CSE 333

Lecture 16 -- networks

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Administrivia

HW3 due Thursday

Today - overview of networking

Then - client-side and server-side TCP sockets

Rest of the quarter

HW4 out by Friday; due last Wed. of the quarter

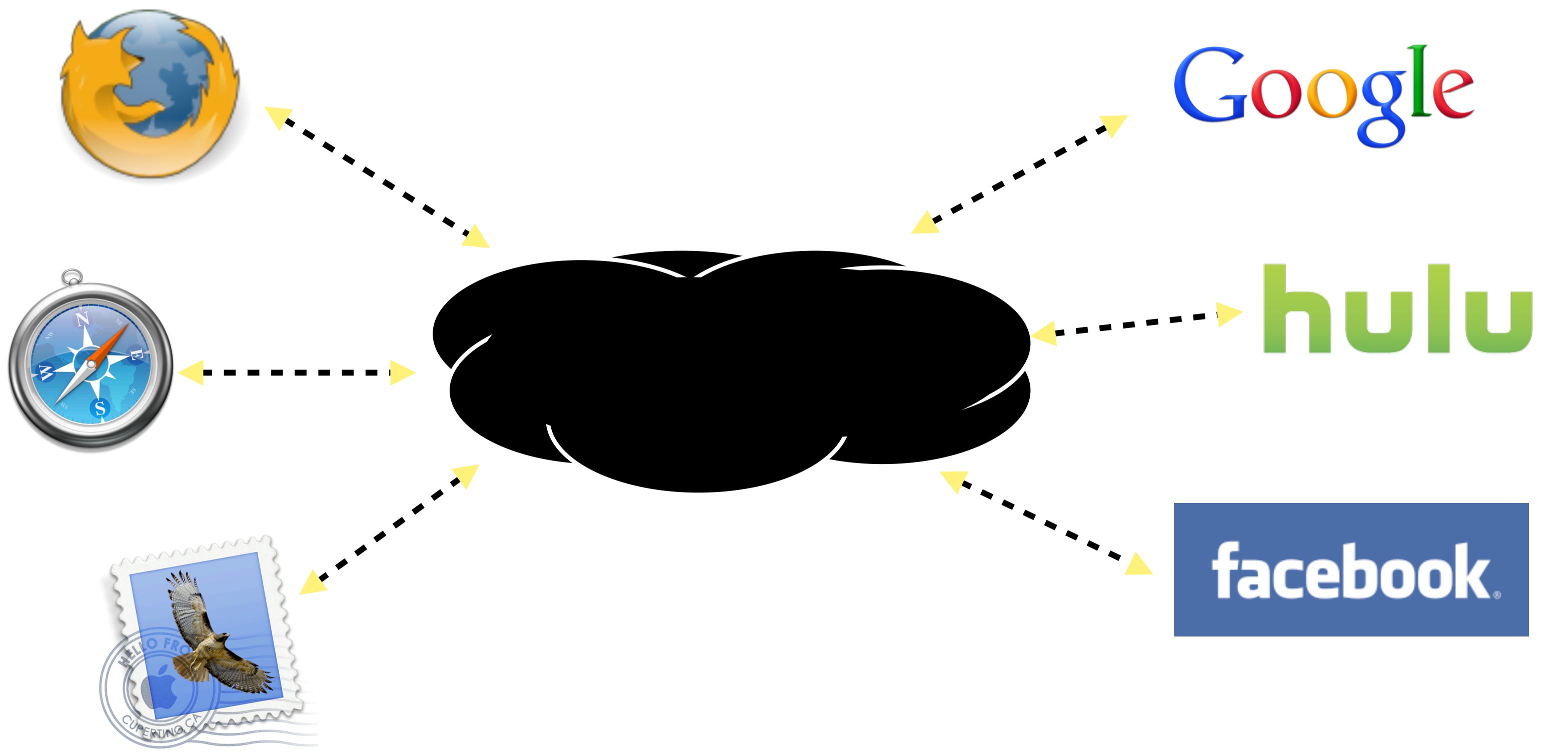
A few more exercises

