Plan

* Recitation Qs

* Recap: Layers

* E2E Overview

* Breakout rooms
  pros & cons

* "Name that layer"

Logistics

* Mid term   April 6 !

* No recitation

* New hands-on — April 2

* Tech feedback on DPPR
  on
  April 9

* Volunteers for next week

1. Sharon

What is the end-to-end argument?
↳ Don't implement "interesting" functionality at low layers.
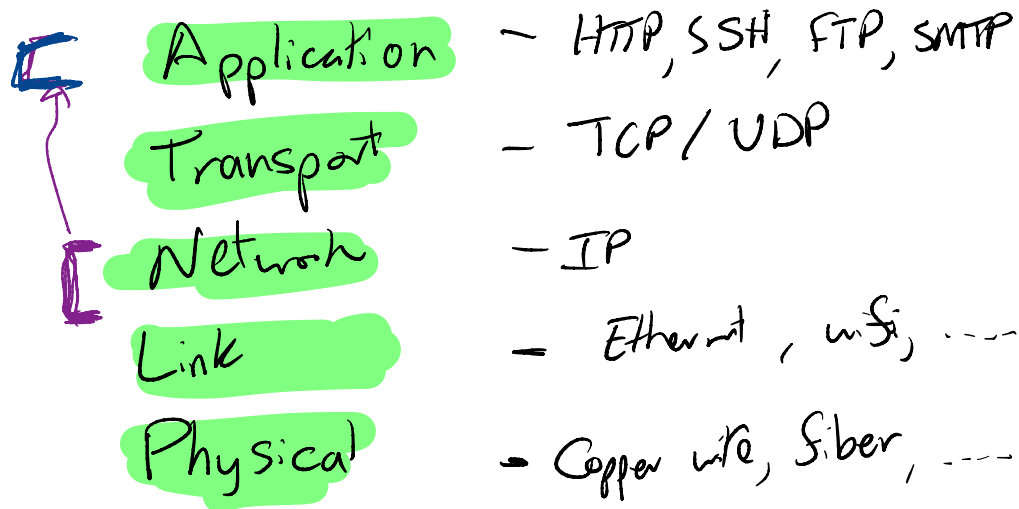
2. Ycan

How is E2E used in practice?
↳ e.g. Voice packets & reliable transfer

3. Shirley

Do you agree w/ E2E arg? Why?
↳ Simplicity & efficiency. Used with caution.

Layering (Recap)

- Application — HTTP, SSH, FTP, SMTP
- Transport — TCP / UDP
- Network — IP
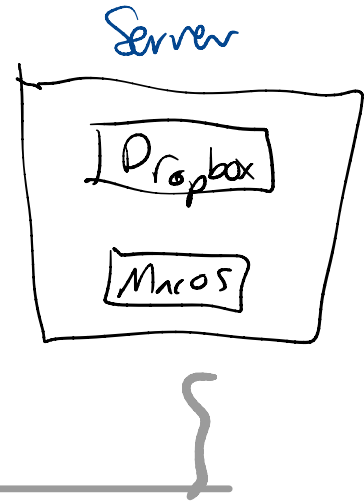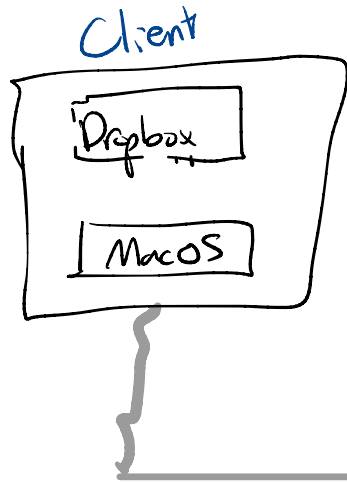- Link — Ethernet, wifi, ...
- Physical — Copper wire, fiber, ...

One way to think about E2E argument...

"The libertarian view of computer systems."

↳ let the app handle it

↳ full freedom for the application

* more flexibility
* more work
* less efficient
* can get it wrong

→ "Dumb network"

Case Study: Robust file transfer

Client

Dropbox

MacOS

Server

Dropbox

MacOS

App
Transport
Network
Link
Physical → expensive
          - imperfect

Examples:

− UNIX — minimal abstractions (file system)

− RISC versus CISC ↓↓↓

   ↳ ARM   X86-64

      50 instructions   ≈ 3000 instructions

C program

Assembly
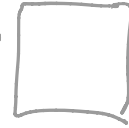
Benefits ^{of E2E}

Drawbacks

+ If going to implement functionality, has to be compatible/harmonized with layers above

+ Modularity — abstraction

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1. What is the E2E argument?

↳ Functionality should be at highest levels of the stack.

