Networking and the Internet

Lecture 4 – COMPSCI111/111G SS 2016

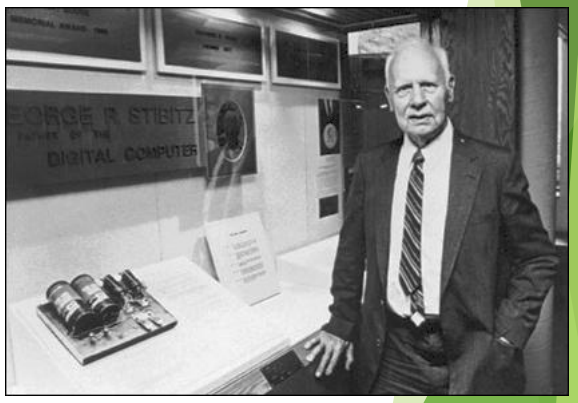
Today's lecture

- 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

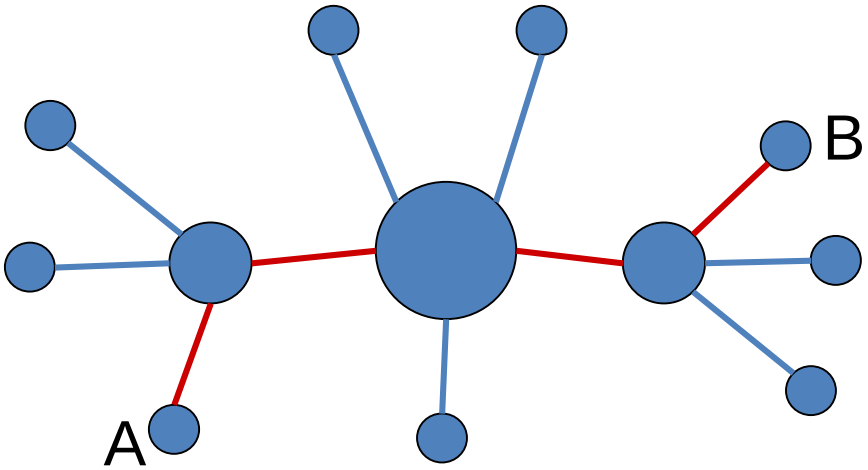


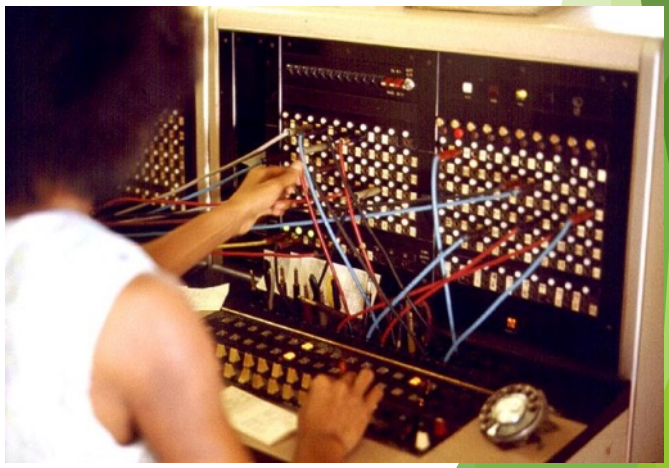
WWII and the Cold War

- 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

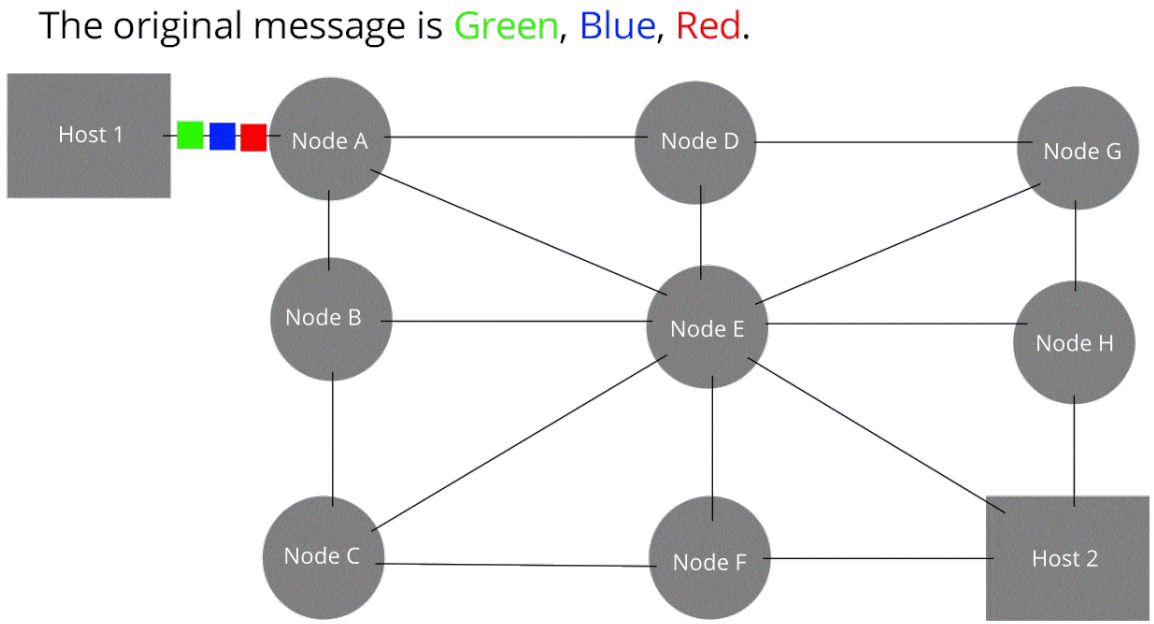
- Nodes are connected physically via a central node