- No more this week; next one due Mon. after HW3

Second exam last day of class, Fri. 8/22

- Review in sections the day before

Networks from 10,000ft



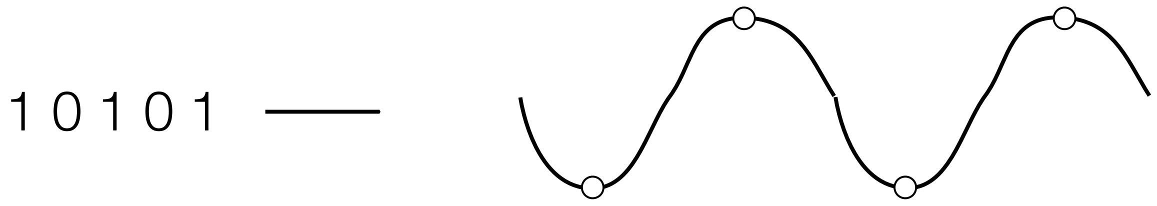
clients

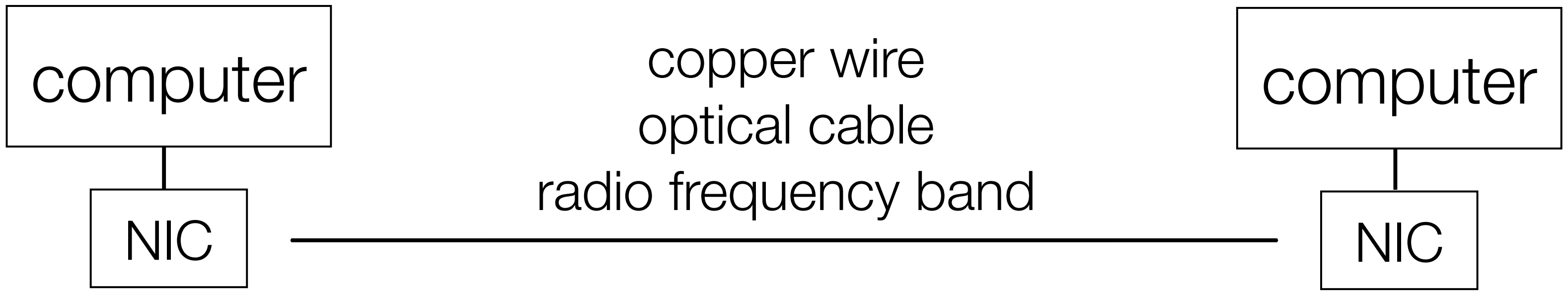
servers

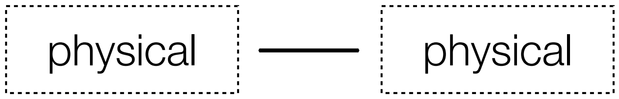
The “physical” layer

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



