

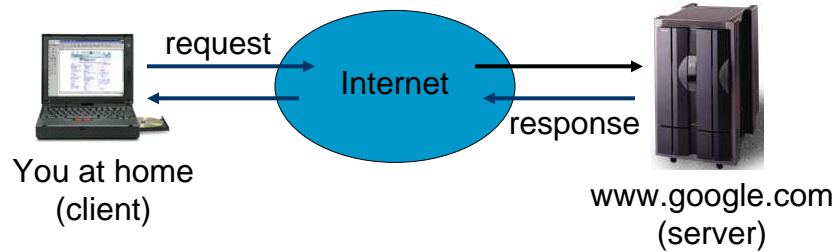
# CSE 461: Protocols and Layering

## **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

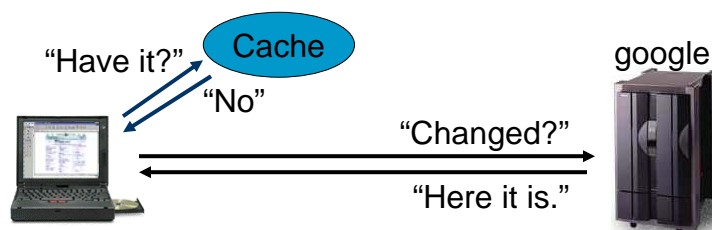
- What happens when you “click” on a web link?



- This is the view from 10,000 ft ...

## 9,000 ft: Scalability

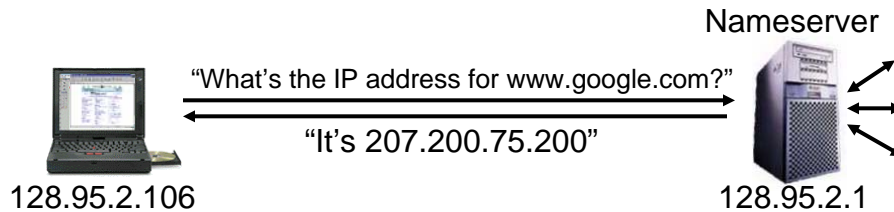
- Caching improves scalability



- 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)

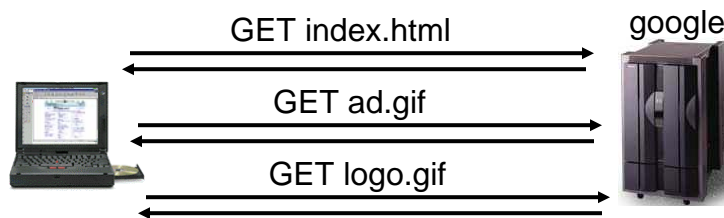
- Map domain names to IP network addresses



- All messages are sent using IP addresses
  - So we have to translate names to addresses first
  - But we cache translations to avoid doing it next time (why?)

## 7,000 ft: Sessions (HTTP)

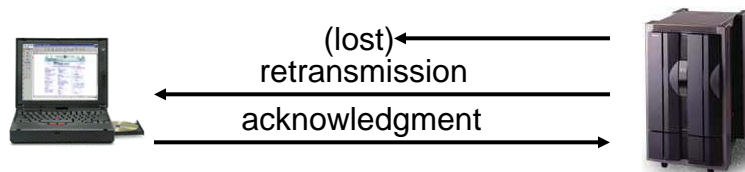
- A single web page can be multiple "objects"



