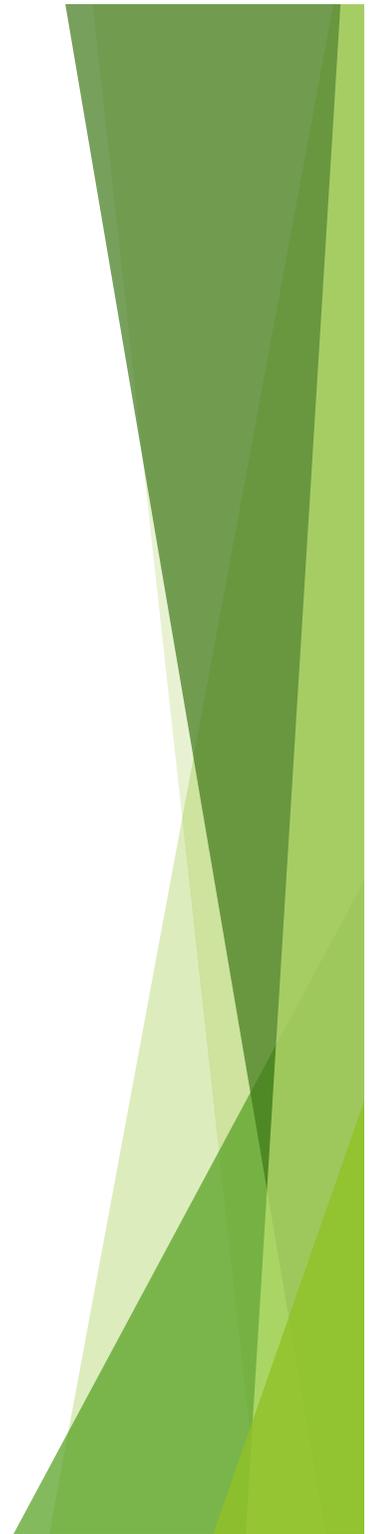


Networking and the Internet

Lecture 4

Today's lecture

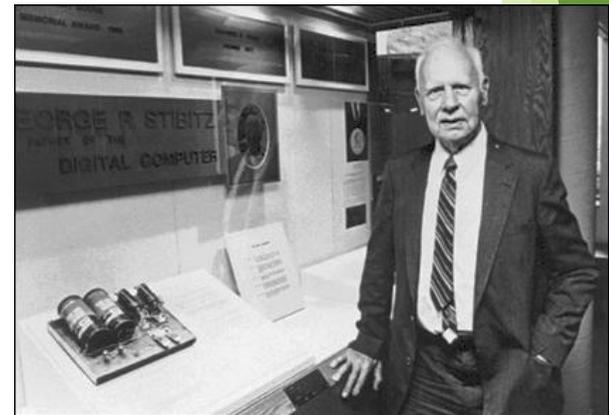
- ▶ History of the Internet
- ▶ How the Internet works
- ▶ Network protocols



The telephone

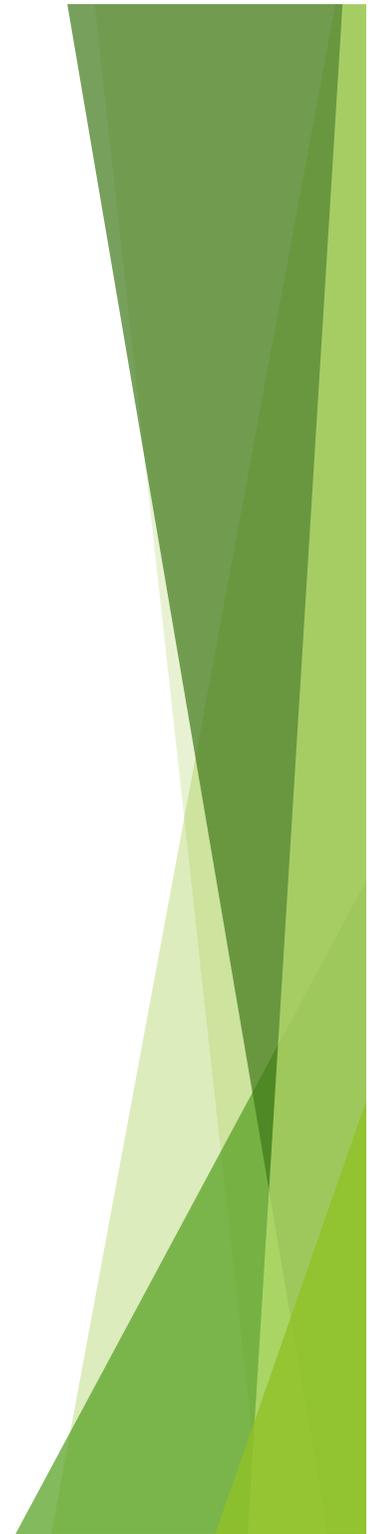
- ▶ 1876: first successful bi-directional transmission of clear speech by Alexander Bell and Thomas Watson

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



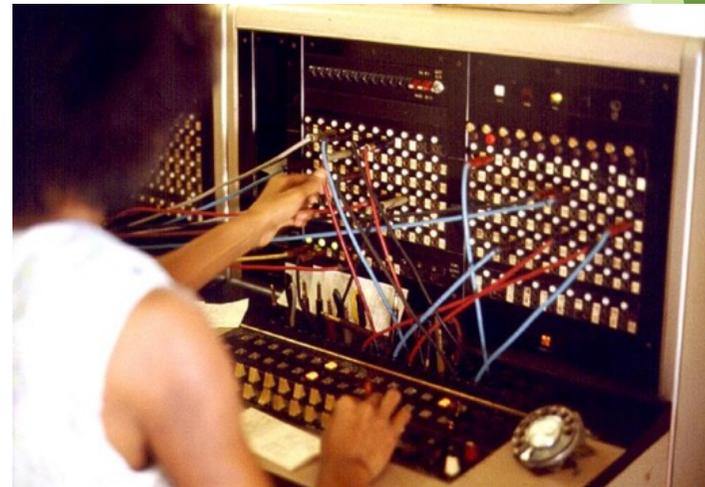
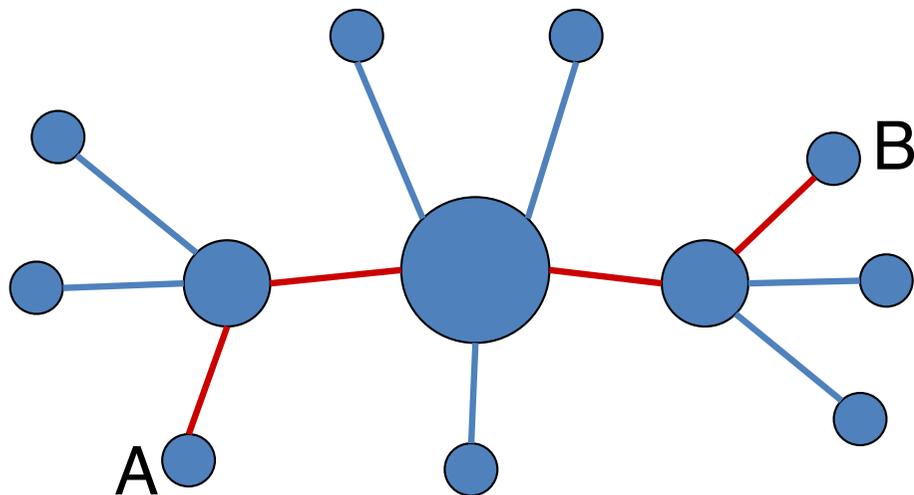
WWII and the Cold War

