Plan

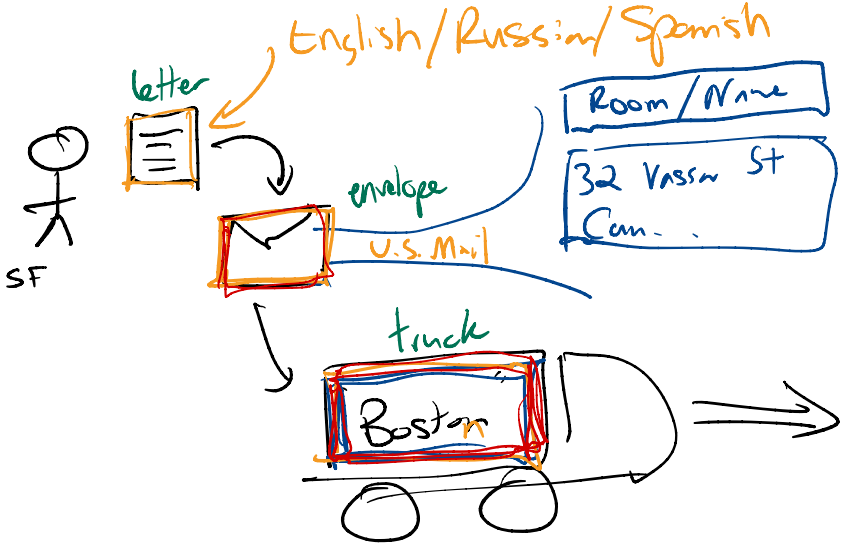
* What is encapsulation?
* Pros/cons
* Application to networks

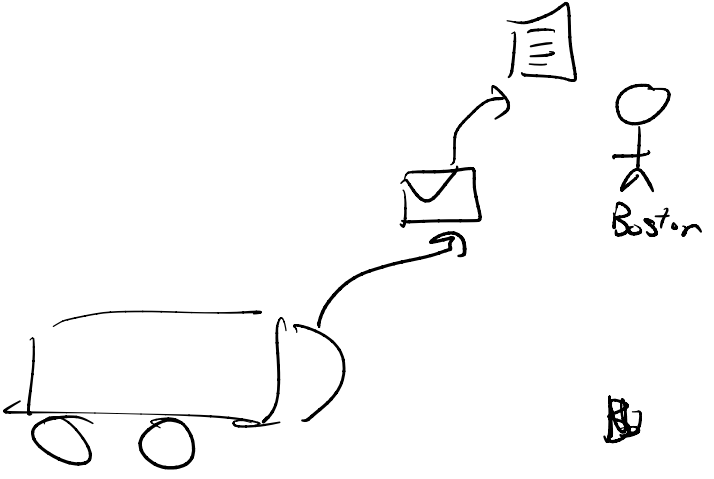
Logistics

* PP prep report assignment due 3/30
* Hands-on (networking) due next Wednesday 3/24
* Read for Thursday: RON

Layering & Encapsulation

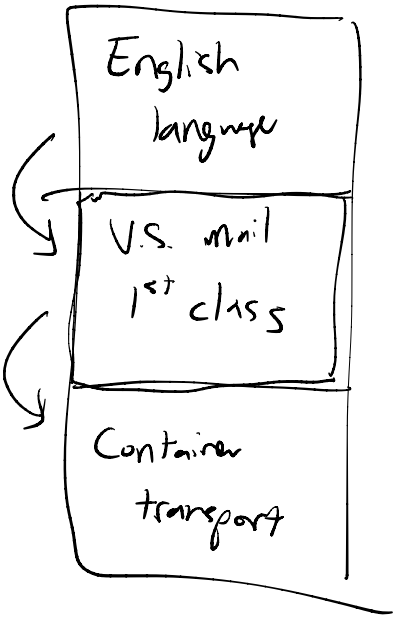
Let's talk about U.S. mail





Encapsulation

* Need to obey the requirements of the layer below.
  - ↳ size/weight
  - ↳ type of content
  - ↳ address well formatted
  - ↳ authentication / payment / rate limiting
* Sender needs to account for guarantees of layer below
  - ↳ reliability
  - ↳ speed / priority