- Used by the telephone network
- Originally, switchboard operators had to manually connect phone calls, today this is done electronically





Packet-switching network

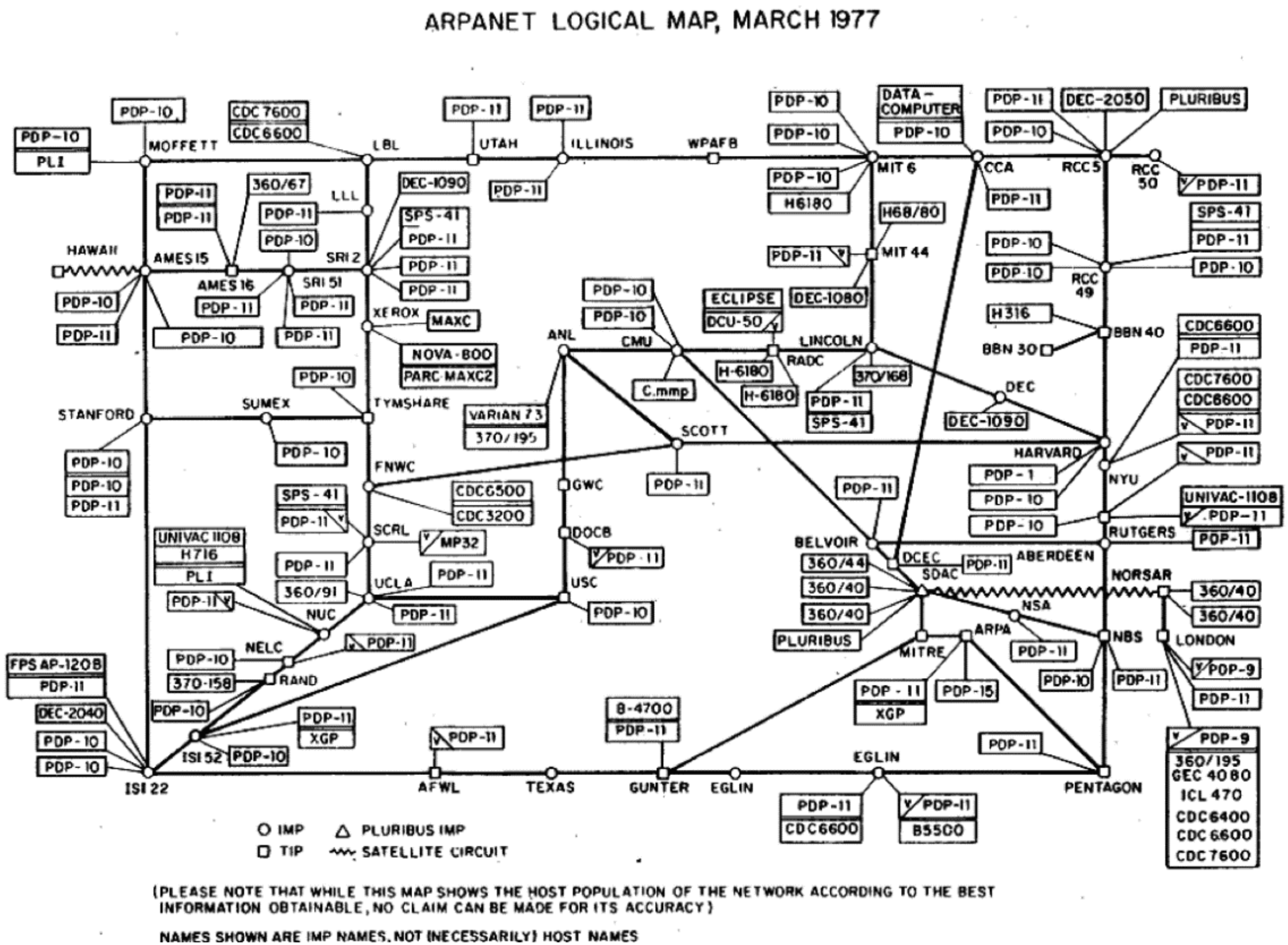
- Data is broken into **packets**, which are then sent on the best route in the network
- Each node on the route sends the packet onto its next destination, avoiding congested or broken nodes



