Our Problem

- Communications is more complicated than it seems
  - Modulation and encoding bits
  - Splitting sequences of bits into packets
  - Fixing errors
  - Controlling access to network
  - Routing
  - Recovering from lost messages
  - Etc….
- Really hard to think about all of this and get it right
- Not all applications need all of it
- How to achieve interoperability?
Protocol Standardization

- Communicating hosts speaking the same protocol
  - Standardization to enable multiple implementations
  - Or, the same folks have to write all the software

- Internet Engineering Task Force
  - Based on working groups that focus on specific issues
  - Produces “Request For Comments” (RFCs)
    - Rough consensus and running code
    - After enough time passes, promoted to Internet Standards

- Other standards bodies exist
  - ISO, ITU, IEEE, etc.
UCSD students recently recognized by IETF!

January 10 — Congratulations to Gautam Akiwate (and his co-authors) for being named as a winner of the Internet Research Task Force’s Applied Networking Research Prize for his work characterizing a domain hijacking risk that is an accidental byproduct of undocumented operational practices between domain registrars and registries. Gautam’s award marks the second year in a row that the group has received the prize (Audrey Randall received it last year). Let's keep the streak going!

**Applied Networking Research Prize**

CSE/CNS graduate student Audrey Randall was recently awarded the Applied Networking Research Prize (ANRP) for her work on DNS caching and privacy. The ANRP winners for 2021 were selected from 76 nominations. They were reviewed according to a diverse set of criteria, including scientific merit, relevance to IETF and/or IRTF activities, and the nominee’s potential to impact the community.

Layering: A Modular Approach

- Sub-divide the problem
  - Each layer relies on services from layer below
  - Each layer exports services to layer above

- Interface between layers defines interaction
  - Hides implementation details (encapsulation)
  - Layers can change without disturbing other layers (modularity)

- Interface among peers in a layer is a protocol
  - If peers speak same protocol, they can interoperate
We will start the class here.
Key Design Decision…

…how do you divide functionality across the layers?

End-to-end argument [Saltzer84]
- Functionality should be implemented at a lower layer iff it can be correctly and completely implemented there.
- Incomplete versions of a function can be used as a performance enhancement, but not for correctness.

Early, and still relevant, example
- ARPAnet (link layer) provided: reliable transfers across links between switches.
- Was this enough for reliable communication?
- No, packets could still get corrupted on host-switch link, or inside of the switches.
- Hence, still need reliability at higher layers.
Layering we ended up with: Internet Protocol Suite

The Hourglass Model

A variety of applications

FTP  HTTP  NV  TFTP
TCP  UDP
IP

Applications
Transport
Data Link
Physical

“The Thin Waist”

...on a variety of networks

The success of the Internet (and its problems) can largely be attributed to the “thin waist”

CSE 123 – Lecture 2: Layers & Framing
Layers encapsulated via headers

- Typical packet in Web transfer
  - Ethernet Hdr
  - IP Hdr
  - TCP Hdr
  - HTTP Hdr
  - Payload (Web object)

- Notice that layers (and thus headers) add overhead
  - Space (headers), effective bandwidth
  - Time (processing headers, “peeling the onion”), latency
Later: Phy/(MAC)Link layer

- **Signal encoding**
  - Encode binary data from source node into signals that physical links carry
  - Signal is decoded back into binary data at receiving node
  - Work performed by network adapter at sender and receiver

- **Media access**
  - Arbitrate which nodes can send frames at any point in time
  - Not always necessary; e.g. point-to-point duplex links
For now: (Data) Link Layer

- **Framing**
  - Break stream of bits up into discrete chunks
  - **Multiplexing**
    » Share a link with multiple sources and destinations
    » Also not always required; again, point-to-point

- **Error handling**
  - Detect and/or correct errors in received frames
Today’s Focus: Framing

Break down a stream of bits into smaller, digestible chunks called **frames**

- Identifies the beginning and end of a chunk of information
- Allows the link to be shared (**Multiplexing**)  
  - Multiple senders and/or receivers can **time multiplex** the link  
    - One frame sent at a time  
  - Each frame can be separately addressed (different src/dest)
- Provides manageable unit for **error handling**  
  - Easy to determine whether something went wrong  
  - And perhaps even to fix it if desired
What’s in a Frame?

- Wraps payload bits up with some additional information
  - Header usually contains addressing information
  - Maybe includes a trailer (w/checksum—next lecture)
- Basic unit of reception
  - Link either delivers entire frame payload, or none of it
  - Typically some maximum transmission unit (MTU)
- Some link layers require absence of frames as well
  - I.e., minimum gaps between frames
Identifying Frames

- First task is to **delineate** frames
  - Receiver needs to know when a frame **starts** and **ends**
  - Otherwise, errors from misinterpretation of data stream

- Several different alternatives
  - Fixed length (bits) frames
  - Explicitly delimited frames
    - Length-based framing
    - Sentinel-based framing
  - Fixed duration (seconds) frames
#1 Fixed-Length Frames

- Easy to manage for receiver
  - Well understood buffering requirements

- Introduces inefficiencies for variable length payloads
  - May waste space (padding) for small payloads
  - Larger payloads need to be fragmented across many frames
  - Very common inside switches

- Requires explicit design tradeoff
  - ATM uses 53-byte frames (cells)
To avoid overhead, we’d like variable length frames
- Each frame declares how long it is
- E.g. DECNet DDCMP

What’s the issue with explicit length field?
- Must correctly read the length field (bad if corrupted)
  » Need to decode while receiving
- Still need to identify the beginning…
For Next Class

- Read 2.4
- Project 1 out on Friday