- ▶ Computer technology played an important role in code-breaking during WW2
- ▶ Cold War between US and USSR led to a technology and arms race
 - ▶ Peaked with the launch of Sputnik in 1957
- ▶ 1958: Advanced Research Projects Agency (ARPA) established
- ▶ April 1969: construction of ARPANET begins, a packet-switching network



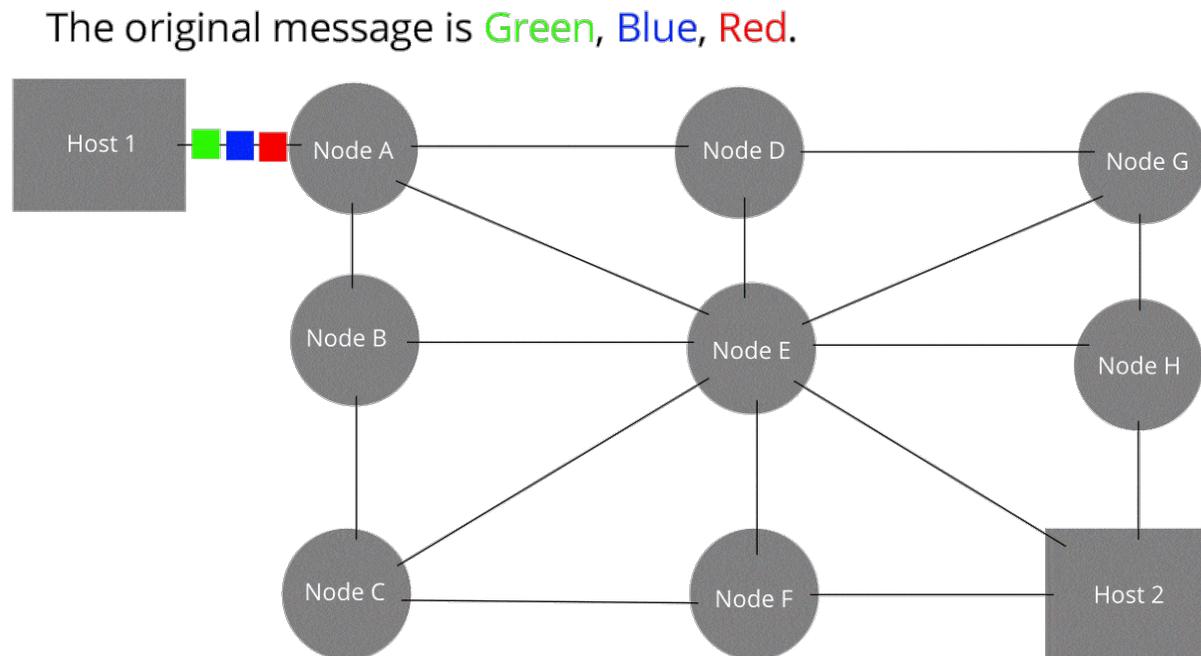
Circuit-switching network

- ▶ 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



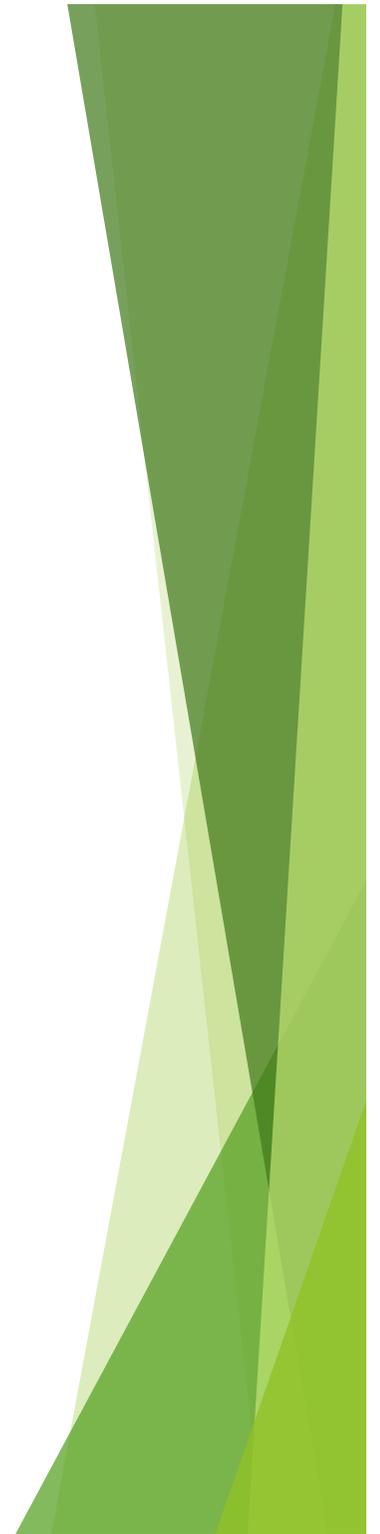
Packet-switching network

- ▶ 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



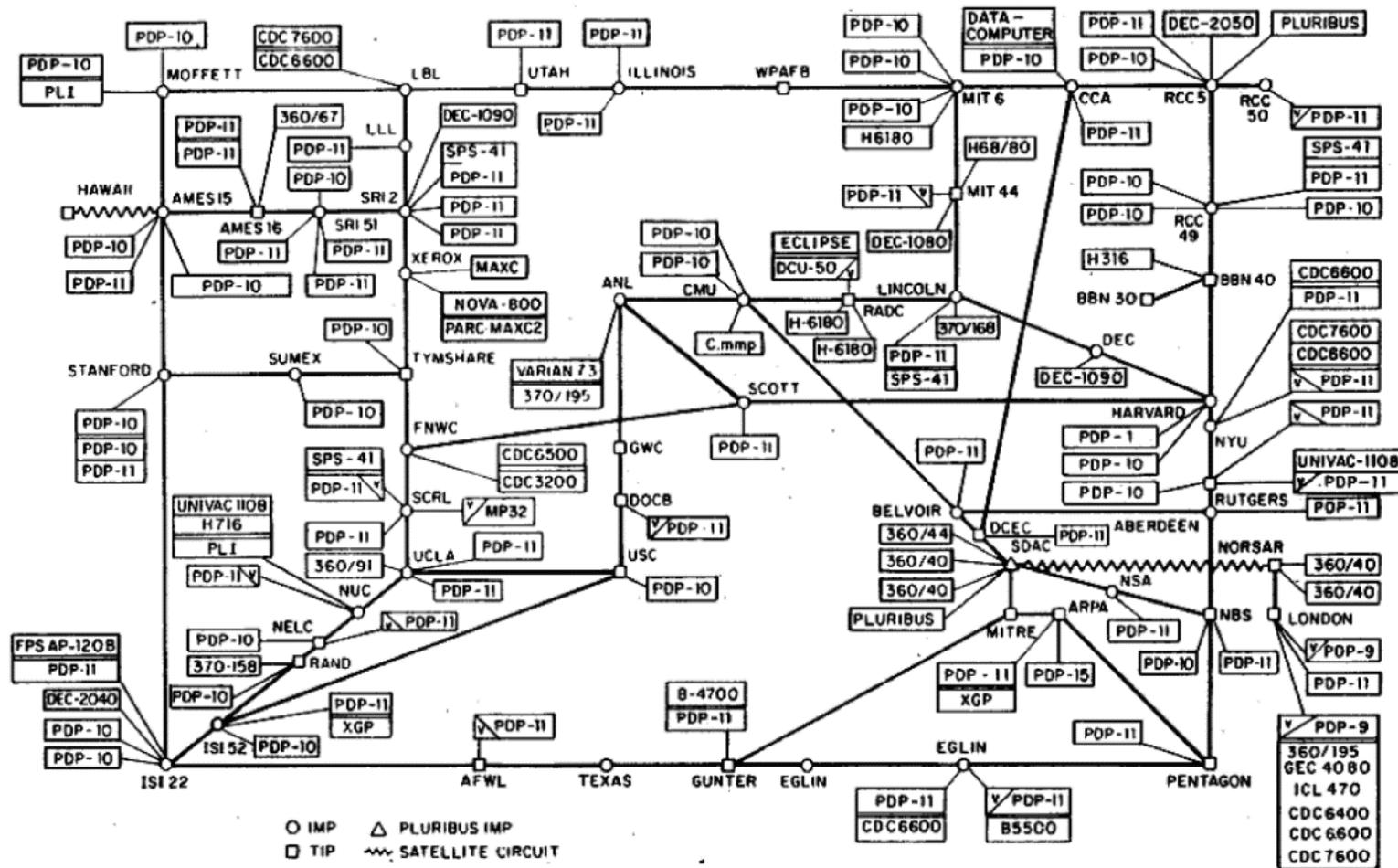
ARPANET

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



ARPANET in 1977

ARPANET LOGICAL MAP, MARCH 1977

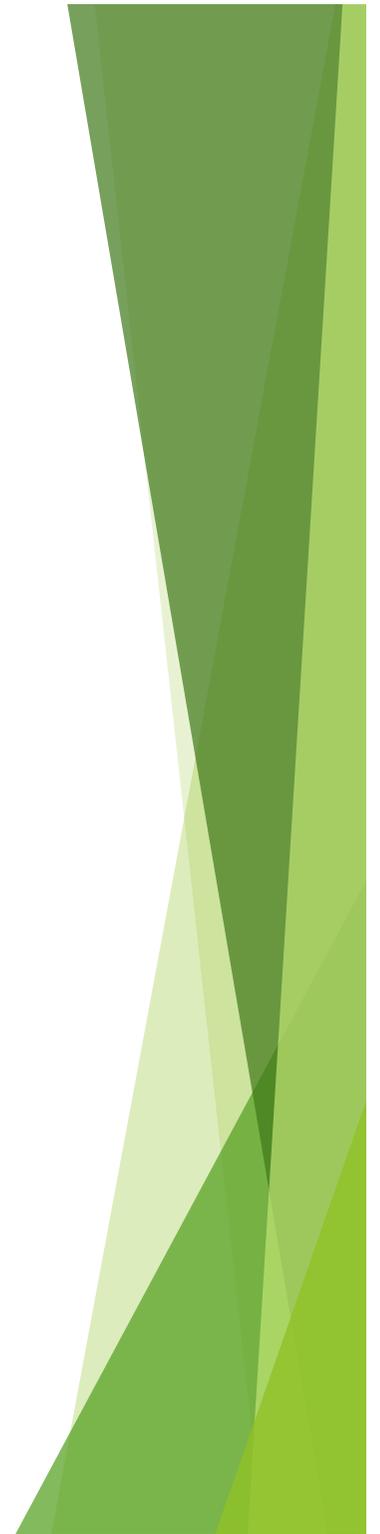


(PLEASE NOTE THAT WHILE THIS MAP SHOWS THE HOST POPULATION OF THE NETWORK ACCORDING TO THE BEST INFORMATION OBTAINABLE, NO CLAIM CAN BE MADE FOR ITS ACCURACY)