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
MOFFETT
LBL
UTAH
ILLINOIS
WPAFB
MIT 6
CCA
RCC 5
RCC 50
LLL
HAWAII
AMES 15
AMES 16
SRI 51
SRI 2
XEROX
MIT 44
RCC 49
ANL
CMU
LINCOLN
RADC
BBN 40
BBN 30
DEC
STANFORD
SUMEX
TYMSHARE
SCOTT
HARVARD
NYU
FNWC
GWC
RUTGERS
SCRL
DOCB
BELVOIR
DCEC
SDAC
ABERDEEN
NORSAR
UCLA
USC
NUC
NSA
NELC
RAND
ARPA
MITRE
NBS
LONDON
ISI 52
ISI 22
AFWL
TEXAS
GUNTER
EGLIN
PENTAGON
O IMP
□ TIP
△ PLURIBUS IMP
SATELLITE CIRCUIT
(PLEASE NOTE THAT WHILE THIS MAP SHOWS THE HOST POPULATION OF THE NETWORK ACCORDING TO THE BEST INFORMATION OBTAINABLE, NO CLAIM CAN BE MADE FOR ITS ACCURACY)
NAMES SHOWN ARE IMP NAMES, NOT (NECESSARILY) HOST NAMES

ARPANET

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

ARPANET to the Internet

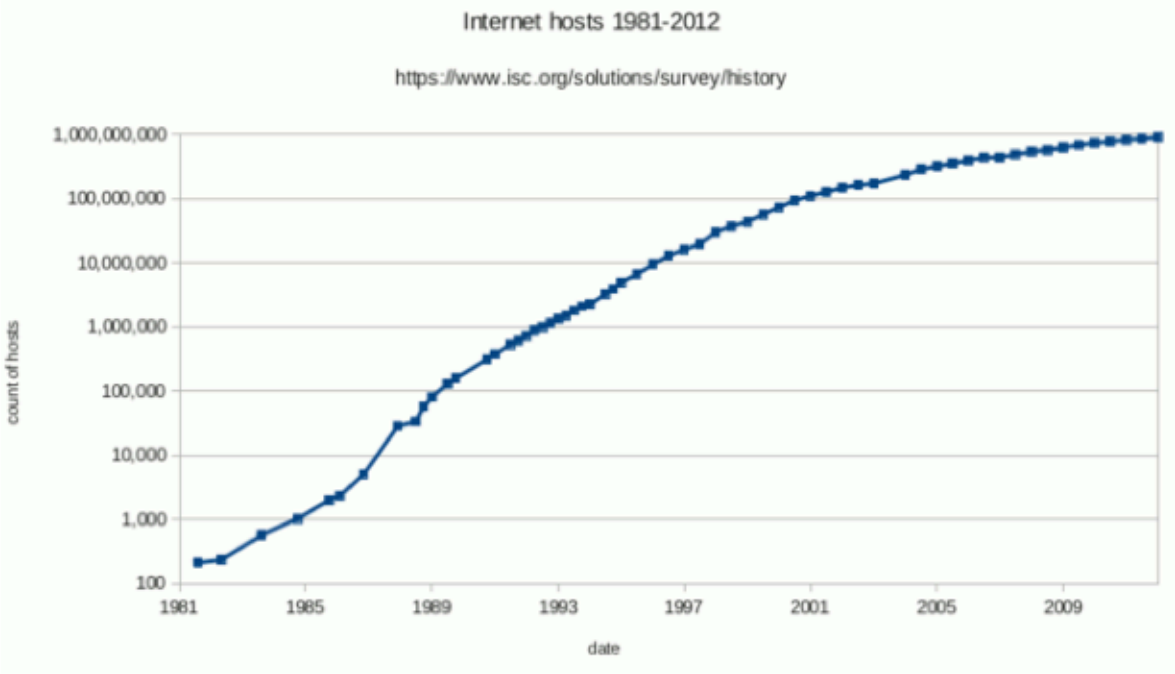
- Networks similar to ARPANET sprang up around the USA and in other countries
- 1984: **domain name system** (DNS) implemented
- 1985: NSFNET was established
- 1989: Waikato University connects to NSFNET
- 1991: **World Wide Web** (WWW) created at **CERN** (European Organization for Nuclear Research)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

