment number at a postal address



The “transport” layer (TCP, UDP)

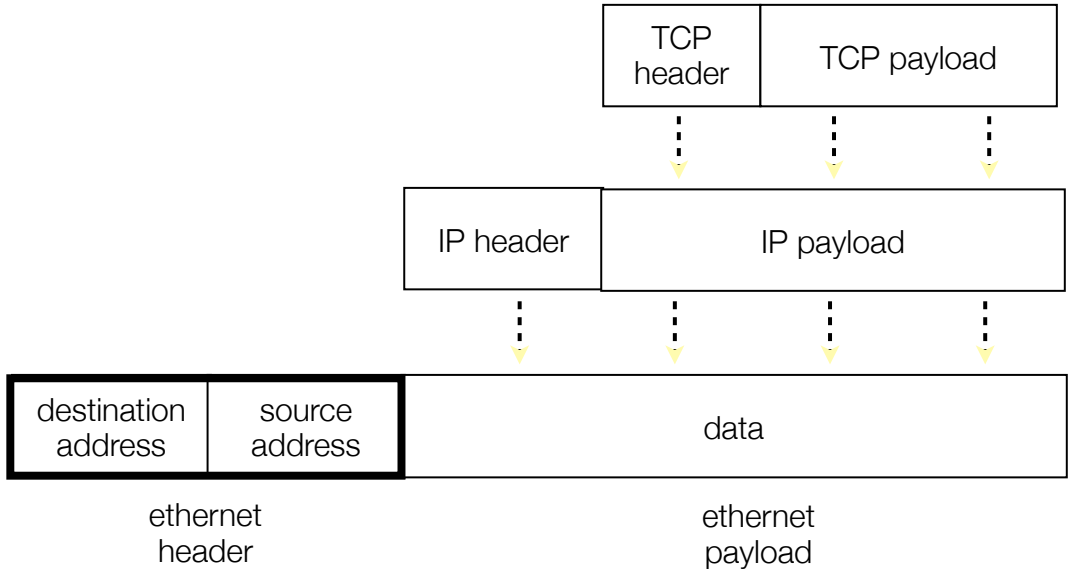
TCP

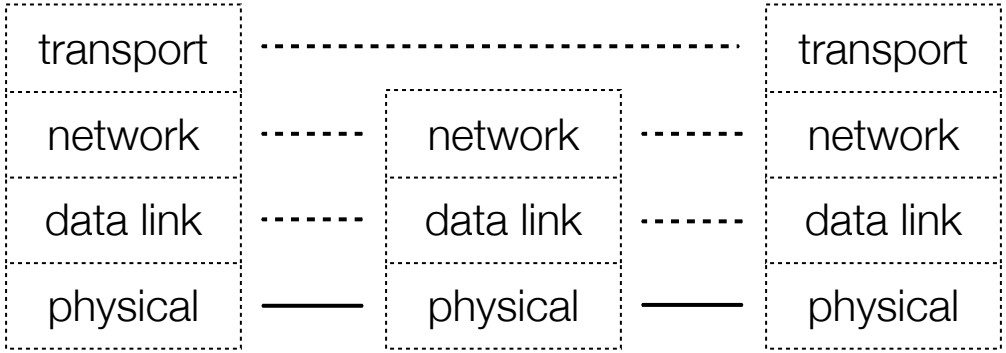
- useful analogy: how would you send a book by mail via postcards?
- split the book into multiple postcards, send each one by one, including sequence numbers that indicate the assembly order
- receiver sends back postcards to acknowledge receipt and indicate which got lost in the mail



The “transport” layer (TCP)

Packet encapsulation -- same as before!

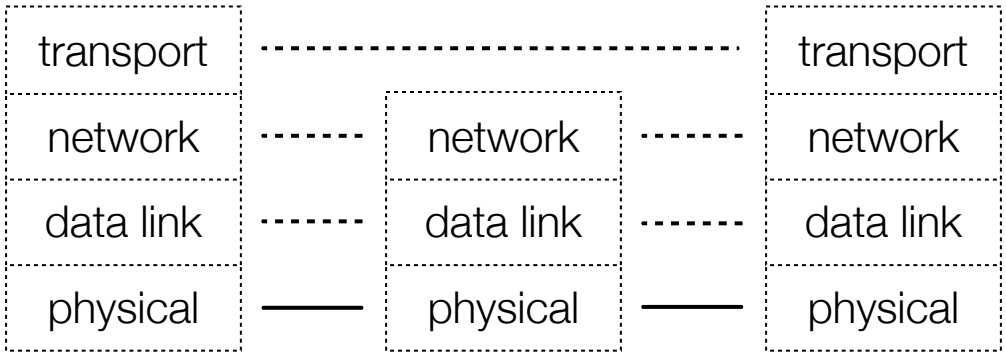




The “transport” layer (TCP)