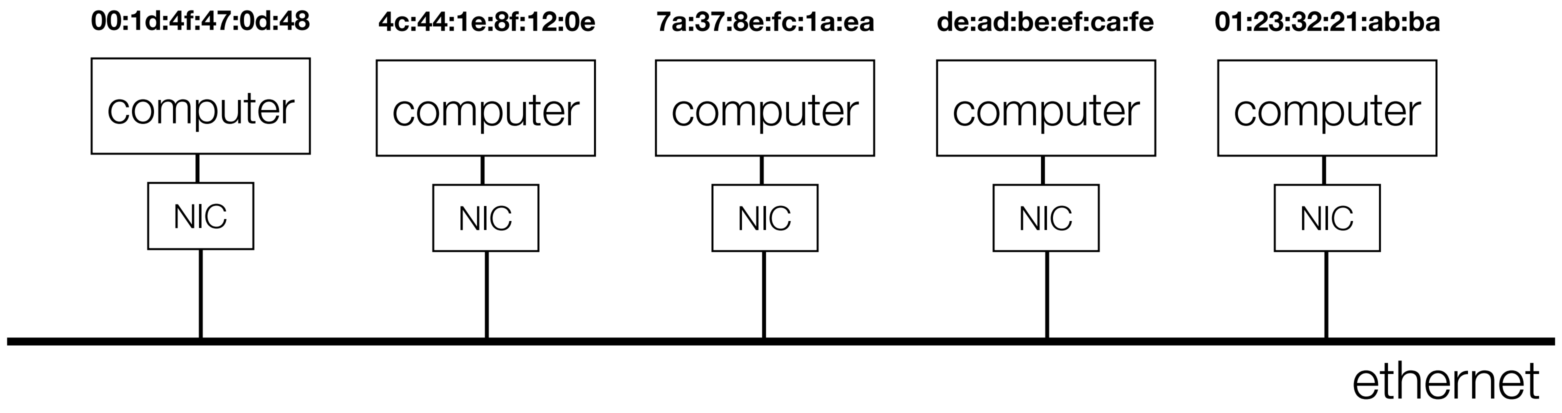


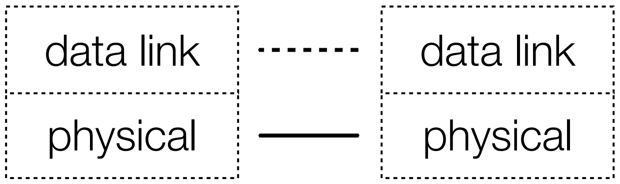


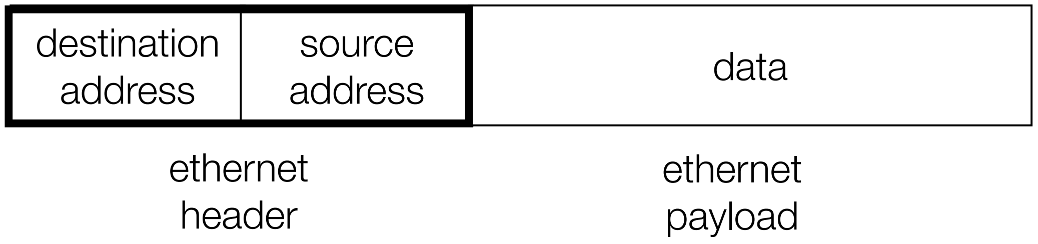
The "data link" layer

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



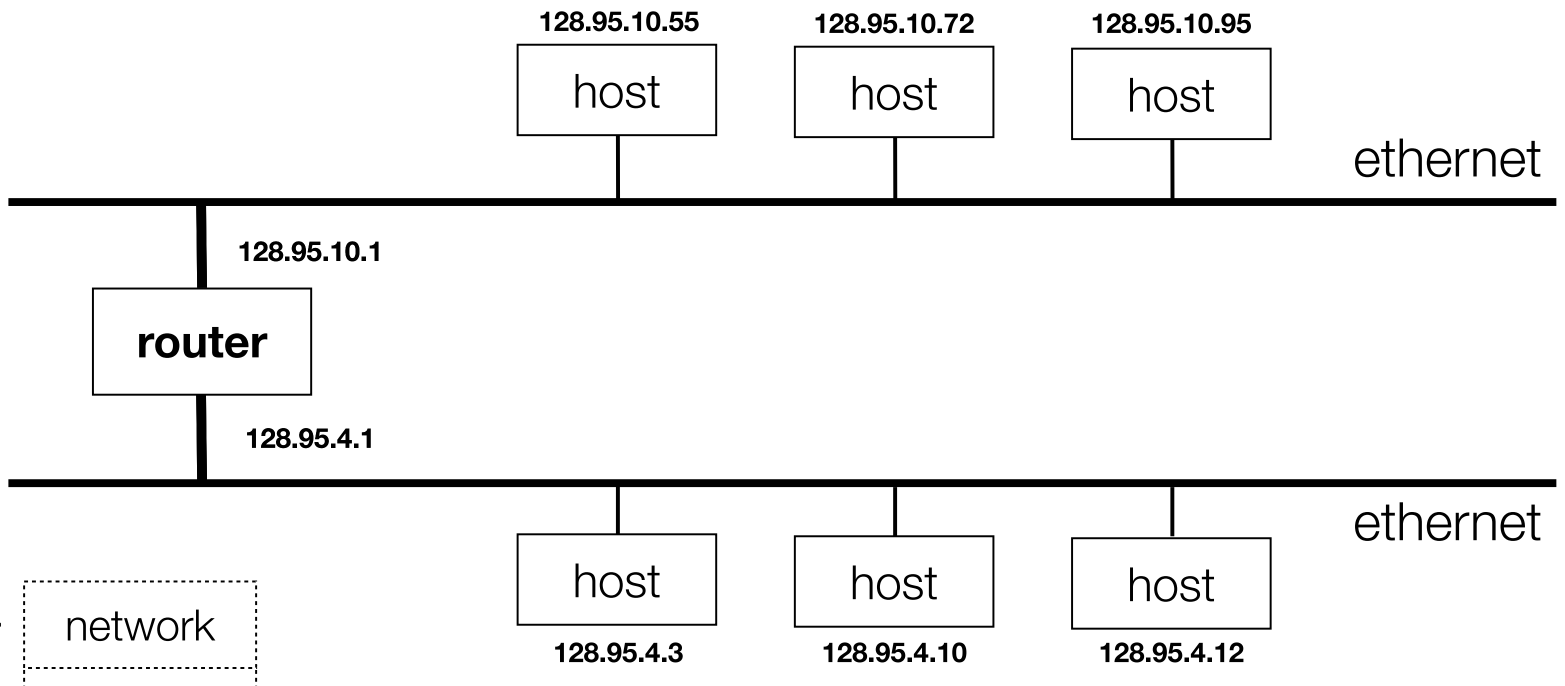


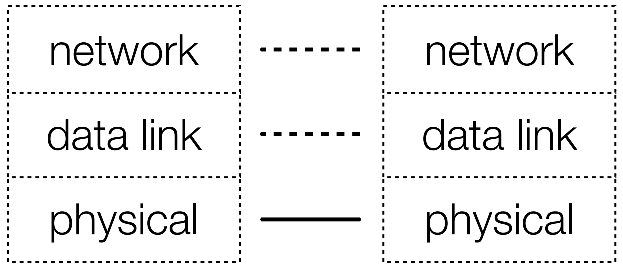


The “network” layer (IP)