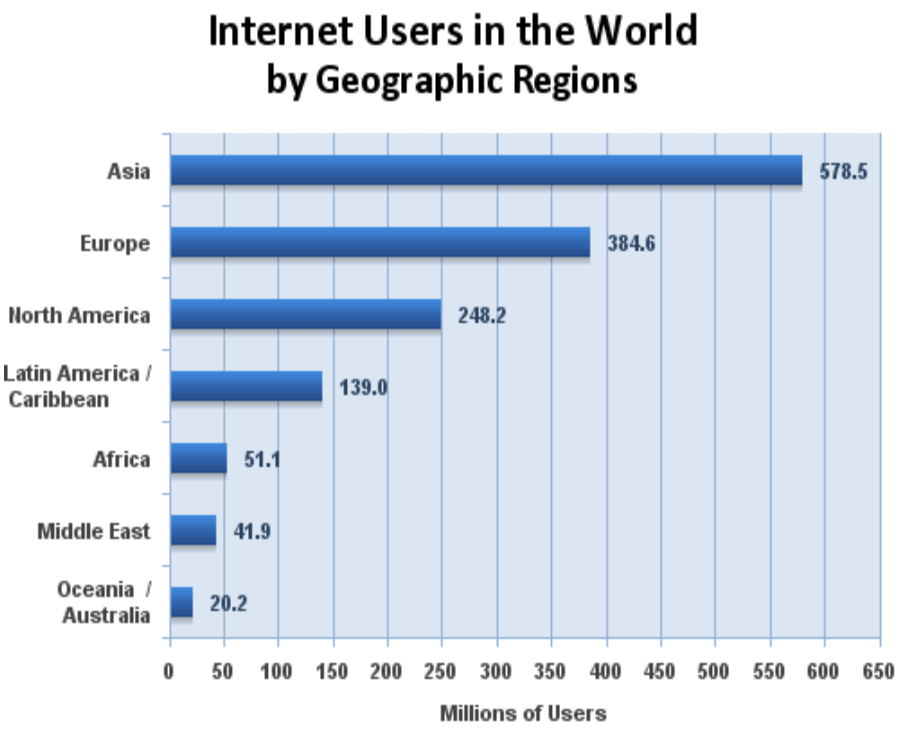
Internet growth

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



Source: Internet World Stats - www.internetworldstats.com/stats.htm
Estimated Internet users is 1,463,632,361 for Q2 2008
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