NAMES SHOWN ARE IMP NAMES, NOT NECESSARILY) HOST NAMES

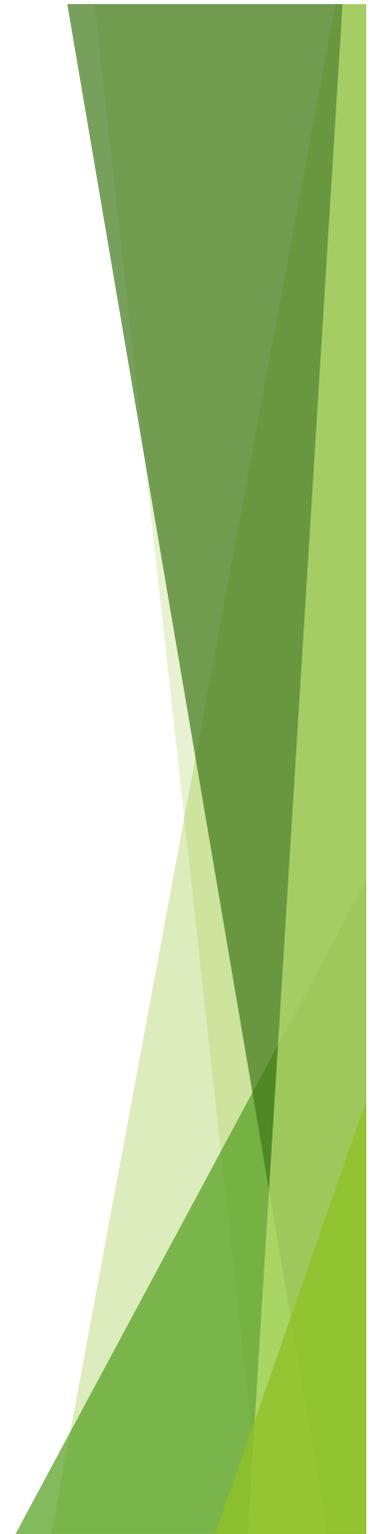
ARPANET

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



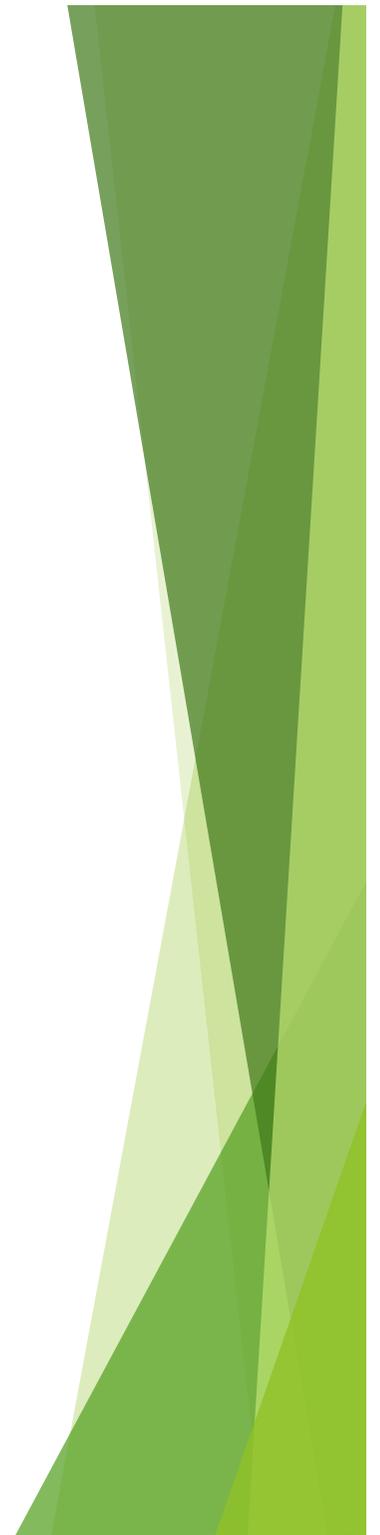
ARPANET to the Internet

- ▶ 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



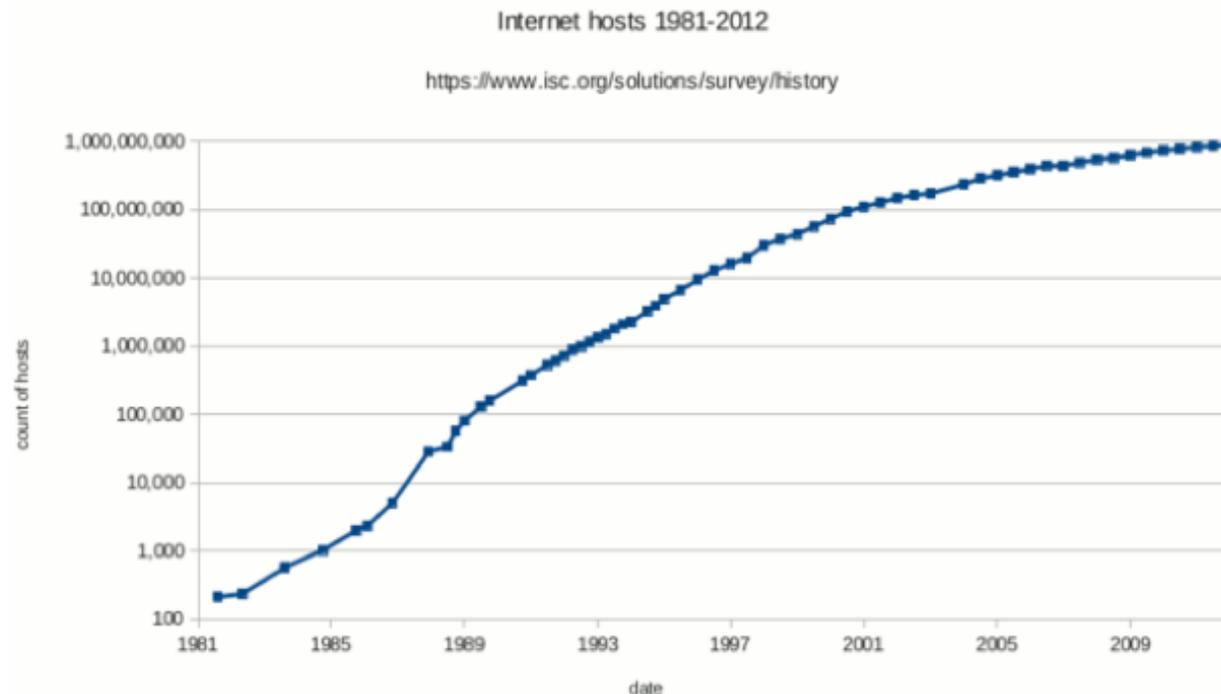
WWW vs Internet

- ▶ The Internet is a global system of interconnected computer networks.
 - ▶ Carries a vast range of resources and services.
- ▶ WWW is a global collection of documents and other resources accessed through the Internet using HTTP - one of many Internet communication protocols.
 - ▶ Documents are linked via hyperlinks and are identified by their URL.