- Fetch each "object"
  - either sequentially or in parallel

## 6,000 ft: Reliability (TCP)

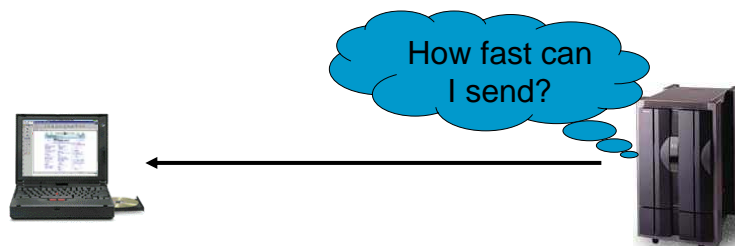
- Messages can get lost



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

## 5,000 ft: Congestion (TCP)

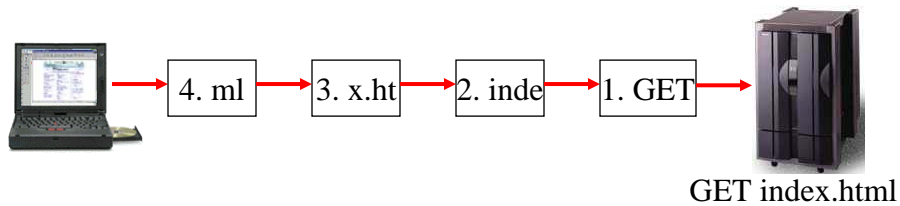
- Need to allocate bandwidth between users



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

## 4,000 ft: Packets (TCP/IP)

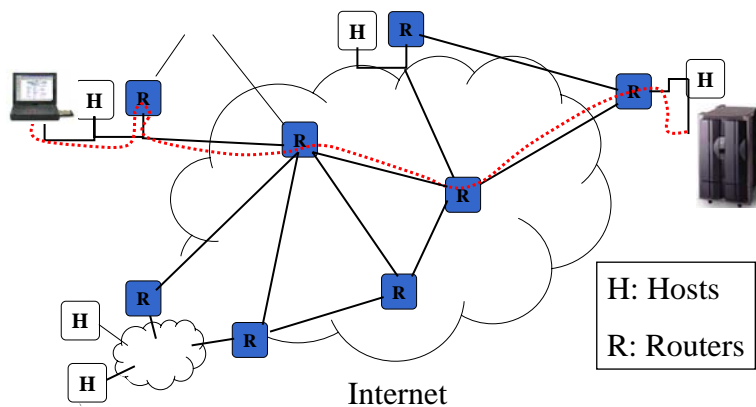
- Long messages are broken into packets
  - Maximum Ethernet packet is 1.5 Kbytes
  - Typical web page is 10 Kbytes



- Number the segments for reassembly

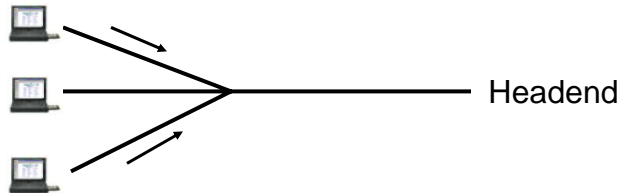
## 3,000 ft: Routing (IP)

- Packets are directed through many routers



## 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 (than IP addresses) is used ... why?

## 1,000 ft: Framing/Modulation

- Protect, delimit and modulate payload as signal

Sync / Unique	Header	Payload w/ error correcting code
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- 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

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- 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: format -- where the bits go
  - Semantics: meaning -- what the words mean, what to do with them
- Examples:
  - Ordering food from a drive-through window
  - IP, the Internet protocol
  - TCP and HTTP, for the Web

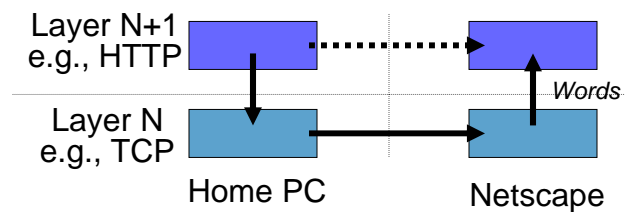
## Protocol Standards

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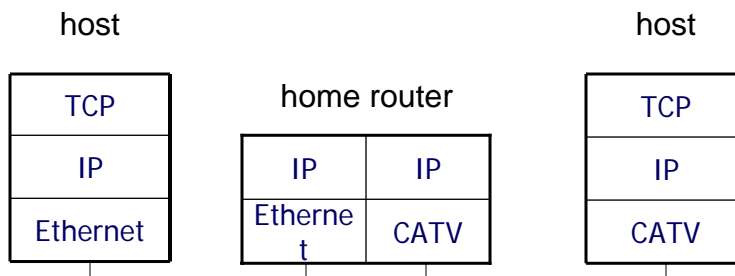
- Different functions require different protocols
- Thus there are many protocol standards
  - E.g., IP, TCP, UDP, HTTP, DNS, FTP, SMTP, NNTP, ARP, Ethernet/802.3, 802.11, RIP, OSPF, 802.1D, NFS, ICMP, IGMP, DVMRP, IPSEC, PIM-SM, BGP, ...
- Organizations: IETF, IEEE, ITU
- IETF ([www.ietf.org](http://www.ietf.org)) 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



