

Networking and the Internet

Lecture 4 - COMPSCI1111/111G SS 2016

Today's lecture

- ▶ History of the Internet
- ▶ How the Internet works
- ▶ Network protocols

The telephone

- ▶ 1876: first successful bi-directional transmission of clear speech by Alexander Bell and Thomas Watson



- ▶ 1940: first successful transmission of digital data through over telegraph wires by George Stibitz

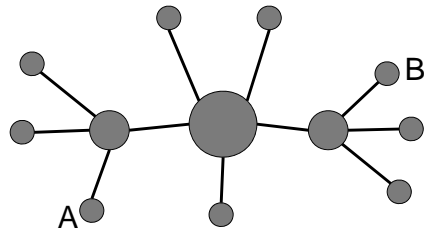


WWII and the Cold War

- ▶ Computer technology played an important role in code-breaking during WW2
- ▶ Cold War between US and USSR led to a technology and arms race
- ▶ 1958: Advanced Research Projects Agency (ARPA) established
- ▶ April 1969: construction of ARPANET begins, a packet-switching network

Circuit-switching network

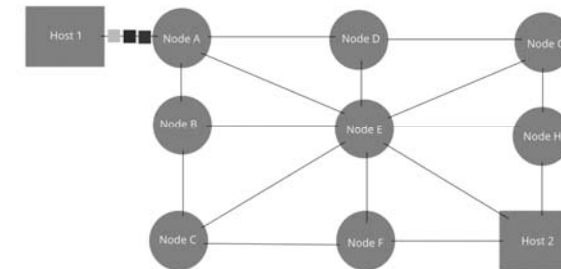
- ▶ Nodes are connected physically via a central node
- ▶ Used by the telephone network
- ▶ Originally, switchboard operators had to manually connect phone calls, today this is done electronically



Packet-switching network

- ▶ Data is broken into packets, which are then sent on the best route in the network
- ▶ Each node on the route sends the packet onto its next destination, avoiding congested or broken nodes

The original message is Green, Blue, Red.

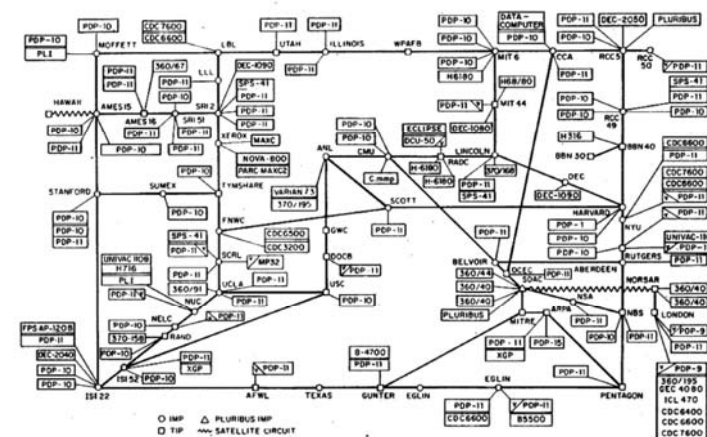


ARPANET

- ▶ October 1969: ARPANET is completed with four nodes
- ▶ 1973: Norway connects to ARPANET via satellite, followed by London via a terrestrial link

ARPANET

ARPANET LOGICAL MAP, MARCH 1977



ARPANET

- ▶ 1983: TCP/IP implemented in ARPANET
- ▶ 1990: ARPANET is formally decommissioned

ARPANET to the Internet

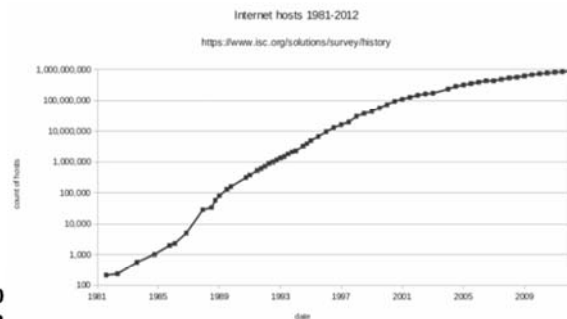
- ▶ Networks similar to ARPANET sprang up around the USA and in other countries
- ▶ 1984: domain name system (DNS) implemented
- ▶ 1985: NSFNET was established
- ▶ 1989: Waikato University connects to NSFNET
- ▶ 1991: World Wide Web (WWW) created at CERN (European Organization for Nuclear Research) by Tim Berners-Lee
- ▶ 1995: NSFNET is retired

WWW vs Internet

- ▶ World Wide Web (WWW) refers to the applications (eg. web pages, email, Skype, Youtube etc) that run on hardware
- ▶ The Internet refers to the hardware on which the WWW runs