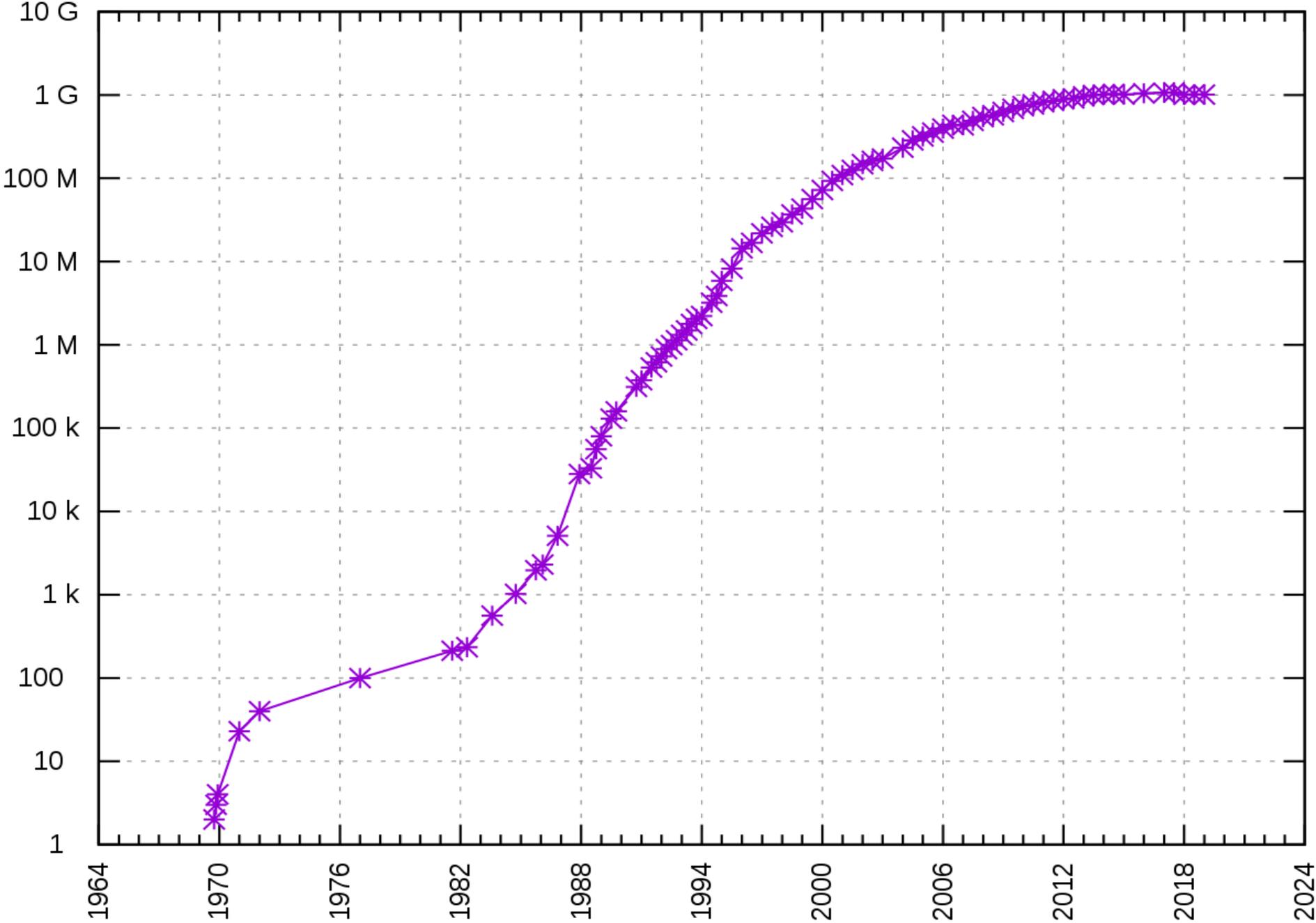
Internet growth

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

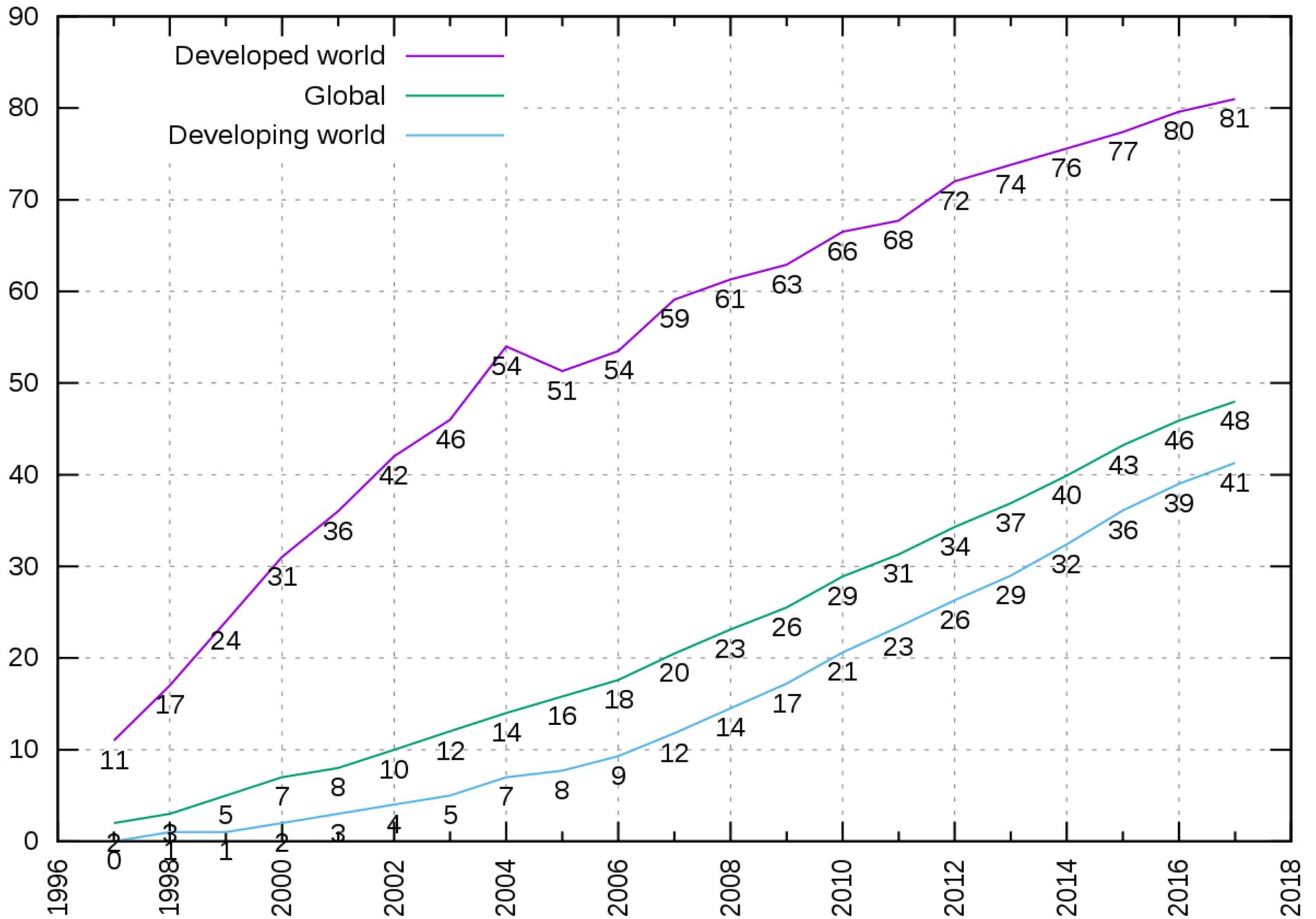


Number of hosts on logarithmic scale until 2012

Internet Hosts Count

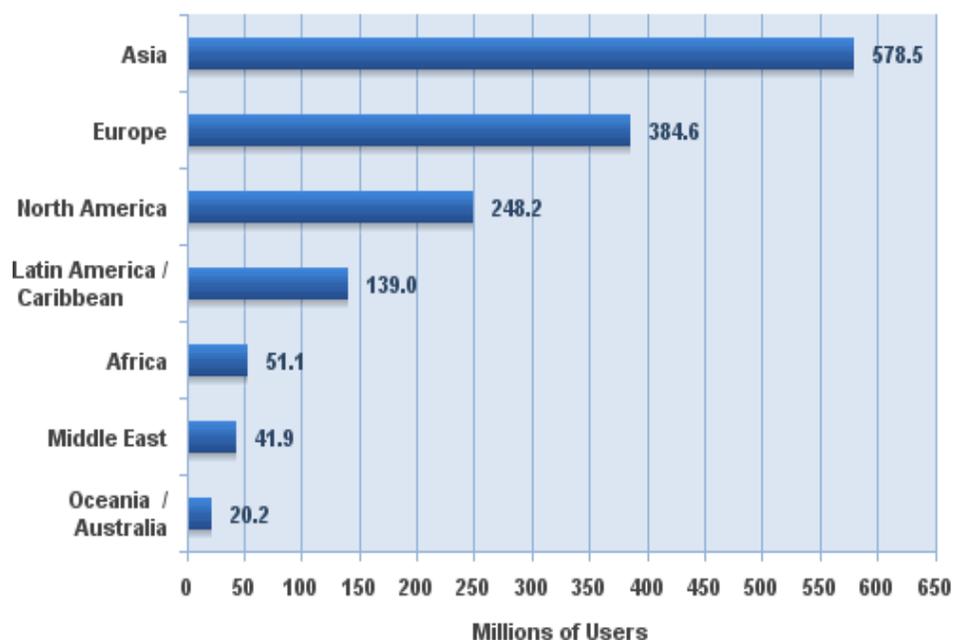