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

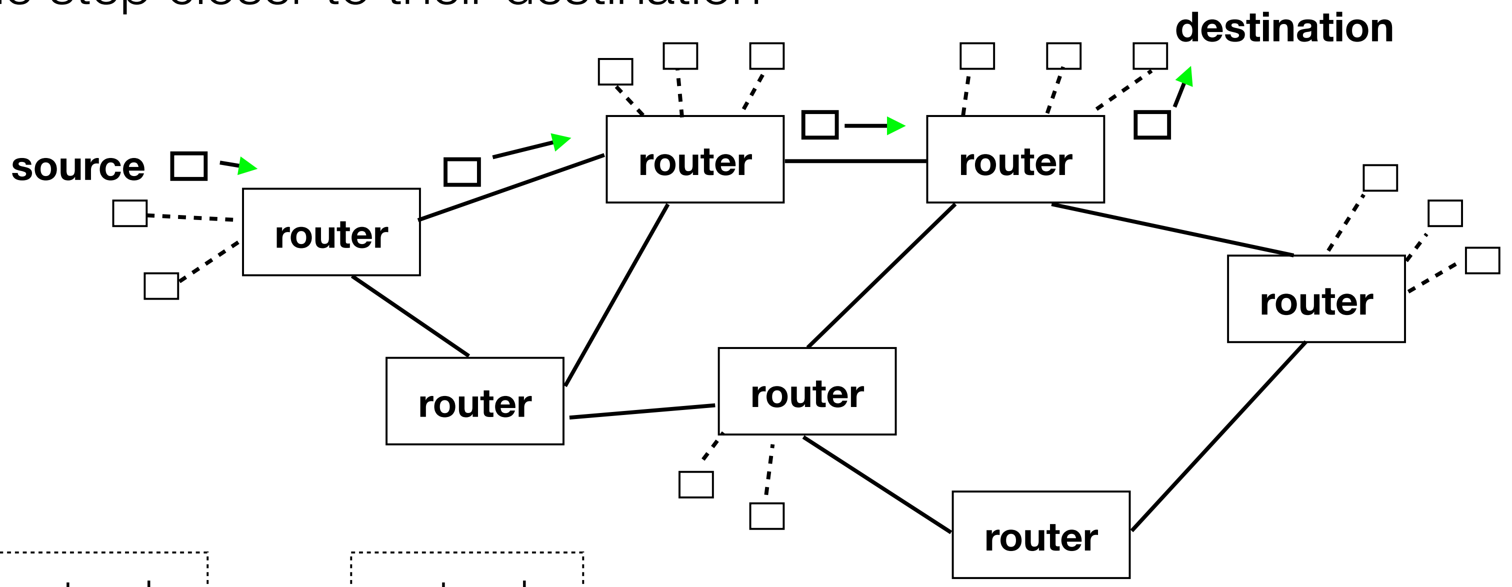


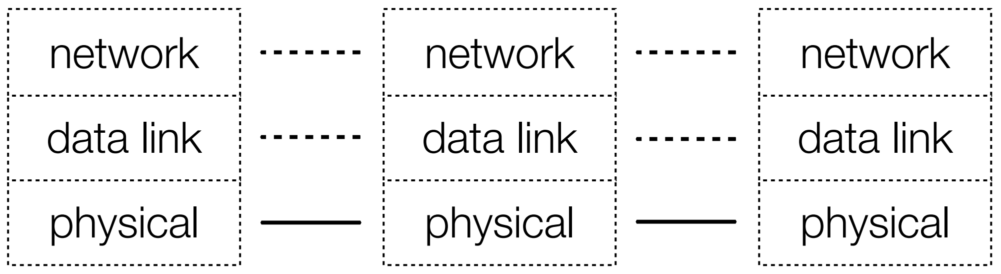


The “network” layer (IP)