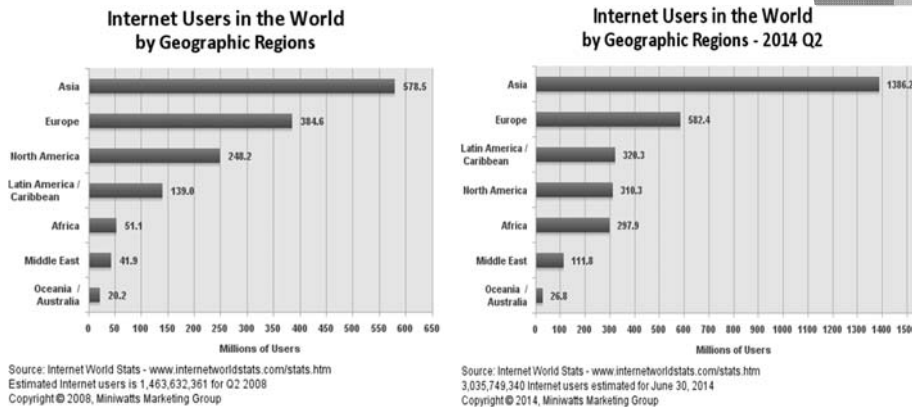
Internet growth

Year	Hosts
1969	4
04/71	23
06/74	62
03/77	111
05/82	235
10/84	1,024
02/86	2,308
07/88	33,000
10/90	313,000
01/92	727,000
01/94	2,217,000
01/96	9,472,000
01/98	29,670,000
01/00	72,398,092
01/02	147,344,723
01/04	233,101,481
01/06	394,991,609



Number of hosts on logarithmic scale until 2012

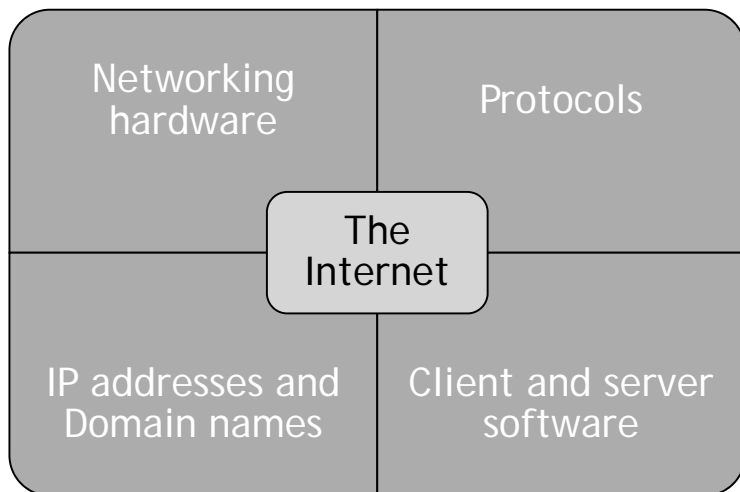
Internet usage



Types of networks

- ▶ Local Area Network (LAN)
 - ▶ Operates within 1 km radius
 - ▶ Client-server or peer-to-peer configuration
 - ▶ Can connect multiple LANs to form an intranet
- ▶ Wide Area Network (WAN)
 - ▶ Distances over 1km
- ▶ The Internet
 - ▶ Network of networks that use the TCP/IP protocol

How the Internet works



Networking hardware

- ▶ Connection
 - ▶ Wired, eg. Ethernet
 - ▶ Wireless, eg. Wi-Fi, cellular
- ▶ Network card
 - ▶ Can be built into the motherboard or an expansion card
 - ▶ Some network cards support wired and wireless connections
- ▶ Switch
 - ▶ Used to connect multiple devices to the same network
- ▶ Router
 - ▶ Directs traffic around the network and connects networks together



Networking hardware

- ▶ Modem (modulator/demodulator)
 - ▶ Responsible for transmitting data on the medium and receiving data from the medium
 - ▶ For example, a modem:
 - ▶ Modulates data from computer/router onto a phone line
 - ▶ Demodulates signals from a phone line and sends to the computer/router
- ▶ There are different kinds of modems
 - ▶ Dial-up modems up to 56 kbit/s
 - ▶ Broadband (DSL; digital subscriber line) modems between 256 kbit/s to 20 mbit/s

Protocol

- ▶ Protocol: a standardised method of communication
- ▶ Very important in a network in order for the sender and receiver to communicate properly
- ▶ Protocols include rules for:
 - ▶ Opening and maintaining a connection
 - ▶ Sending and receiving data
 - ▶ Ending the connection