Internet Users Per 100 Inhabitants



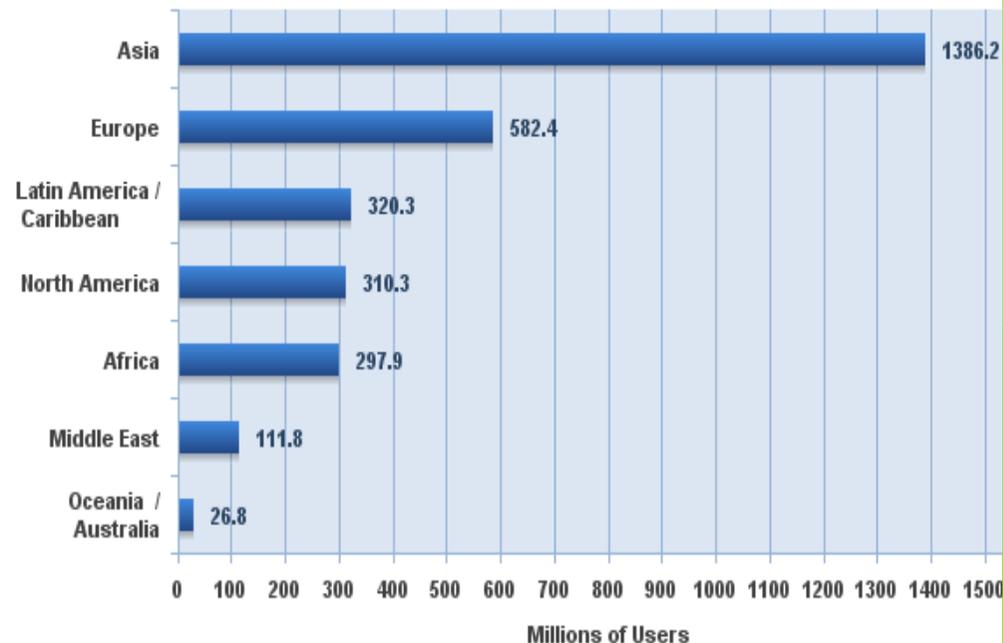
Internet usage

Internet Users in the World by Geographic Regions



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

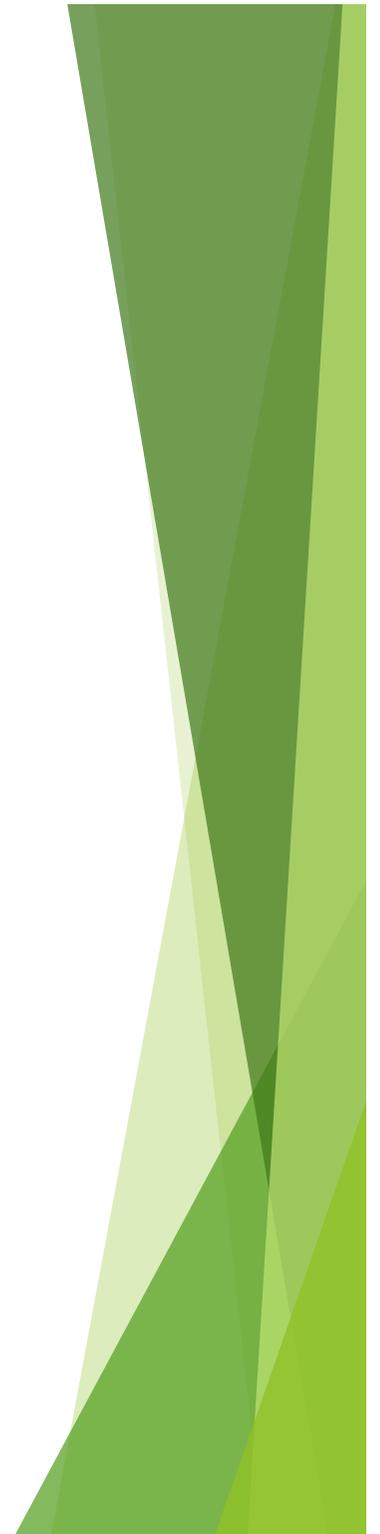
Internet Users in the World by Geographic Regions - 2014 Q2