Benefits

+ Scalability (address space)
+ Separation of concerns
+ Privacy (encryption)

Drawbacks

- Need to worry about layer below and what guarantees it does/doesn't provide
- Any layer can fail ⇒ problem
- Inefficiency →
- "Dumb network"

Layering in Networks

Application — What do you want? HTTP Web, FTP, DNS, SSH
(English text of the letter)

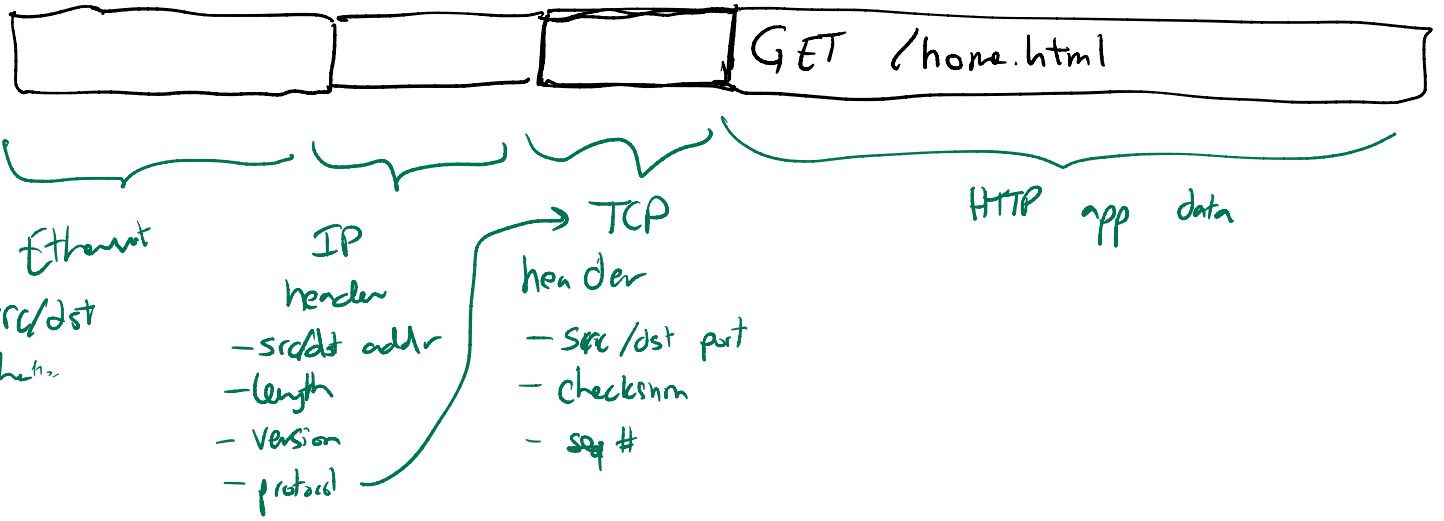
Transport — How do you want it?
TCP = stream of bytes
UDP = individual packets
↳ Which app on your computer gets which messages
(room # on envelope) — port #

Network — Where is it?
IP = address on internet (12.5.72.80)

Link — How is it getting there?
Ethernet, Wifi, DSL, Cable, ...
↳ aa:bb:cc:dd:ee:ff ← MAC address

Physical

When you send data over Internet...



