CSE/EE 461 – Lecture 2

Protocols and Layering

Last Time …

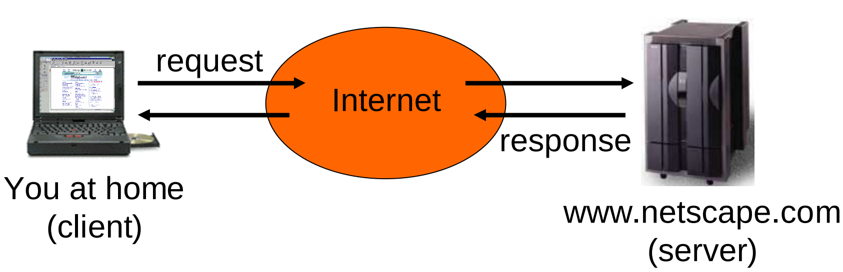
- Networks are used to share distributed resources
  - Key problems revolve around effective resource sharing
- Statistical multiplexing
  - It's well-suited to data communications

This Lecture

1. A top-down look at the Internet
2. Mechanics of protocols and layering
3. The OSI/Internet models

1. A Brief Tour of the Internet

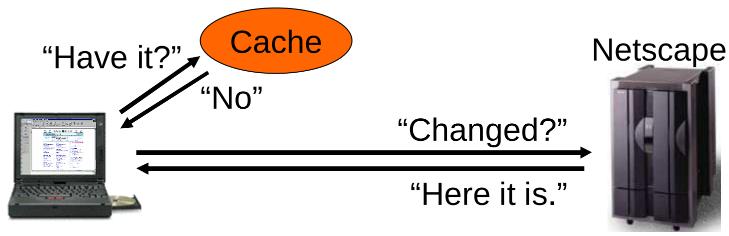
- What happens when you "click" on a web link?



- This is the view from 10,000 ft …

9,000 ft: Scalability

- Caching improves scalability



- We cut down on transfers:
  - Check cache (local or proxy) for a copy
  - Check with server for a new version

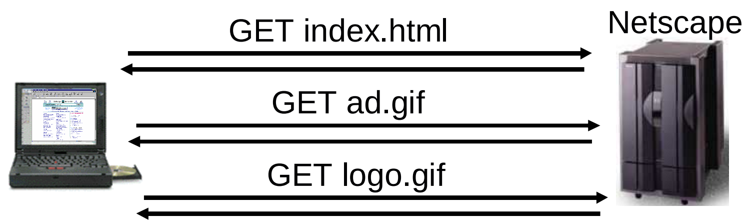
8,000 ft: Naming (DNS)

- Map domain names to IP network addresses

- All messages are sent using IP addresses
  - So we have to translate names to addresses first
  - But we cache translations to avoid next time

7,000 ft: Sessions (HTTP)

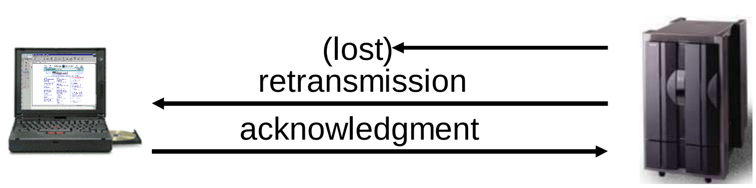
- A single web page can be multiple “objects”



- Fetch each “object”
  - either sequentially or in parallel

6,000 ft: Reliability (TCP)

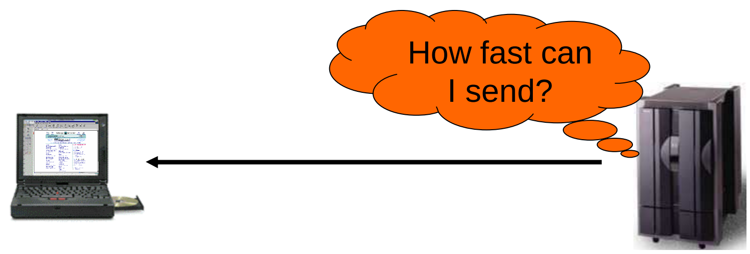
- Messages can get lost



- We acknowledge successful receipt and detect and retransmit lost messages (e.g., timeouts)