Applications use OS services to establish TCP streams

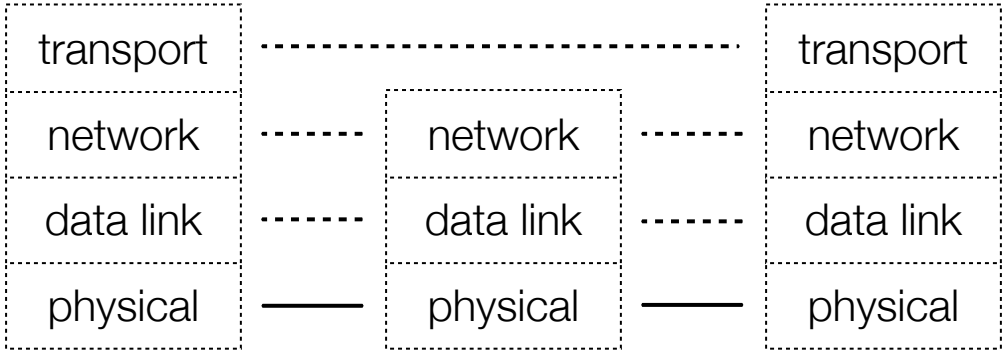
- the “Berkeley sockets” API -- a set of OS system calls
- clients ***connect( )*** to a server IP address + application port number
- servers ***listen( )*** for and ***accept( )*** client connections
- clients, servers ***read( )*** and ***write( )*** data to each other



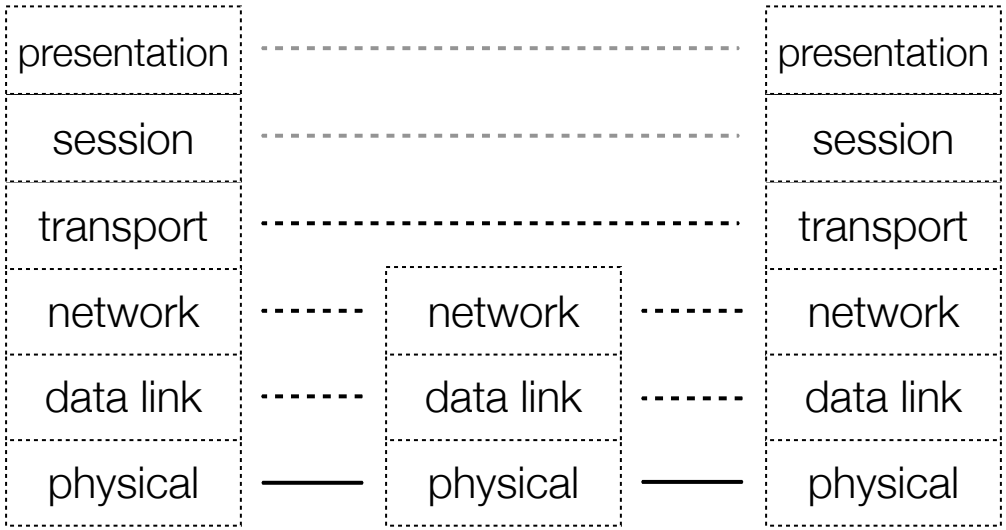
The “transport” layer (UDP)

UDP

- the “user datagram protocol”
- provides apps with unreliable packet delivery
- UDP datagrams are fragmented into multiple IP packets
  - UDP is a really thin, simple layer on top of IP



The (mostly missing) layers 5,6



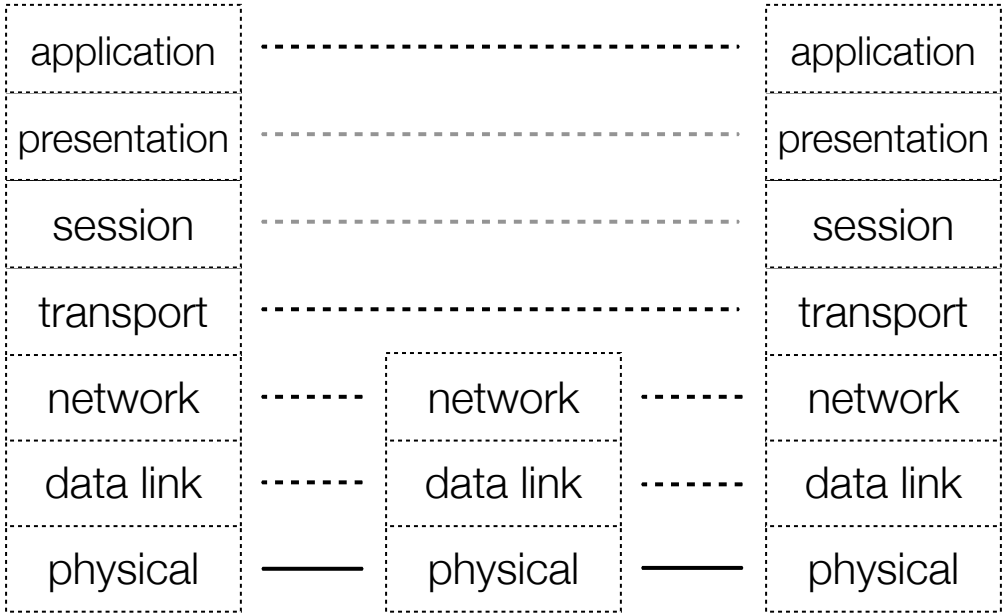
Layer 5: session layer

- supposedly handles establishing, terminating application sessions
- RPC kind of fits in here