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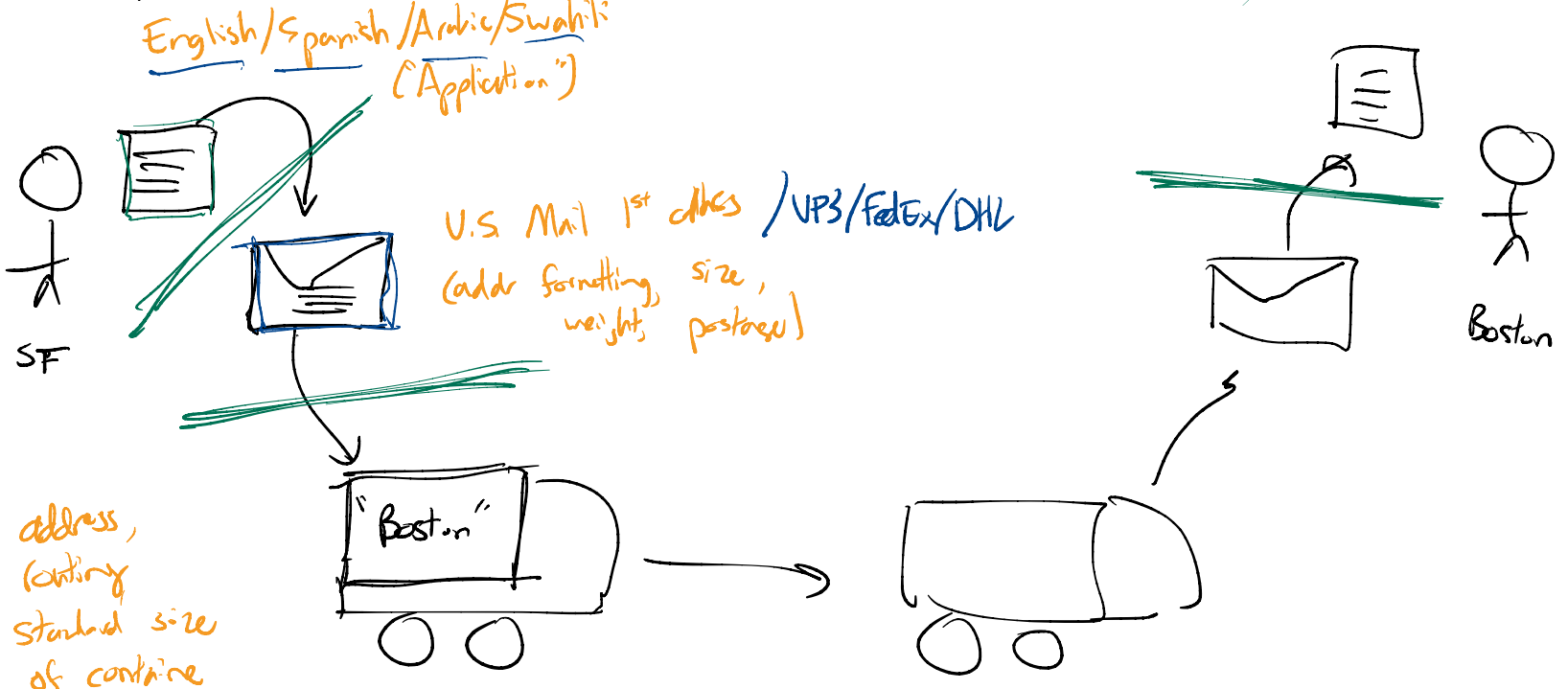
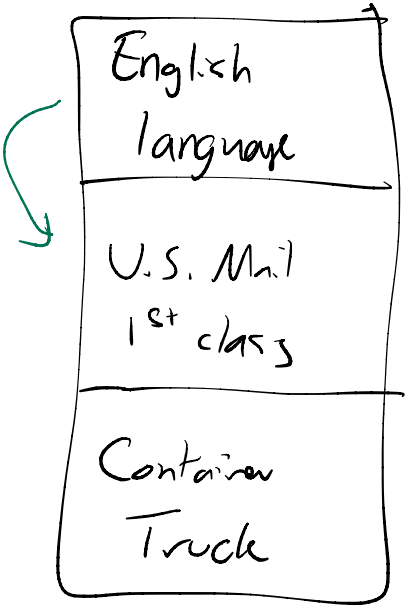
Layering & Encapsulation

helpful to think about in context U.S. Mail



Encapsulation

* Need to obey the requirements of the layer below
  - address formatting
  - size and weight
  - stamp/payment
  - formatting of data
  - ⋮
* Need to be aware of the guarantees of the layer below
  - speed/priority
  - damage/corruption ←
  - ~~loss~~
  - ⋮



Benefits

+ Modular – mix & match
+ Clear contracts / "separation of concerns"
+ Easy to change
  ↳ changes on one level do not affect others — it's chill.