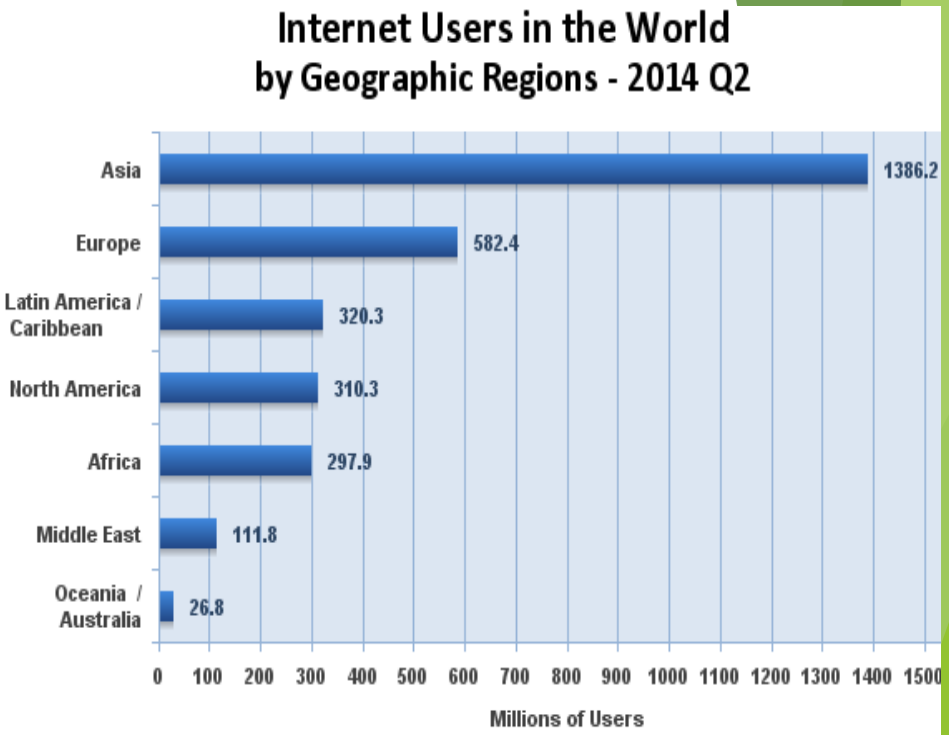

Source: Internet World Stats - www.internetworldstats.com/stats.htm
3,035,749,340 Internet users estimated for June 30, 2014
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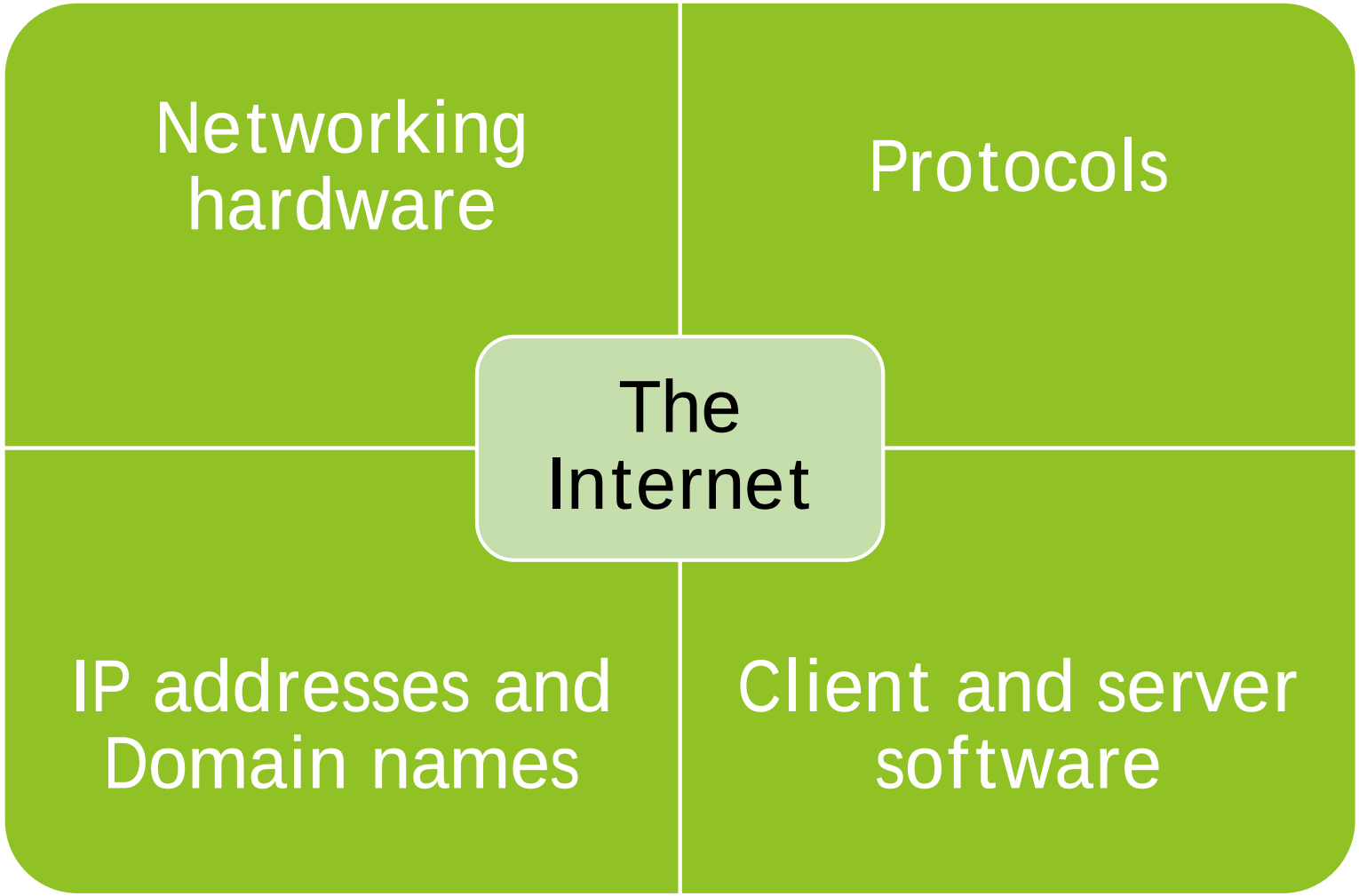
Types of networks