Protocols

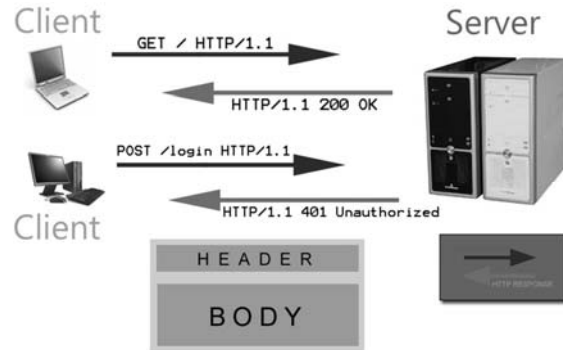
- ▶ Common Internet protocols:
 - ▶ TCP/IP: transports data reliably
 - ▶ UDP: transports data faster but less reliably
 - ▶ FTP: used for transferring files
 - ▶ HTTP: used for client/server communication, mostly web pages.
 - ▶ POP3, IMAP, SMTP: used for email
- ▶ Many protocols used in networking are defined in their RFC (Request for Comments)
 - ▶ RFC 791: IP
 - ▶ RFC 2616: HTTP

Protocols - TCP/IP, UDP

- ▶ IP - Internet Protocol:
 - ▶ A unique identifier for computers on the network
 - ▶ Defines routing information
 - ▶ v4: 32-bit addresses (eg. 192.168.1.1), ran out of addresses
 - ▶ v6: 128-bit addresses (eg. 2001:0db8:0a0b:12f0:0000:0000:0000:0001)
- ▶ TCP - Transmission Control Protocol:
 - ▶ Divides the message into packets (typically about 1 KB)
 - ▶ Checks that all packets arrive (error detection)
 - ▶ Ensures packets are not sent faster than they can be received (flow control)
 - ▶ Combines packets to recreate the data
- ▶ UDP - User Datagram Protocol:
 - ▶ Lacks error detection and flow control, better suited to real-time data

Protocols - HTTP

- ▶ HyperText Transfer Protocol
- ▶ Used by web browsers to request objects (eg. webpages, images, sounds etc) from the server

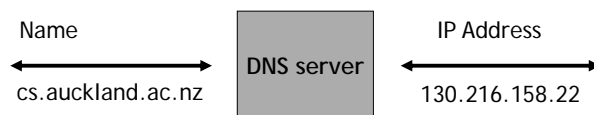


Protocols - Email

- ▶ These protocols are used by email clients (eg. Outlook, Apple Mail) to send and receive email
- ▶ POP3 - Post Office Protocol v3:
 - ▶ Emails downloaded from server to email client
 - ▶ Emails are then deleted from server
- ▶ IMAP - Internet Message Access Protocol:
 - ▶ Downloads messages to email client and keeps them on the server
- ▶ SMTP - Simple Mail Transfer Protocol:
 - ▶ Used to send emails from an email client via the email server

IP addresses and domain names

- ▶ Domain name system (DNS) is used to convert between IP addresses and human-readable text (domain name)
- ▶ A domain name against an IP address
- ▶ DNS servers perform the translation between IP address and URL



Client and server software

- ▶ Client software:

- ▶ Web browsers



- ▶ Email clients:

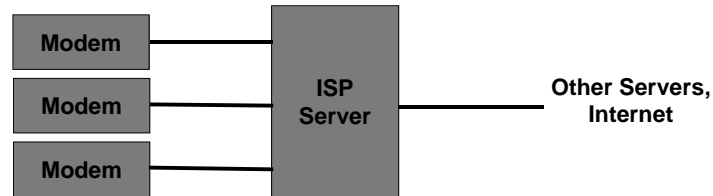


- ▶ Server software:



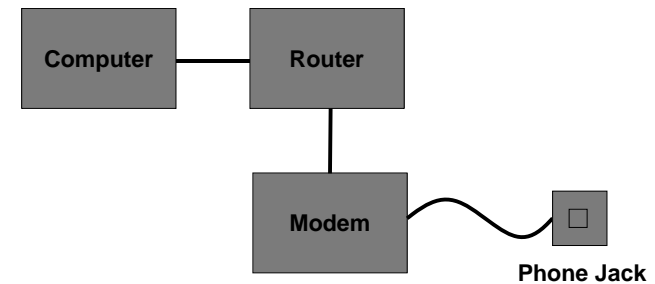
Connecting to the Internet

- ▶ An Internet Service Provider (ISP) provides you with an IP address and a connection to the Internet



Connecting to the Internet

- ▶ At home, you plug your modem into your phone jack
- ▶ Your modem sends and receives information from the Internet over your phone line



The Internet's backbone

- ▶ High-capacity fibre cables, on land and under the sea
- ▶ Owned by a few carriers who rent out capacity
- ▶ See www.submarinecablemap.com



Summary

- ▶ The Internet is packet-switching network consisting of multiple networks joined together
- ▶ A number of protocols and technologies underpin the Internet
- ▶ As more people use the Internet, authorities tasked with maintaining it need to ensure the Internet can handle the increased demand (eg. IPv4 to IPv6)