Layer 6: presentation layer

- supposedly maps application-specific data units into a more network-neutral representation
- encryption (SSL) kind of fits in here

The “application” layer

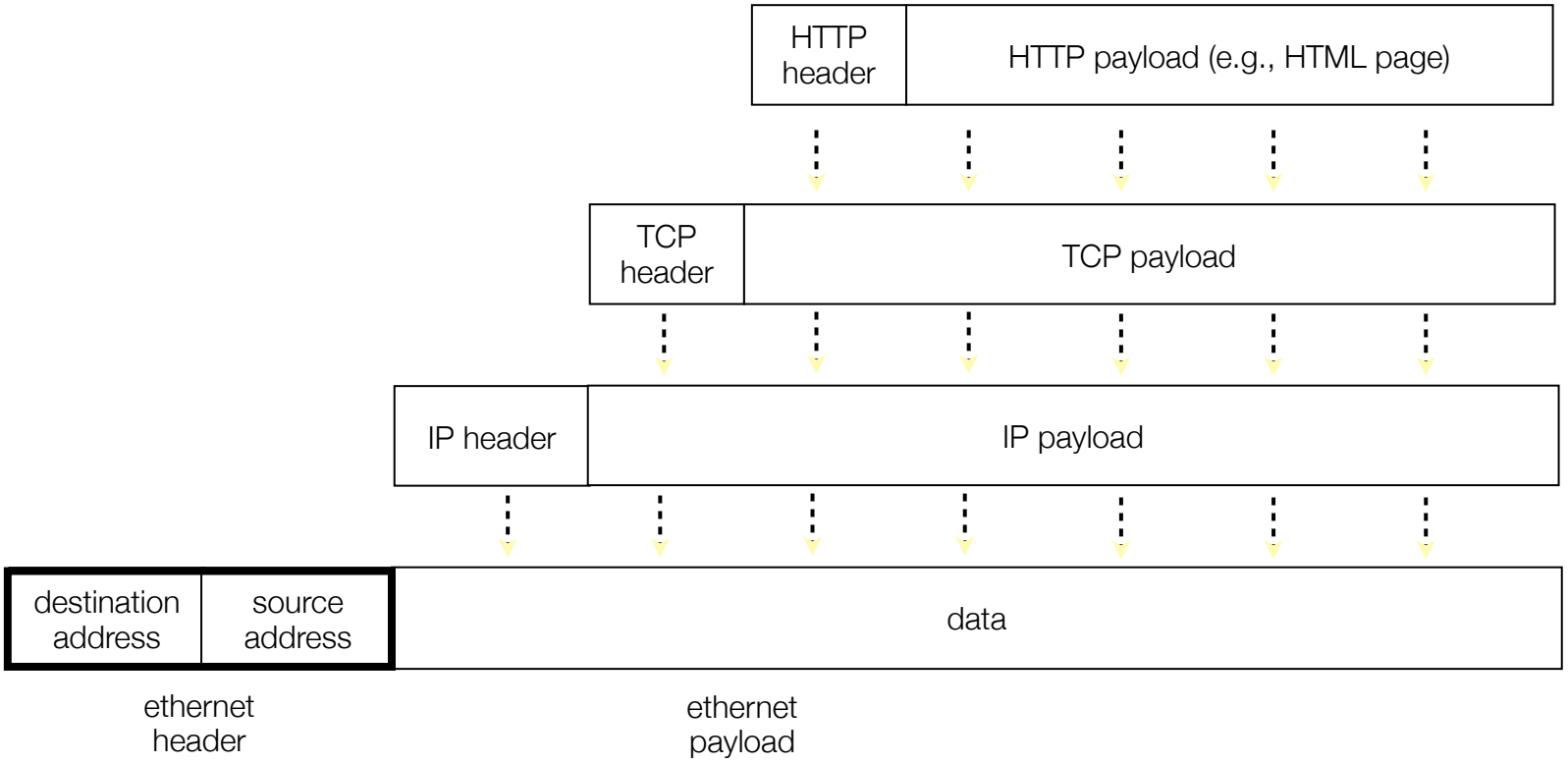


Application protocols

- the format and meaning of messages between application entities
- e.g., HTTP is an application level protocol that dictates how web browsers and web servers communicate
  - HTTP is implemented on top of TCP streams

The “application” layer

Packet encapsulation -- same as before!



The “application” layer

Packet encapsulation -- same as before!

The “application” layer

Popular application-level protocols:

- **DNS**: translates a DNS name (**www.google.com**) into one or more IP addresses (74.125.155.105, 74.125.155.106, ...)
  - a hierarchy of DNS servers cooperate to do this
- **HTTP**: web protocols
- **SMTP**, **IMAP**, **POP**: mail delivery and access protocols
- **ssh**: remote login protocol
- **bittorrent**: peer-to-peer, swarming file sharing protocol

See you on Wednesday!