Drawbacks

– Not as efficient / fast
– Have to obey rules of layer below, even if inconvenient
– "Dumb network"
  ↳ harder to implement in-network functionality

Layers in Networks

Application Data — What do you want?

HTTP, HTTPS, SSH, SCP, FTP, DNS, IMAP, POP

Transport Layer — How do you want it?

UDP, TCP

TCP = streams of bytes in order, no loss

UDP = individual packets (video, audio)

port # 1-65536

http://mit.edu:8080/

Network Layer — Where is it?

IP

IP = address on internet

72.31.5.123

32-bit addr (v4)

Link Layer — How are packets moving across a link?

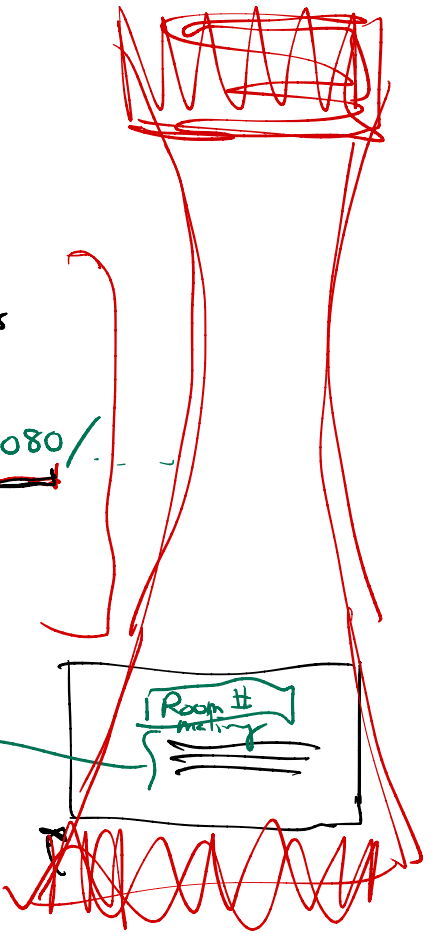
Ethernet, MAC, ... protocol

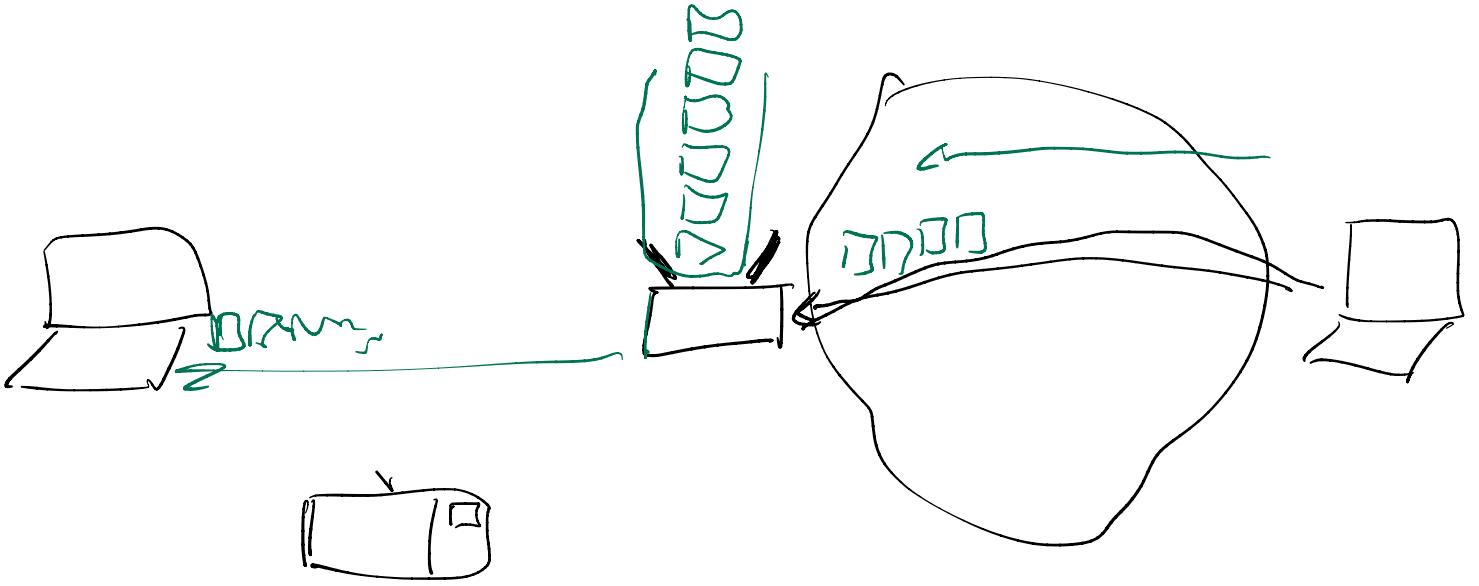
In Ethernet (aa:bb:cc:dd:ee:ff)