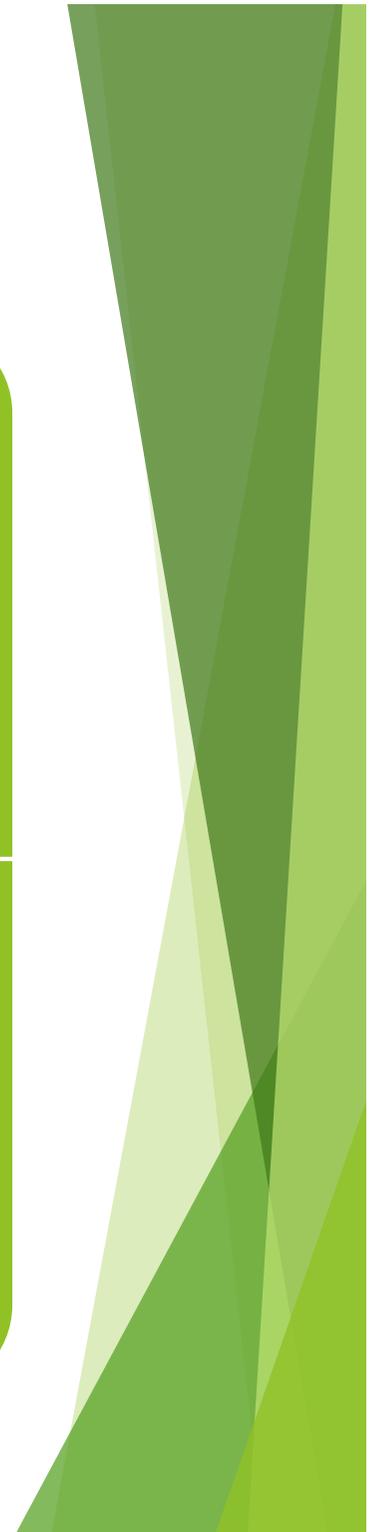
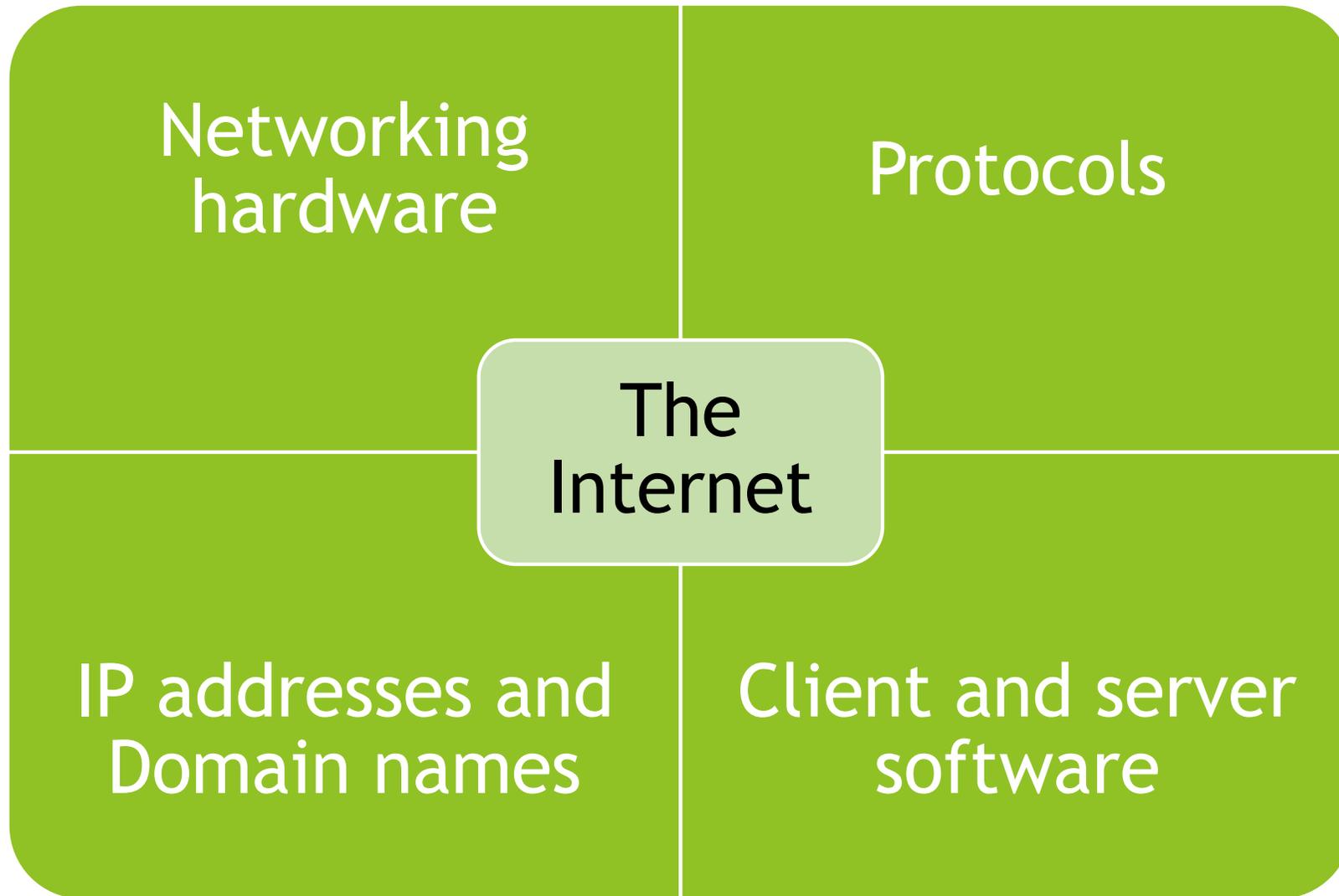
Source: Internet World Stats - www.internetworldstats.com/stats.htm
3,035,749,340 Internet users estimated for June 30, 2014
Copyright © 2014, Miniwatts Marketing Group