5,000 ft: Congestion (TCP)

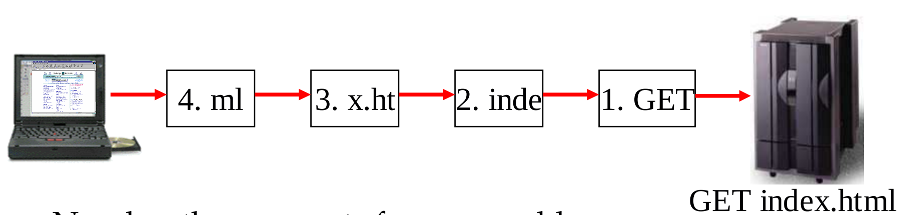
- Need to allocate bandwidth between users



- Senders balance available and required bandwidths by probing network path and observing the response

4,000 ft: Packets (TCP/IP)

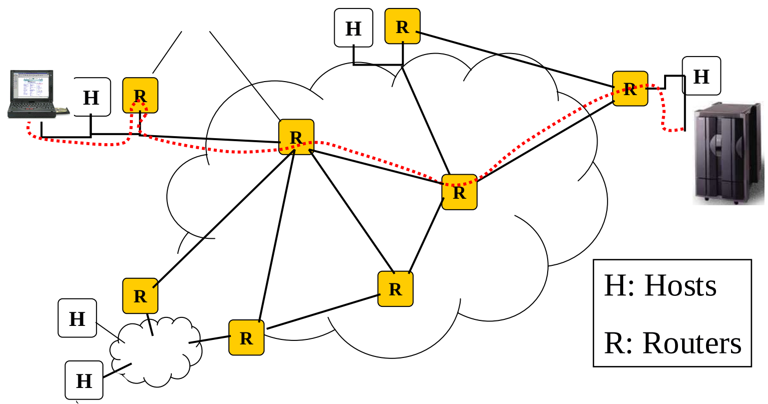
- Long messages are broken into packets
  - Maximum Ethernet packet is 1.5 Kbytes
  - Typical web page is 10 Kbytes



- Number the segments for reassembly

3,000 ft: Routing (IP)

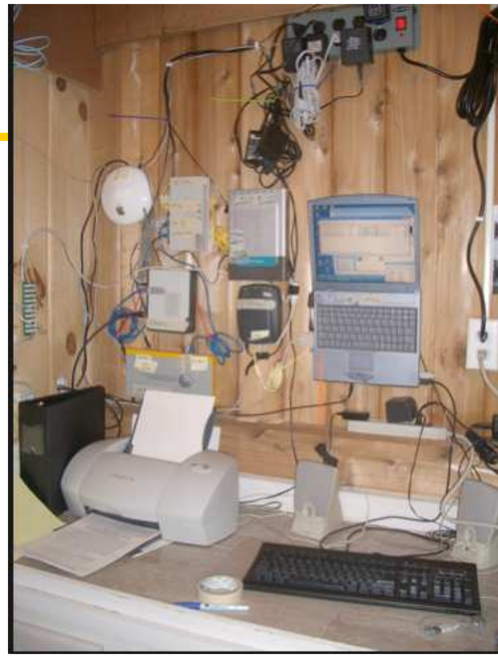
- Packets are directed through many routers



Routers

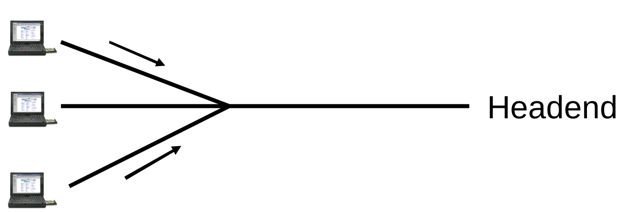
1-10Mb/s < 1Gb/s 92Tb/s

bfr



2,000 ft: Multi-access (e.g., Cable)

