UNIT 11B
The Internet ctd...
Last Lecture

• Internet system
  – Hardware
  – protocols
  – IP addresses

• Servers
  – What do they do?
  – How to configure them?

• Emails
  – How they work
Questions?

• Who owns the internet?  
  No one

• What is the purpose of a router?

• Does a router know you are sending email or a picture?

• How does the internet handle multiple size files?

• Is the internet a circuit-switch system like the telephone system?
Internet as a packet switched system

• Design internet as a packet switched system
• Capacity of the internet is only limited by data traffic
• Limit the size of a packet to n bytes (n<1500)
• Packets don’t have to arrive in sequence or at the same time or even the same route
Internet as a system

• Core elements and edge nodes
Domain Name servers

- The service that ties domain names to IP addresses
  - www.cmu.edu (128.2.42.52)
  - www.google.com (173.194.75.147)
  - www.facebook.com (173.252.101.26)
Network Address Translation (NAT)

Packets are tagged with a few more bits, indicating a "port" number.
Passing packets
Routing messages

• Routers do not know anything about the packets they are passing.

• Routers can check the integrity of a packet by testing for errors in the packet:
  – Missing bits
  – What can router do if it detects an error?

• Routers can also “buffer” packets.

• Packets are formatted according to Internet Protocol (IP).
Protocols

• Agreement between communicating parties
  – Web (HTTP, SSL)
  – Email (SMTP, POP3, IMAP)
  – File Transfer (FTP)

• protocols
  – define format
  – order of messages sent and received among network entities
  – actions taken on messages receipt
Quiz

• Who controls the internet? *No one*

• Can anyone join internet? *Yes*

• Is it possible that an email message can get lost?
Maintaining Reliability

• Use a higher level protocol to deliver messages reliably
  – Individual packet delivery may be unreliable
• Transport Control Protocol (TCP)
  – Higher level protocol to assure reliability
• TCP/IP
Reliable Communication with TCP

- Suppose Alice and Bob are the TCP implementations of two computers.
  - Alice is asked to send a message to Bob.
  - Alice breaks the message into several packets.
    - Each packet includes parity information, so Bob can check it for accuracy.
    - Packets are sent via IP.
  - Bob receives the packets.
    - If Bob is missing a packet or receives a corrupt packet, he can request retransmission.
    - If the packet is OK, Bob sends an acknowledgement.
  - If Alice doesn’t get an acknowledgement, she will retransmit.
  - Bob assembles the incoming packets in order and provides the message to the appropriate application.
Other protocols

• Live streaming of data
  – Video
  – VoIP

• User Datagram Protocol (UDP)
  – a simple transmission model with a minimum of protocol mechanism
  – No “handshaking”
  – Error checking is not necessary or done by the application
quiz

• Can entire internet fail for some reason?

• Can it stand a nuclear attack?

• Can your computer fail to send a message?
How web pages work
Hypertext Transfer Protocol (HTTP/S)

- Retrieves documents (in HTML and other formats) over TCP using port 80
- Can also send form data to the server
- Support multiple requests per connection
- HTTPS = HTTP + TSL/SSL (secure socket layer)
Example: Web page Delivery

• A Web page is identified by a Uniform Resource Locator (URL)
• protocol://host address/page
• An HTTP Request
Example: Web page Delivery

1. Web browser extracts the name of the machine and gets it translated to an IP address (e.g. 128.2.217.13)
2. Establishes a TCP connection to port 80 at 128.2.217.13
3. Constructs a message
   
   GET /~15110/index.html HTTP/1.1

4. Sends the message to server using services of TCP/IP
5. Web server locates the file and send a response back to browser using services of TCP/IP
6. The connection is terminated.
Email protocols

- Email protocols governs the communication between mail servers and clients

- **SMTP**
  - user-level client mail applications typically use SMTP only for sending messages to a mail server for **relaying**

- **POP3**
  - allows email client software to retrieve email from a remote server

- **IMAP**
  - newer protocol and oriented toward a "connected" mode of operation
Internet architecture

Source: blown to bits
Back to IP Addresses
IP Addresses (IPv4)

• Computers on the Internet are assigned an IP Address consisting of four numbers between 0 and 255 inclusive

   _____ · _____ · _____ · _____

Example: 128.2.13.163

• This means that each part of the address is an 8-bit value, and an IP address is 32 bits. Hence, it supports up to $2^{32}$ computers on the network at the same time.

• ISPs can reassign IP addresses dynamically.
IPv4 Address Assignment

The original IPv4 had several classes of addresses that could be decomposed into a network and host part:

- **Class A** 0 + 7-bit network + 24-bit address
  Accommodates up to $2^{24}$ unique IP addresses in a company or location.

- **Class B** 10 + 14 bit network + 16-bit address
  Accommodates up to $2^{16}$ unique IP addresses in a company or location.

- **Class C** 110 + 21-bit network + 8-bit address
  Accommodates up to $2^8$ unique IP addresses in a company or location.
IPv4 Address Assignment

• In 1993, the Internet switched to classless internet-domain routing.

• In this scheme, the network part is an arbitrary length prefix of the address, such as 10.10.1.32/27, which has a 27-bit network part and a 5-bit host part (so there can only be 32 machines on that network).
New IP (IPv6)

- IPv6 uses 128-bit addresses, which implies \(2^{128} \approx 3.4 \times 10^{38}\) unique computer addresses, \(4.8 \times 10^{28}\) addresses per person).

- Allows for many more devices (cell phones, video game machines, appliances, automobiles, etc.).

- Designed to deal with the approaching use of all available addresses in IPv4.

- IPv6 also follows classless routing, but the standard subnetwork size is 64-bits.
Questions?

• Can entire internet fail on its weight?

• What would be an alternate model?

• How has internet changed humanity? Opportunity?

• How do we define intelligence?
Bonus Slides

You will not be tested on these slides
Internet layers
Layering Abstractions

• It is often useful to divide large systems into layers
  – Higher layer uses a lower layer as a service
  – Lower layers are implemented independently from higher layers
  – Interface between two layers needs to be specified

• Example: Dice game uses \texttt{roll}
  \begin{verbatim}
  roll uses rand
  \end{verbatim}
  \texttt{rand} uses some LCRG method
Open system interconnection

Source: Washington.edu
Link Layer
Physical Links

Bit pipe

There may be errors in transmission
Link Layer
Data Links

m1, m2, m3
Message pipe
Messages arrive correctly
m1, m2, m3
Network Layer

• The link layer enables us to transmit messages from node A to node B, only if these two are connected by a physical link.

• In networks other than LANs, majority of nodes are not directly connected.

• Network layer is responsible for delivering messages from their source to destination.

• Key functions:
  – Create a universal addressing scheme for all network nodes
  – Deliver messages between any two nodes in the network
Transport Layer

• Internet Protocol (IP)
  – Delivers packets to IP address
  – Best effort delivery

• Transport Control Protocol
  – Creates a reliable bi-directional stream (source address/port and destination address/port)
    • acknowledgements, resend, reassembly in correct order,
    • error detection
    • connection must be opened and closed
    • flow/congestion control
Transport Layer

Program 1 -> Host -> Program 2

Reliable TCP connection

unreliable network delivery