- 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

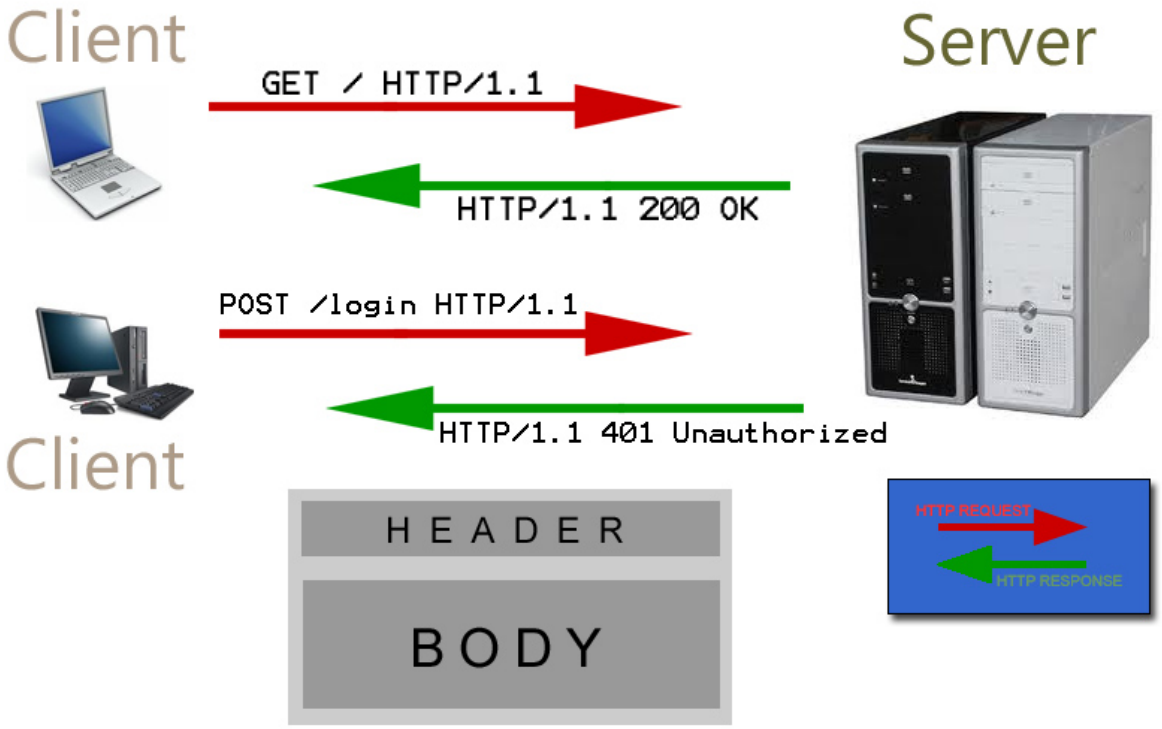
- Common Internet protocols:
  - TCP/IP: transports data reliably
  - UDP: transports data faster but less reliably
  - FTP: used for transferring files
  - HTTP: used for client/server communication, mostly web pages.
  - POP3, IMAP, SMTP: used for email
- Many protocols used in networking are defined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