- May need to share links with other senders



- Poll headend to receive a timeslot to send upstream
  - Headend controls all downstream transmissions
  - A lower level of addressing is used …

1,000 ft: Framing/Modulation

- Protect, delimit and modulate payload as a signal

Sync / Unique	Header	Payload w/ error correcting code

- E.g, for cable, take payload, add error protection (Reed-Solomon), header and framing, then turn into a signal
  - Modulate data to assigned channel and time (upstream)
  - Downstream, 6 MHz (~30 Mbps), Upstream ~2 MHz (~3 Mbps)

2. Protocols and Layering

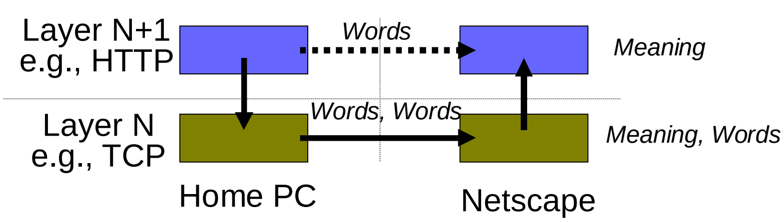
- We need abstractions to handle all this system complexity
- *A protocol is an agreement dictating the form and function of data exchanged between parties to effect communication*
- Two parts:
  - Syntax: Words.
    - where the bits go
  - Semantics:Meaning
    - what the words mean, what to do with them
- Examples:
  - Ordering pizza
  - IP, the Internet protocol
  - TCP and HTTP, for the Web

Protocol Standards

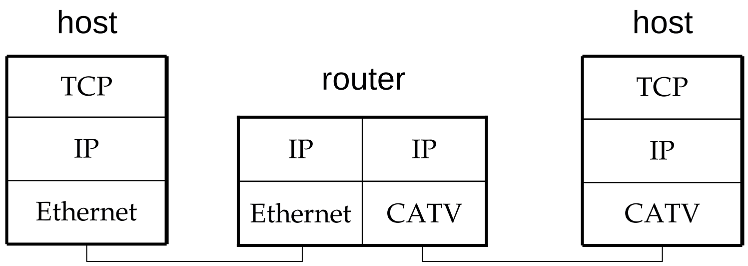
- Different functions require different protocols
- Thus there are many protocol standards
  - E.g., IP, TCP, UDP, HTTP, DNS, FTP, SMTP, NNTP, ARP, Ethernet/802.3, 802.11, RIP, OPSF, 802.1D, NFS, ICMP, IGMP, DVMRP, IPSEC, PIM-SM, BGP, …
- Organizations: IETF, IEEE, ITU
- IETF (www.ietf.org) specifies Internet-related protocols
  - RFCs (Requests for Comments)
  - "We reject kings, presidents and voting. We believe in rough consensus and running code." – Dave Clark.

Layering and Protocol Stacks

- Layering is how we combine protocols
  - Higher level protocols build on services provided by lower levels
  - Peer layers communicate with each other