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

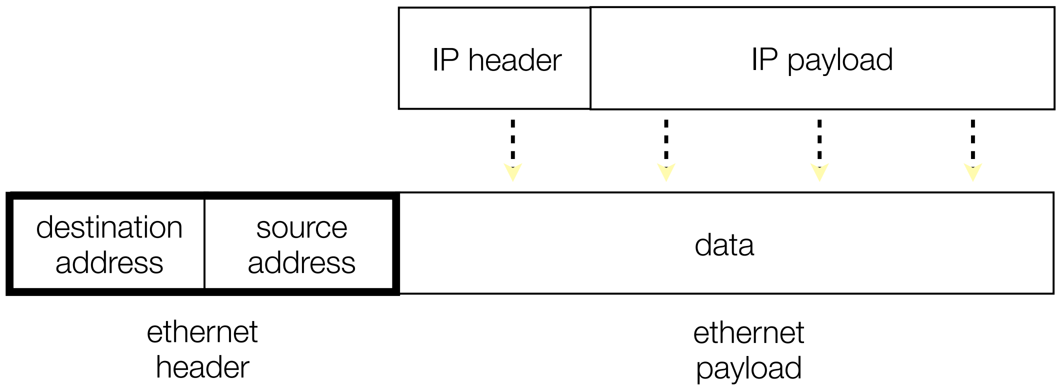


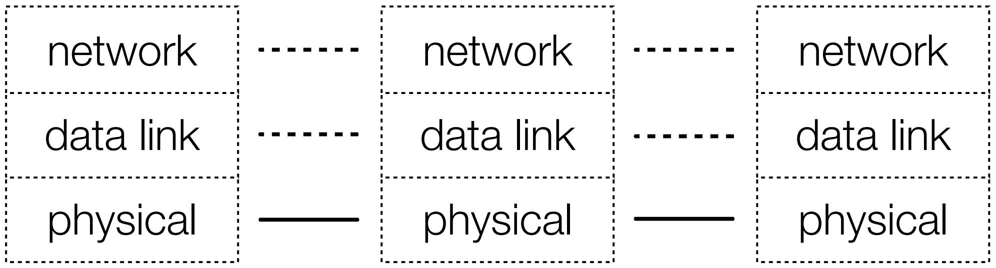


The “network” layer (IP)

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

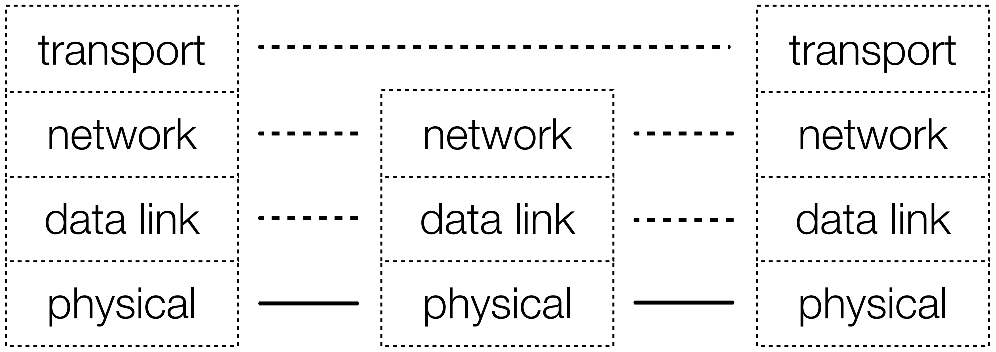




The “transport” layer (TCP, UDP)

TCP

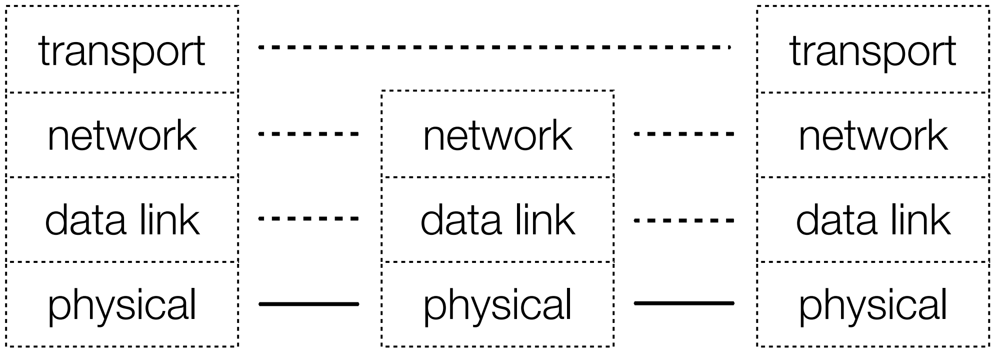
- the “transmission control protocol”
- provides apps with reliable, ordered, congestion-controlled byte streams
- fabricates them by sending multiple IP packets, using sequence numbers to detect missing packets, and retransmitting them
- a single host (IP address) can have up to 65,535 “ports”
  - kind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



The "transport" layer (TCP, UDP)