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



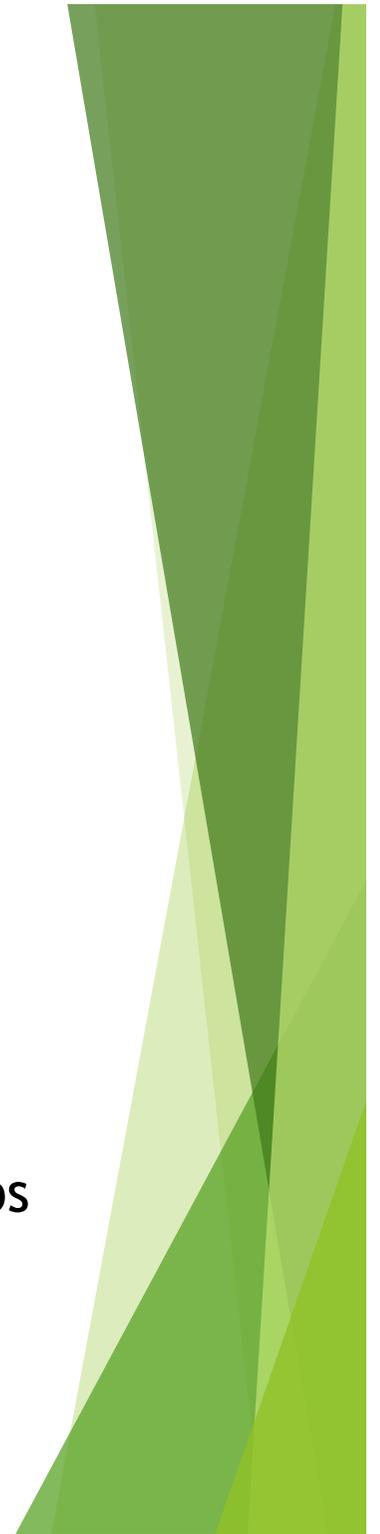
▶ Router

- ▶ Directs traffic around the network and connects networks together



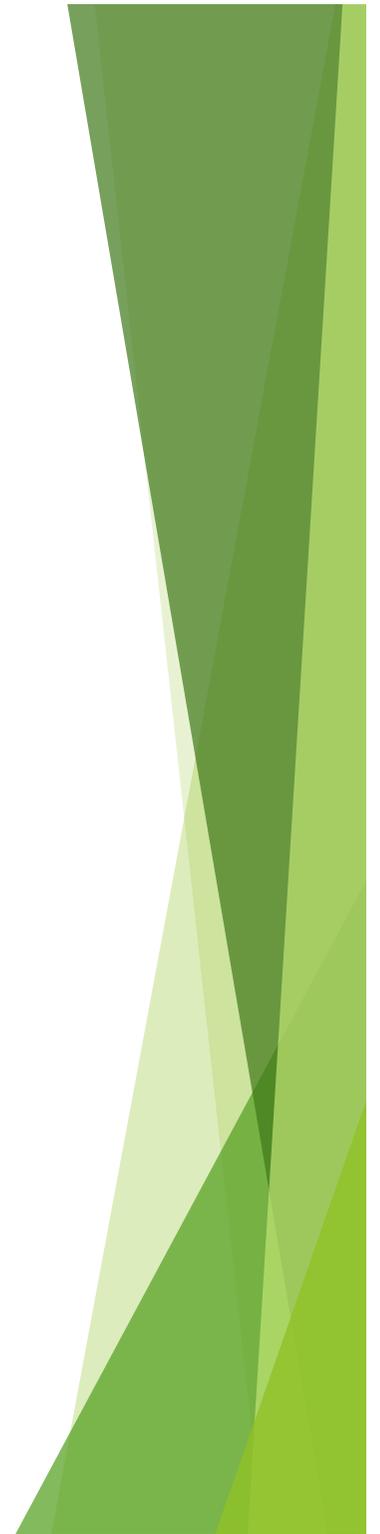
Networking hardware

- ▶ Modem (modulator/demodulator)
 - ▶ Responsible for transmitting and receiving data on the physical 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 - 56Kbps
 - ▶ ADSL (Asymmetric Digital Subscriber Line) - 24Mbps
 - ▶ VDSL (Very high bit rate Digital Subscriber Line) - 70Mbps
 - ▶ Fibre Optic modems - 1Gbps



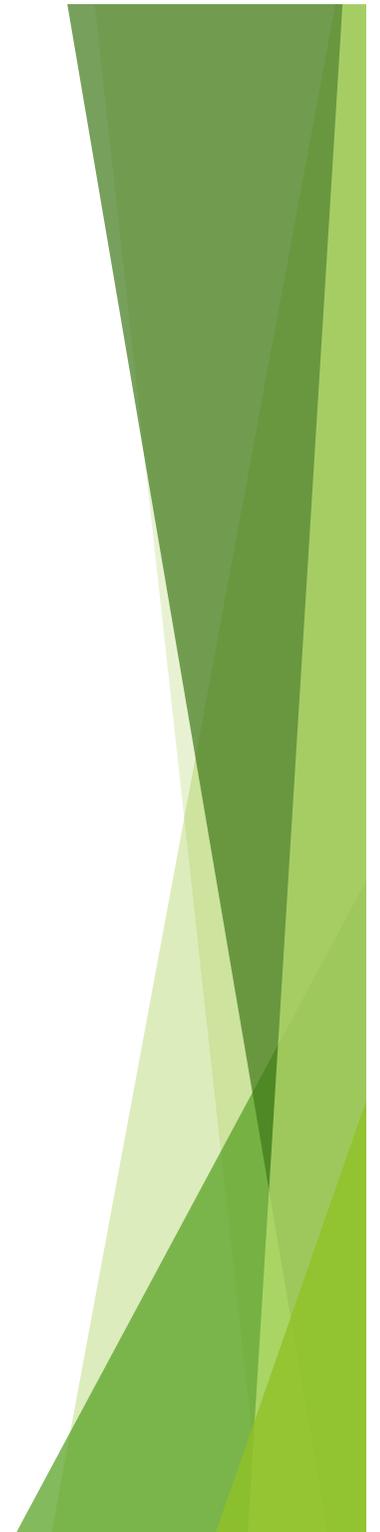
Protocol

- ▶ Protocol: a standardised method of communication
- ▶ Ensures that the sender and receiver can 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 over a network
 - ▶ HTTP: used for client/server communication such as transferring web pages
 - ▶ POP3, IMAP, SMTP: used for email
- ▶ Many protocols used in networking are defined in a RFC (Request for Comments) document
 - ▶ RFC 791: IP
 - ▶ RFC 2616: HTTP



Protocols - TCP/IP, UDP

- ▶ IP - Internet Protocol:
 - ▶ A unique identifier for computers on the Internet
 - ▶ 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 such as video streaming, Skype calls etc.

IP Address

- ▶ Every host on the Internet needs an IP address.
- ▶ Version 4
 - ▶ 32-bit number
 - ▶ Maximum addresses possible 2^{32} (~4.3 billion)
- ▶ Version 6
 - ▶ 128-bit number

