CSE 333
Lecture 16 -- networks

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HW3 due Thursday night

Today - overview of networking

Then - client-side and server-side TCP sockets
Rest of the quarter

HW4 out Friday; due last Wednesday of the quarter (plus late days if you have/need them)

A few more exercises, but nothing more due this week

Second exam in class last day of the quarter, Fri. 8/19
   Review in section the previous day
Networks from 10,000ft

clients

servers
The “physical” layer

Individual bits are modulated onto a wire or transmitted over radio. The physical layer specifies how bits are encoded at a signal level. E.g., a simple spec would encode “1” as +1V, “0” as -1V.

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1 0 1 0 1
The “data link” layer

Multiple computers on a LAN contend for the network medium. Media access control (MAC) specifies how computers cooperate. The link layer also specifies how bits are packetized and NICs are addressed.

```

computer         computer         computer         computer         computer
                 NIC               NIC               NIC               NIC
```

data link

```

computer         computer         computer         computer         computer
                 NIC               NIC               NIC               NIC
```

data link

```
destination address  source address  data
```

data link

```

computer         computer         computer         computer         computer
                 NIC               NIC               NIC               NIC
```

data link

```

computer         computer         computer         computer         computer
                 NIC               NIC               NIC               NIC
```

data link

```
edestination address  source address  data
```

data link

```

computer         computer         computer         computer         computer
                 NIC               NIC               NIC               NIC
```

data link

```
edestination address  source address  data
```

data link
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.

![Diagram of network with IP addresses and router connections.]

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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

![Diagram showing the encapsulation of an IP packet within an Ethernet frame.](image-url)
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!

| ethernet header | IP header | TCP header | HTTP header | HTTP payload (e.g., HTML page) |
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 Friday!

(But wait! There’s More….)