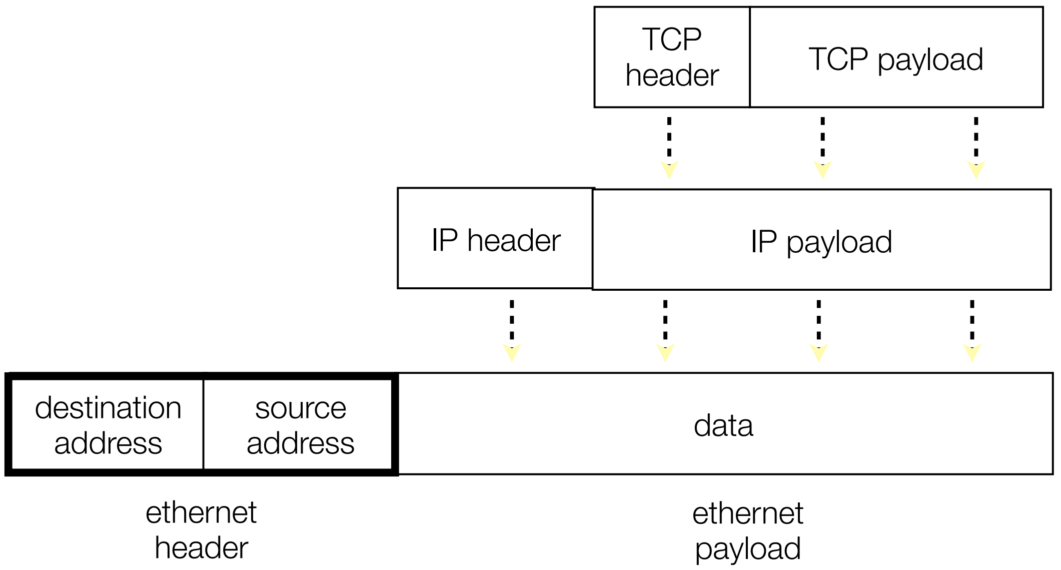
TCP

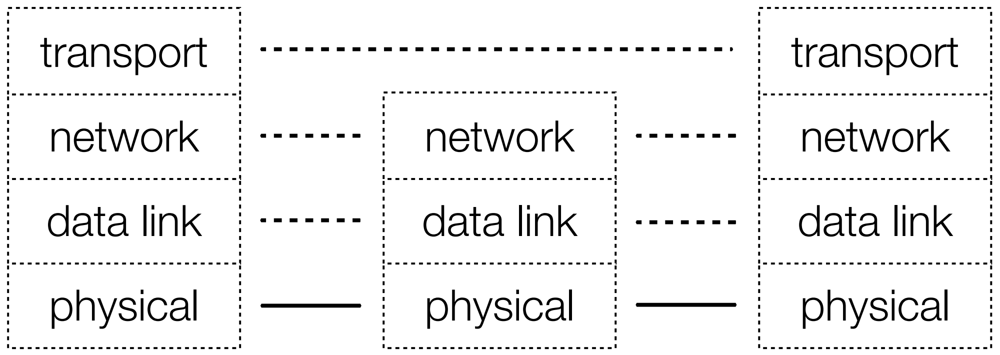
- useful analogy: how would you send a book by mail via postcards?
- split the book into multiple postcards, send each one by one, including sequence numbers that indicate the assembly order
- receiver sends back postcards to acknowledge receipt and indicate which got lost in the mail



The “transport” layer (TCP)

Packet encapsulation -- same as before!

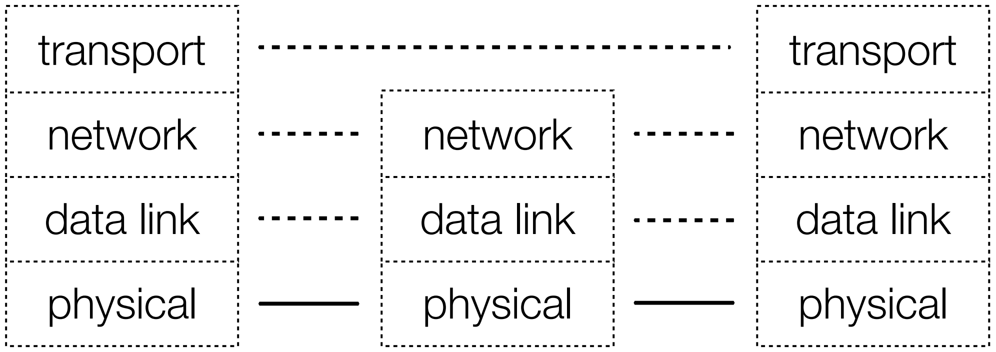




The “transport” layer (TCP)