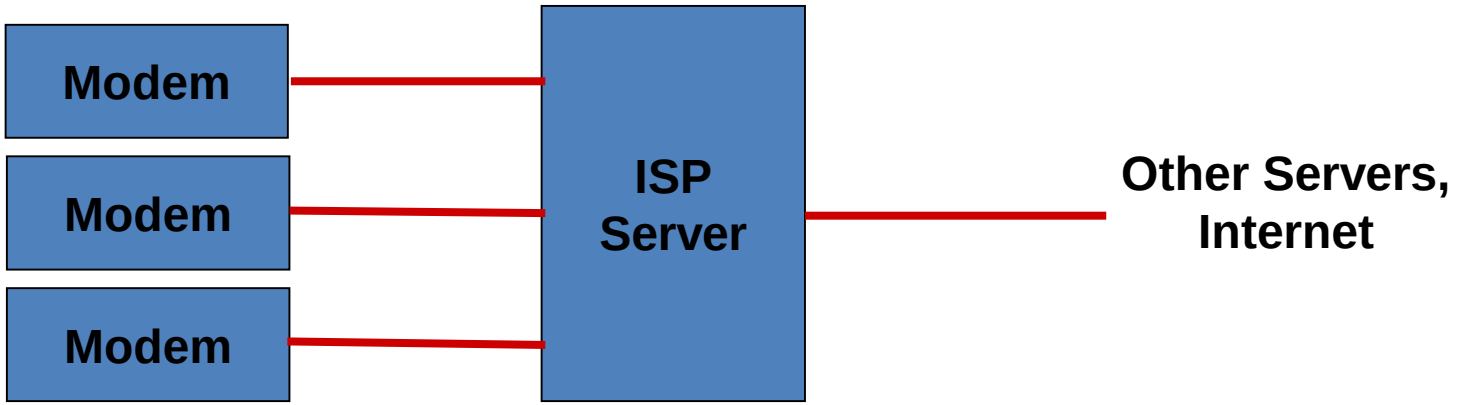
- Client software:
  - Web browsers

  - Email clients:

- Server software:

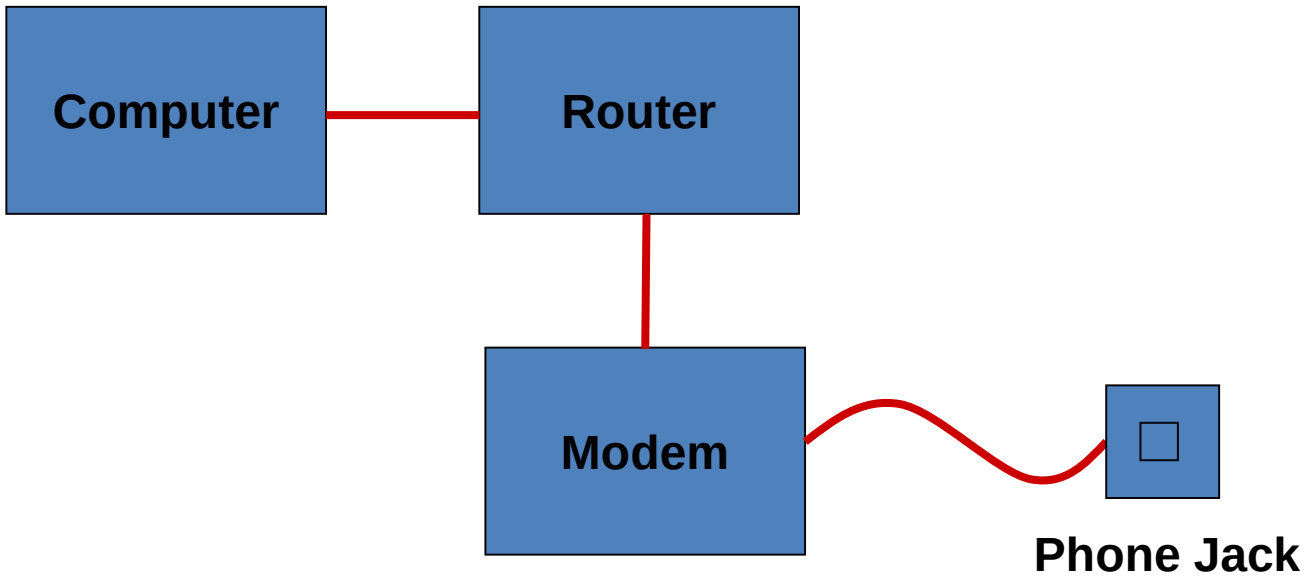
Connecting to the Internet

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



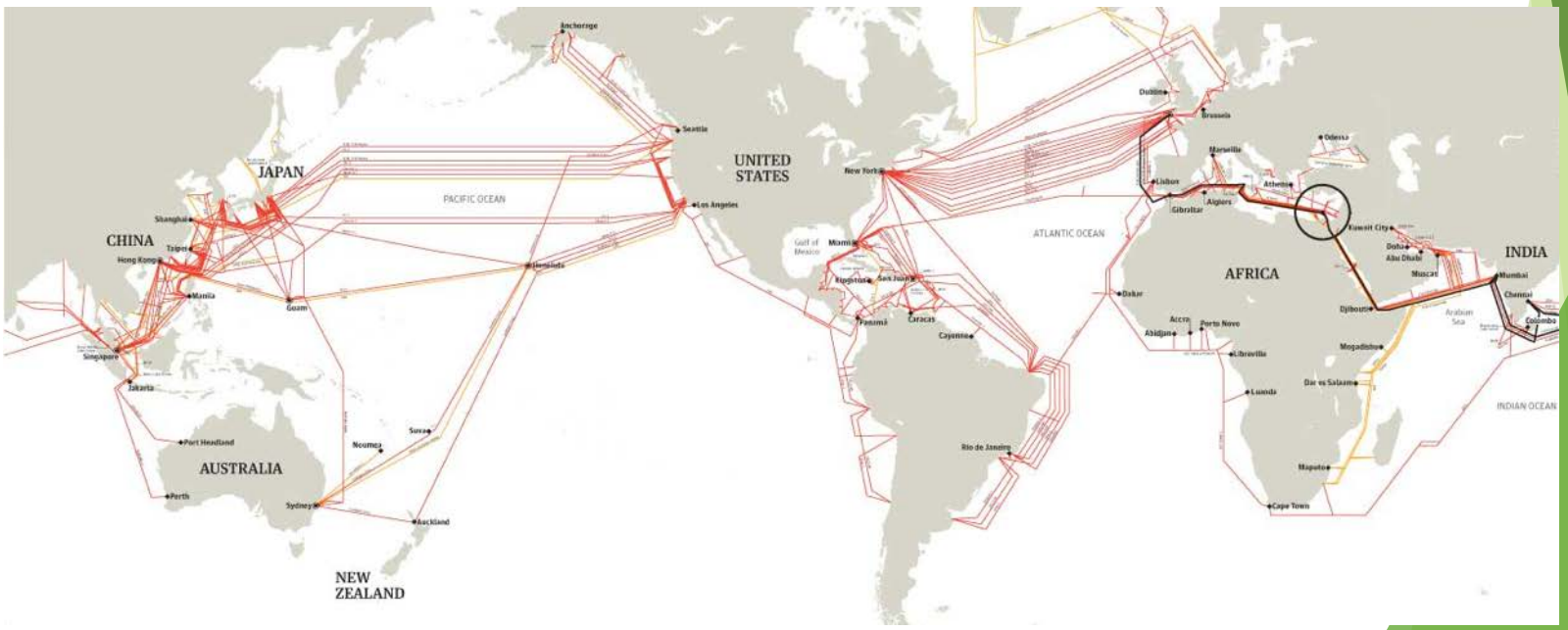
Connecting to the Internet

- 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)