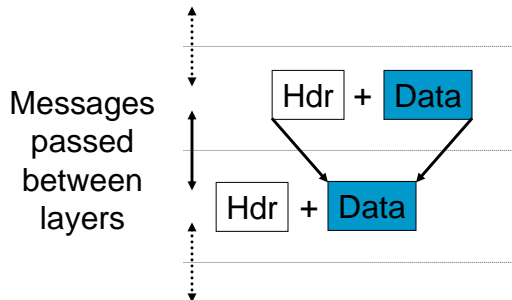
## Example – Layering at work





## Layering Mechanics

- Encapsulation and de(en)capsulation



## A Packet on the Wire

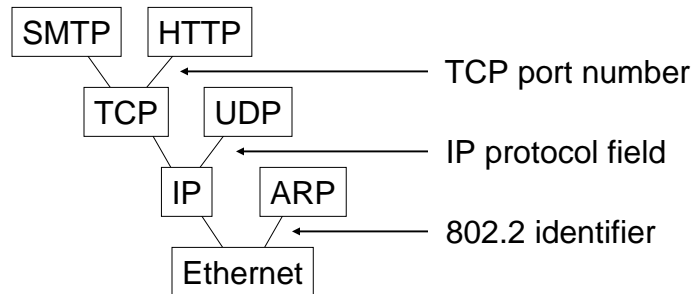
- Starts looking like an onion!



- 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

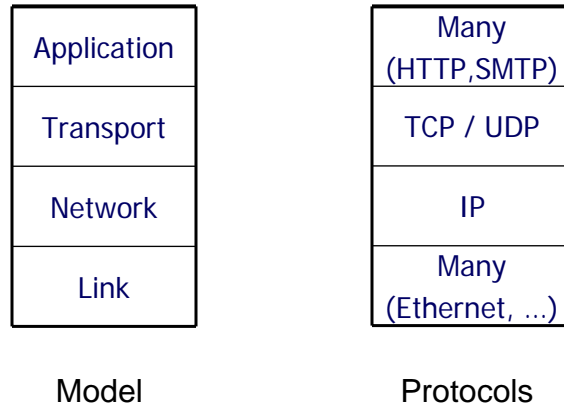


## 3. OSI/Internet Protocol Stacks

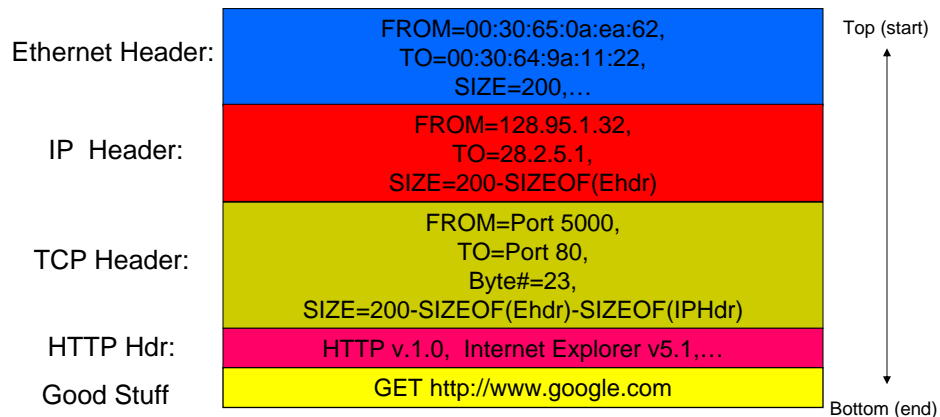
Key Question: What functionality goes in which protocol?

- 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



## What's Inside a Packet



## OSI “Seven Layer” Reference Model

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- Seven Layers:

Application
Presentation
Session
Transport
Network
Link
Physical

Their functions:

- Up to the application
- Encode/decode messages
- Manage connections
- Reliability, congestion control
- Routing
- Framing, multiple access
- Symbol coding, modulation

## Key Concepts

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- 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