Class announcements

- Reading for Tues (12/4):
  - Messerschmitt Ch 10 (293-321)

- Student Presentations Tuesday 12/4
  - Jiabi(Stephy) He (Business Paper)
  - Jeffrey Hogg (Business Paper)
Student Presentations

Student Presentation
Link and Network Layer Interaction

Strip MAC header off frame.
Forward IP packet based on Routing table.
Transport Protocols

- The Internet is unreliable
  - It will make a “best effort” to get your packet to its destination

- Packets can be lost because of
  - Congestion
  - Link errors
  - Routing problems
**Transmission Control Protocol (TCP)**

- **Retransmit mechanism for reliability**
  - Receiver sends acknowledgements to sender
  - If a packet is lost, source fails to get ACK, and then retransmits.

- **Congestion control**
  - If congestion perceived (by lost packets)
  - Source reduces its send rate
    - When loss, sender reduces send rate by half
    - Otherwise slowly increases
TCP cont’d

TCP port numbers
- TCP Header has a “port” number field
- Helps host sort out how to route packets to applications

<table>
<thead>
<tr>
<th>IP Header</th>
<th>TCP Header</th>
<th>Payload</th>
</tr>
</thead>
</table>

Your Computer

Port 80

Email Client

Port 143

Port 80 Packet
For some applications packet retransmissions are not worthwhile
  - Why?
For those applications, we use UDP
UDP is a transport protocol that
  - Does not do retransmissions
  - Does not do congestion control
When networks are congested, certain sessions (Source-destination pairs) should reduce offered rates.
- Today all TCP sessions slow down when they detect packet losses.
- UDP sessions do not slow down.

What are some alternative strategies?
- Have those whose applications aren’t as sensitive slow down more?
  - How would we know which are less sensitive
Pricing within the Internet

- **Customer pays an ISP**
  - Often Flat Rate per month
- **ISP pays a backbone AS**
  - Often just flat rate, dependent on access link speed.
  - Sometimes based on total usage
- **Backbone NSPs peer with each other**
  - Often for free if they exchange comparable amounts of traffic.
- **Overall...**
  - Internet billing today is much more course grained than telephone billing.
Domain Names

IP addresses are inconvenient for people

- 32 bits hard to remember
- 128 bits very hard to remember

Domain names

- e.g. argus.eecs.berkeley.edu

- Easier to remember than IP addresses

- However, we need some way of mapping domain names to IP addresses.
Domain Name System (DNS)

- Root Name Server
  - Berkeley Name Server
    - EECS Name Server
  - UCSC Name Server
    - SoE Name Server
Hierarchy in Addresses vs. Names

Addresses hierarchical in topology
- Maximize “wild cards” and distribute address administration

Names hierarchical in administration
- Single administered organizations often distributed topologically (e.g. ibm.com)
OSI Layers

Application

Presentation

Session

Transport

Network

Link

Physical

Internet Explorer, Outlook Email, Real Player, ...

TCP, UDP

Internet Protocol (IP), ...

Ethernet, Wi-Fi, SONNET, ...

Modulation Schemes: QAM, OFDM, etc…
Some Typical Topologies

Home Network

- Ethernet Switch
- Router
- DSL Modem
- Telephone Line (to local Office)
Small/Medium Business

- Web Site Server
- T1 Line
- T1 Modem
- Ethernet Switch
- Router with Firewall
- To Local Office
ISP Topology

Telephone Company
Local Office

Local Loop

Local Loop

Local Loop

Telephone Switch

ISP Point of Presence

DSL Modem

DSL Modem

DSL Modem

DSLAM

Leased Line to NAP

To Telephone Network

To

Leased

Telephone

Network

NAP
Network Service Provider

Network Access Point

Network Access Point

Network Access Point

Network Access Point

Network Access Point

Network Access Point

Network Access Point

Network Access Point

Network Access Point
Large E-Business

Presentation Logic (Assembling Web page)

Logic Flow of Interaction

Web Servers

Application Servers

Databases

Customers

Merchandise

Orders

Incoming HTTP Requests

Interconnected with Gigabit Ethernet or other technology
Web Caching

- Speed up web page loading by storing previously seen components locally

http://www.ucsc.edu

Cache on Hard Drive
Akamai Case
Quiz

1) What term best describes Akamai’s business
   - A) Content Distribution Network
   - B) Enterprise Resource Planning
   - C) Internet Service Provider

2) Akamai’s first service was known as

3) What was not a way Akamai sold its products?
   - A) Through Partners
   - B) Retail Stores
   - C) Akamai’s salesforce
**Internet Bottlenecks**

- **First Mile (Server Capacity)** - 70% of website performance problems according to one study

- **Backbone** - Plentiful, but some shortage within metropolitan areas

- **Peering** - Exchange of traffic between NSPs

- **Last Mile to home**
  - 56 K modems are slow
  - Shared LAN limitations
Solutions

- Expand Bandwidth
  - Being done
- Mirroring web cites
  - Put exact copy of same web page to multiple servers
  - Tricky to duplicate content
- Caching
  - Problem: Stale Content
  - Problem: Hard to count “click throughs”
- Content Distribution Networks...
Freeflow

- Deployed in 1999
- Akamai Infrastructure
  - 13000 servers in 954 networks by 2001
- Customers -
  - Large Commercial Websites
- Revenue model - $2000 per mbps served
  - (For comparison, normal Internet access cost 500 mbps at time)