Applications use OS services to establish TCP streams

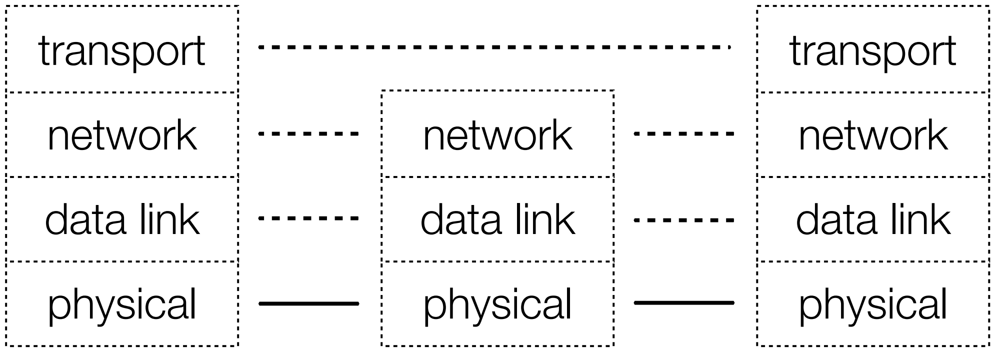
- the “Berkeley sockets” API -- a set of OS system calls
- clients ***connect( )*** to a server IP address + application port number
- servers ***listen( )*** for and ***accept( )*** client connections
- clients, servers ***read( )*** and ***write( )*** data to each other



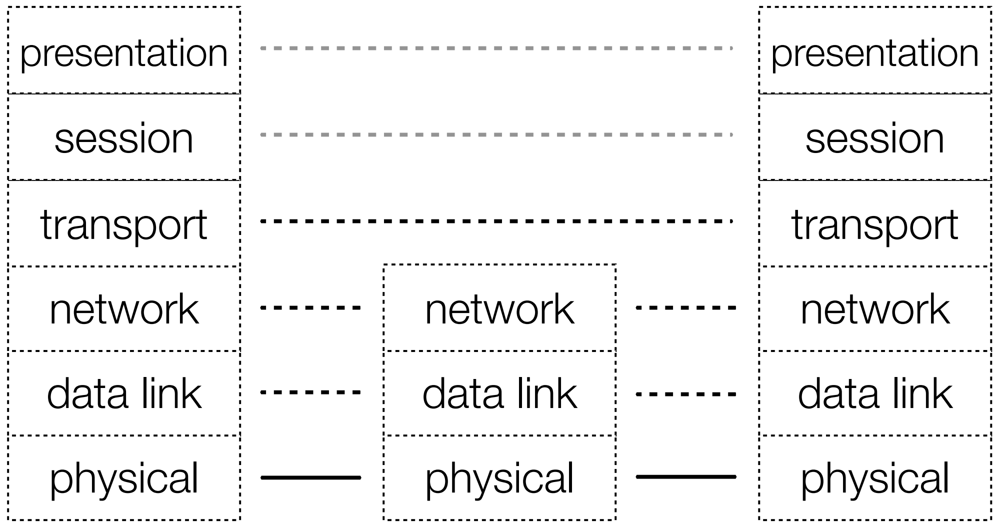
The “transport” layer (UDP)