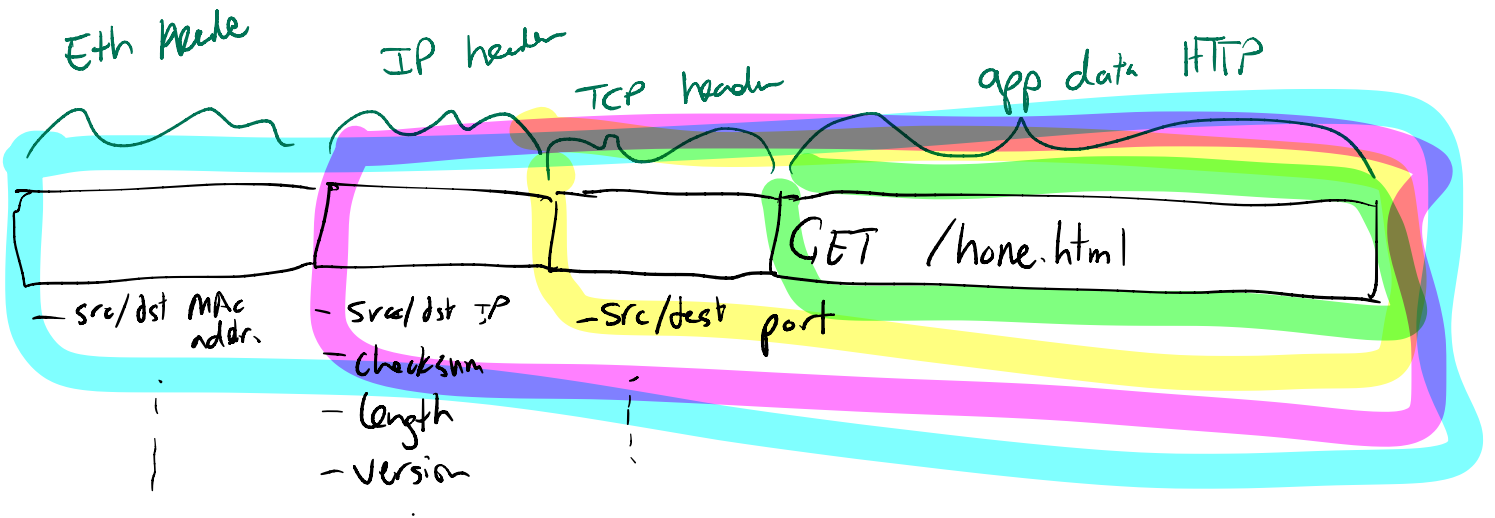
48-bit MAC

Physical

Hourglass shape




מנוחה


Eth header
IP header
TCP header
app data HTTP
GET /home.html
- src/dst MAC addr.
- src/dst IP
- Checksum
- length
- version
- src/dest port