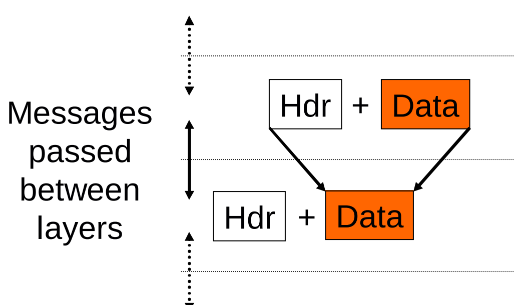
Example – Layering at work



- We can connect different systems

Layering Mechanics

- Encapsulation and deencapsulation



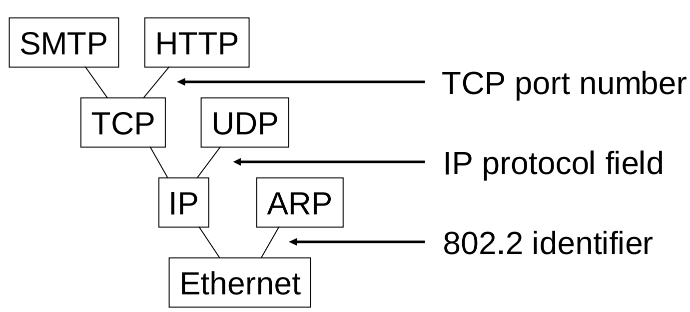
A Packet on the Wire

- Starts looking like an onion!

- This isn't entirely accurate
  - ignores segmentation and reassembly, Ethernet trailers, etc.
- But you can see that layering adds overhead

More Layering Mechanics

- Multiplexing and demultiplexing in a protocol graph



3. OSI/Internet Protocol Stacks

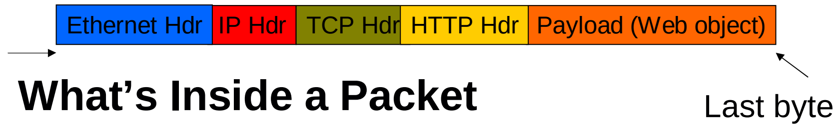
Key Question: What functionality goes in which protocol?

The “End to End Argument” (Reed, Saltzer, Clark, 1984):

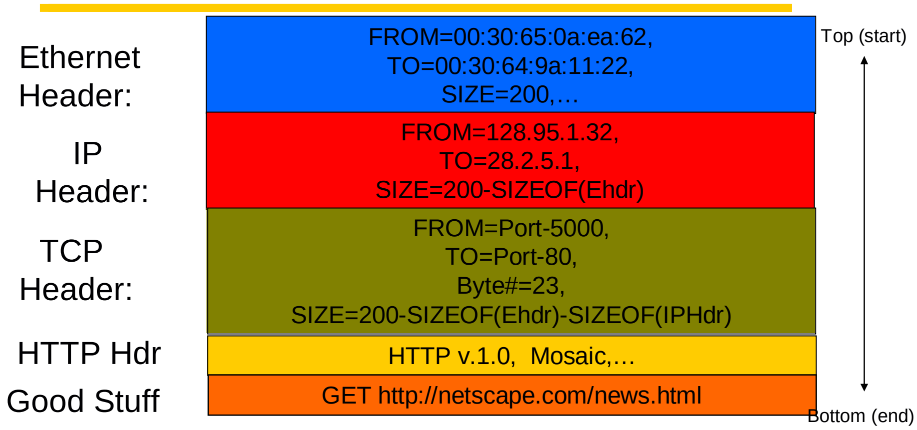
- *Functionality should be implemented at a lower layer only if it can be correctly and completely implemented. (Sometimes an incomplete implementation can be useful as a performance optimization.)*
- Tends to push functions to the endpoints, which has aided the transparency and extensibility of the Internet.

Internet Protocol Framework

Model	Protocols
Application	Many (HTTP,SMTP)
Transport	TCP / UDP
Network	IP
Link	Many (Ethernet, …)



What's Inside a Packet



A Protocol is an ENCAPSULATION.
One protocol's *payload* may be another encapsulated protocol.

OSI "Seven Layer" Reference Model

- Seven Layers:

Application
Presentation
Session
Transport
Network
Link
Physical

Their functions:

- Your call
- Encode/decode messages
- Manage connections
- Reliability, congestion control
- Routing
- Framing, multiple access
- Symbol coding, modulation

Key Concepts

- Protocol layers are the modularity that is used in networks to handle complexity
- The Internet/OSI models give us a roadmap of what kind of function belongs at what layer