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



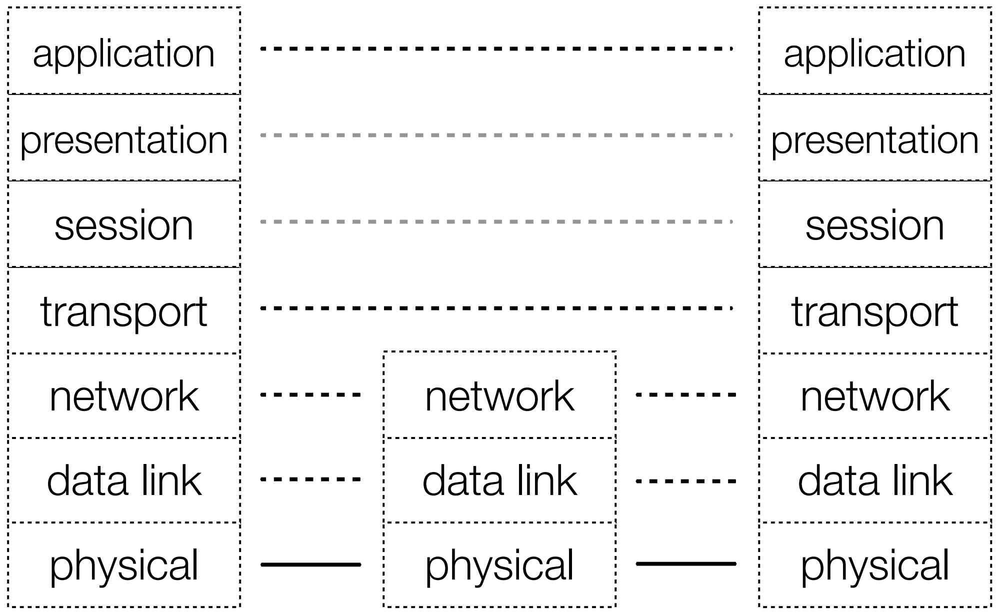
Layer 5: session layer

- 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

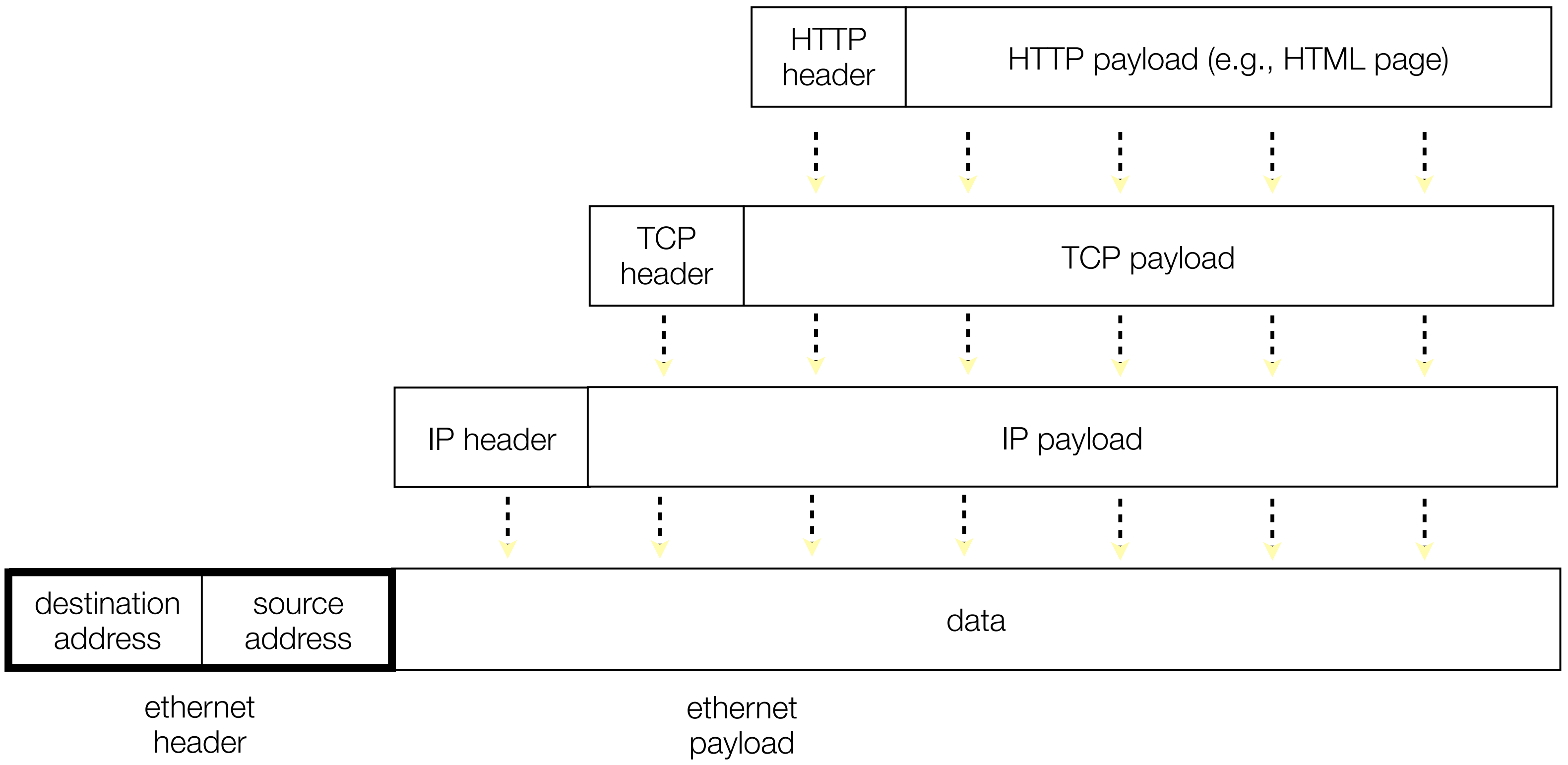


Application protocols

- 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

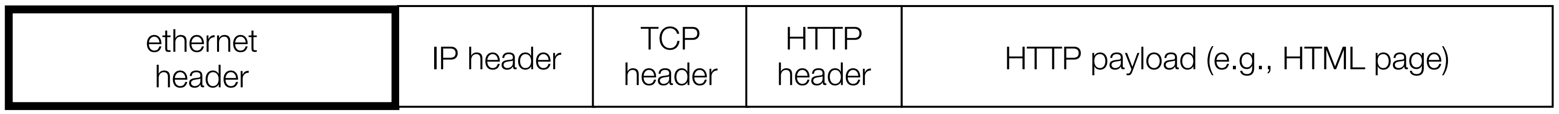
The “application” layer

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!