Announcements

- DB 2 Due Tuesday
- Final Business Papers Due 12/1
**IP Addresses vs Mac Addresses**

- **Hierarchical**
  - The beginning bits tell you which network the host is on
  - Ex: UCSC addresses start with 128.114.X.X
  - The last bits tell you which host of the network

- **Changeable**
  - Changes with location of Host
  - 4 bytes
  - Only 4.2 billion

- **Not Hierarchical**
  - Beginning bits tell nothing useful

- **Not Changeable**
  - 6 bytes
  - 281 Trillion
Link and Network Layer Interaction

MAC Header

Ethernet Frame  Payload

IP Header  IP Payload

Host A

Router

MAC address 00-A4-B7-34-57-23

Ethernet Frame  Payload

IP Header  IP Payload

Router

Host B

128.114.60.202

Host C

Strip MAC header off frame. Forward IP packet based on Routing table.
Issues In Networking

- Sharing of Limited Resources
  - How Should A and B share a link with limited bit rate?

```
Source A                  Source B
  C bits per second
                  | C bits per second |
                  Destination A
                  Destination B
```
Issues In Networking

- **Time Division Multiplexing**
  - gives each connection the use of the link a fixed fraction of time
  - Fixed fraction of resources reserved for each connection
  - Technology called *circuit switching*.

- **Problem**
  - When A is silent, A’s fraction of link goes unused.
Issues In Networking

- **Statistical Multiplexing**
  - Link shared in such a way that connections are not assigned fixed fraction of Link.
  - A and B unlikely to offer peak rate at the same time.
  - \( \max(A + B) < \max(A) + \max(B) \)
Statistical Multiplexing

- Because resources aren’t reserved. It’s possible offered load is too high.
- Packets are put into a queue.
- If offered load remains too high, queue will fill up and overflow.
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 port numbers**
  - TCP Header has a “port” number field
  - Helps host sort out how to route packets to applications

### TCP Header
- **IP Header**
- **TCP Header**
- **Payload**

![Diagram](image-url)
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.
The Global Internet

The World Wide Web

- **HTML (Hypertext Markup Language):**
  - Formats documents for display on Web
- **Hypertext Transfer Protocol (HTTP):**
  - Communications standard used for transferring Web pages
- **Uniform resource locators (URLs):**
  - Addresses of Web pages
  - E.g., http://www.megacorp.com/content/features/082602.html
Domain Names

IP addresses are inconvenient for people
- 32 bits hard to remember
- 128 bits very hard to remember

Domain names
- e.g. ucsc.edu

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

- **Application**: Internet Explorer, Outlook Email, Real Player, ...
- **Presentation**: TCP, UDP
- **Session**: Internet Protocol (IP), ...
- **Transport**: Ethernet, Wi-Fi, SONNET, ...
- **Network**: Modulation Schemes: QAM, OFDM, etc...
- **Link**
- **Physical**
Some Typical Topologies

Home Network

[Diagram showing the network topology with DSL Modem, Telephone Line, Router, Ethernet Switch, and two computers.]
Small/Medium Business

- Ethernet Switch
- Router with Firewall
- T1 Modem
- Web Site Server
- T1 Line
- 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 Telephone Network

To Telephone Network
Network Service Provider

Network Access Point

Network Access Point