Network doesn't do enough

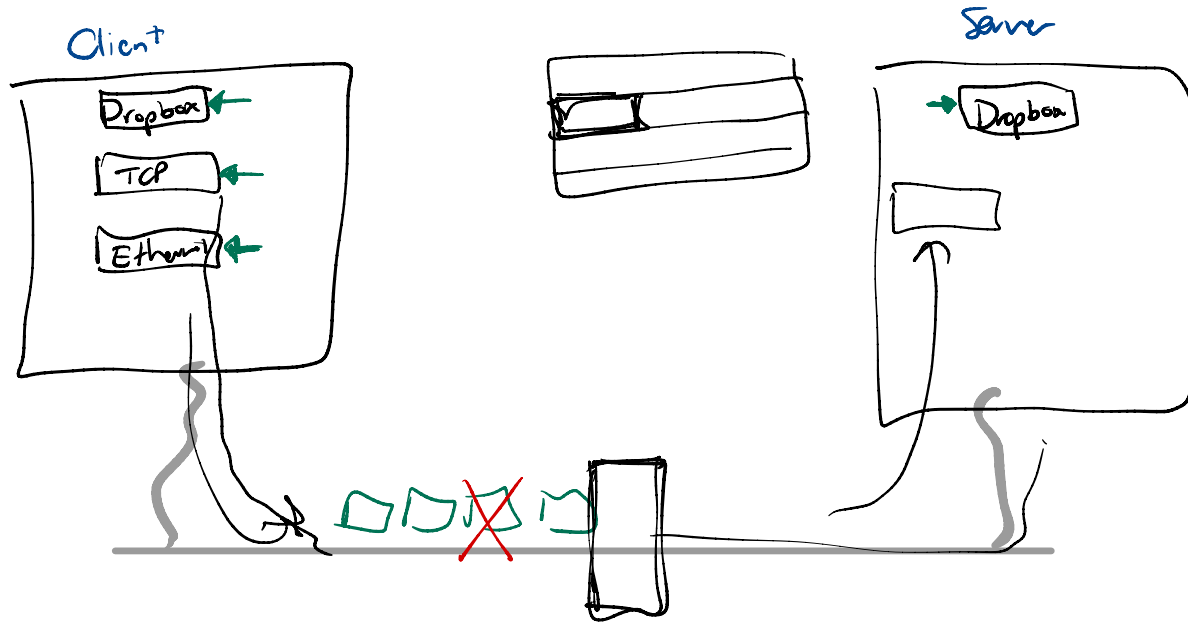Network does something app doesn't need/want (Cost)

Layers

↑

- **Application** — Web HTTP / SMTP / FTP / ...
- **Transport** — TCP / UDP
- **Network** — IP
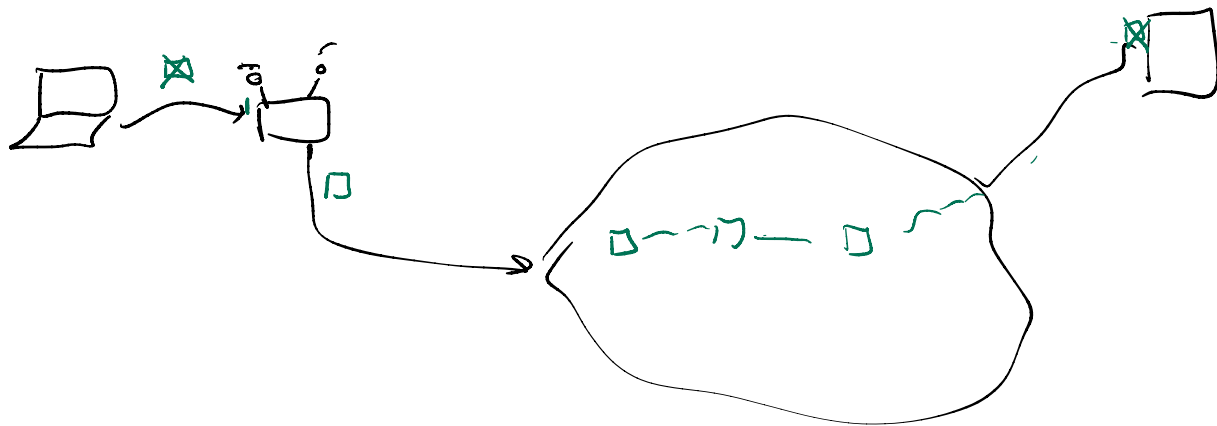- **Link** — Ethernet, wifi, ...
- **Physical** — Copper wire, fiber, ...

2. How is E2E argument used in practice?

↳ "Open OS"

- Reliable transport in gateway / network

- Checksum

Client

Dropbox

TCP

Ethernet

Server

Dropbox

3. Do you agree with E2E argument?

- Some benefits to having functionality at both levels
- In-network functionality can be very useful

→ "Dumb network"   "Smart endpoint"

Benefits of fn at highest/app layer

+ Less redundancy
+ No extra cost / unnecessary functionality

+ Modularity
+ Simplicity of implementation

+ Performance

+ Flexibility

Drawbacks

- Failure localization harder
- Waste
- Each app has to reinvent the wheel

- Relies on clear API/assumption

- Lose opportunities for optimization
  ↳ caching

Simple & easy

DIY transport

98%   2%

TCP UDP

IP

Go
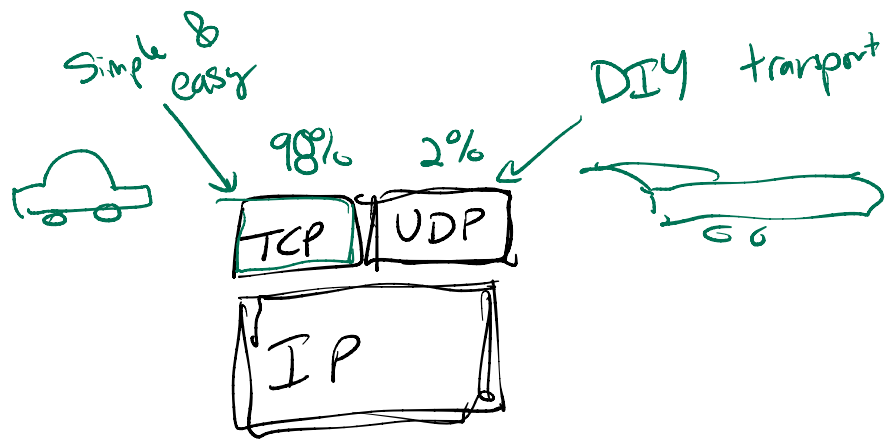
Poll: Which layer?

- Encryption

- Denial-of-service prevention