69 . 89 . 31 . 226

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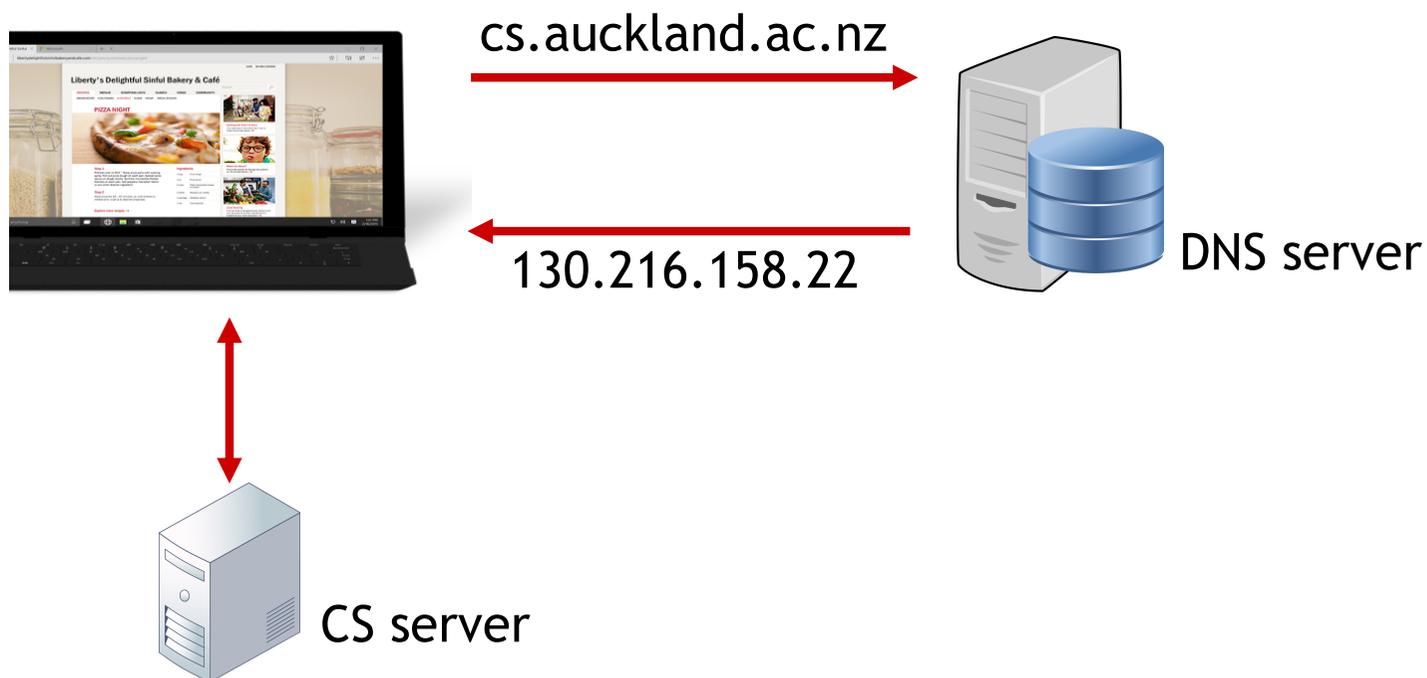
01000101 . 01011001 . 00011111 . 11100010

1st Octet 2nd Octet 3rd Octet 4th Octet

IPv4 ip address (32 bits)

IP addresses and domain names

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



Client and server software

- ▶ Client software:

- ▶ Web browsers



- ▶ Email clients:

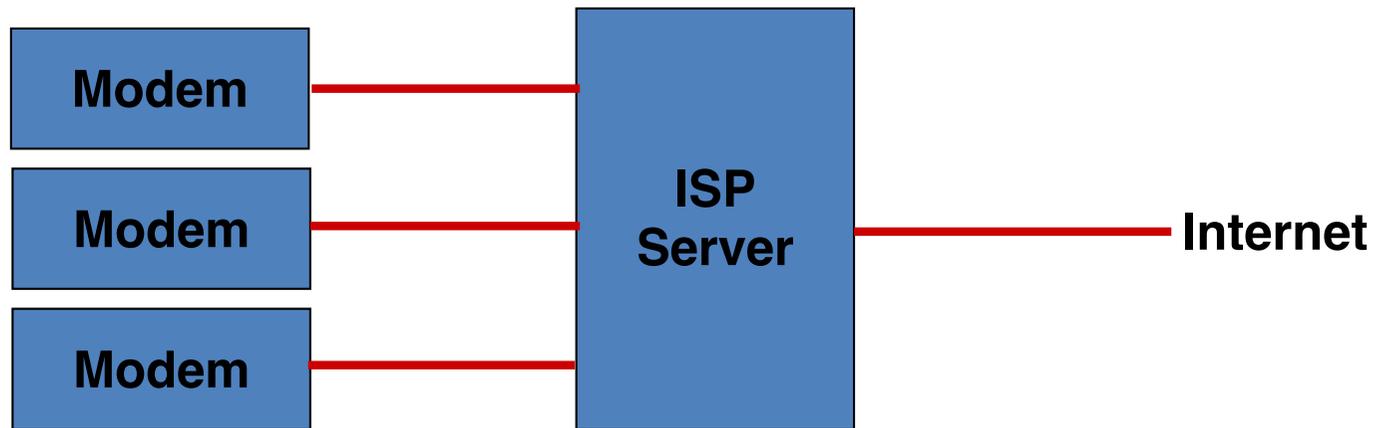


- ▶ Server software:



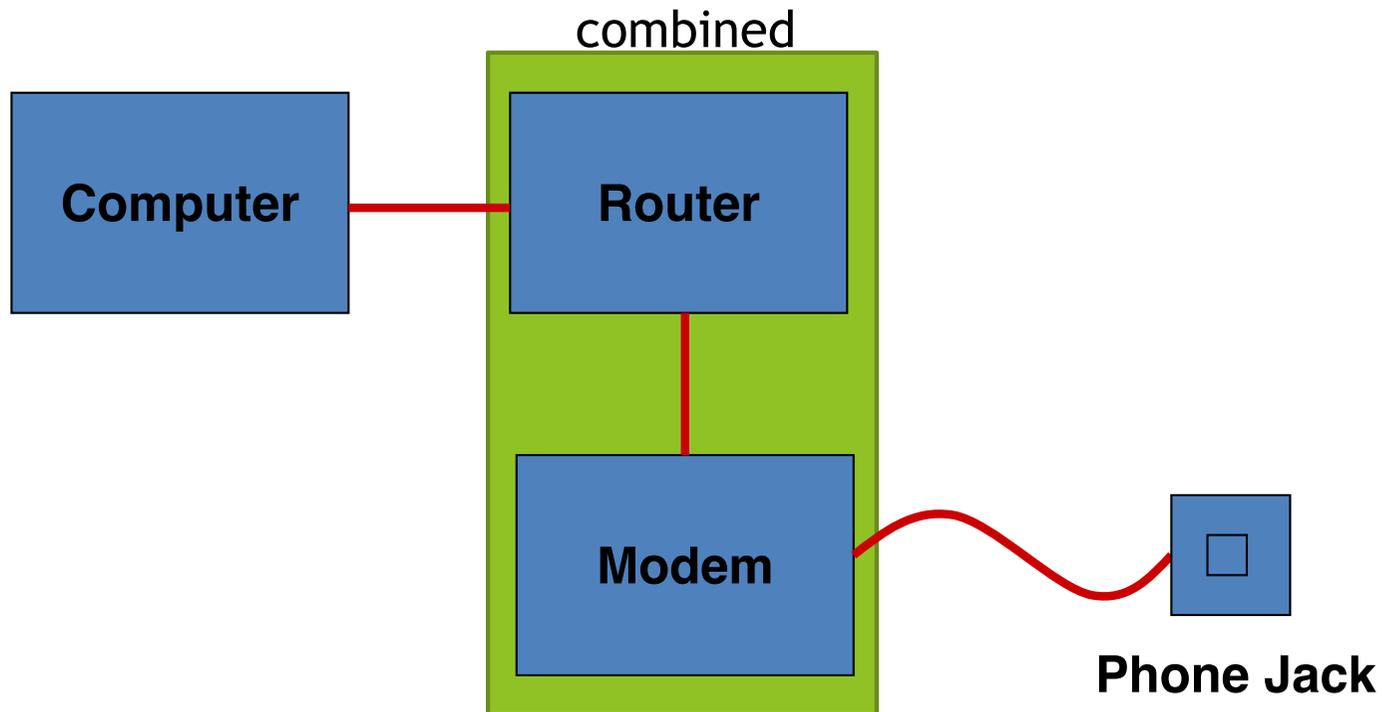
Connecting to the Internet

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



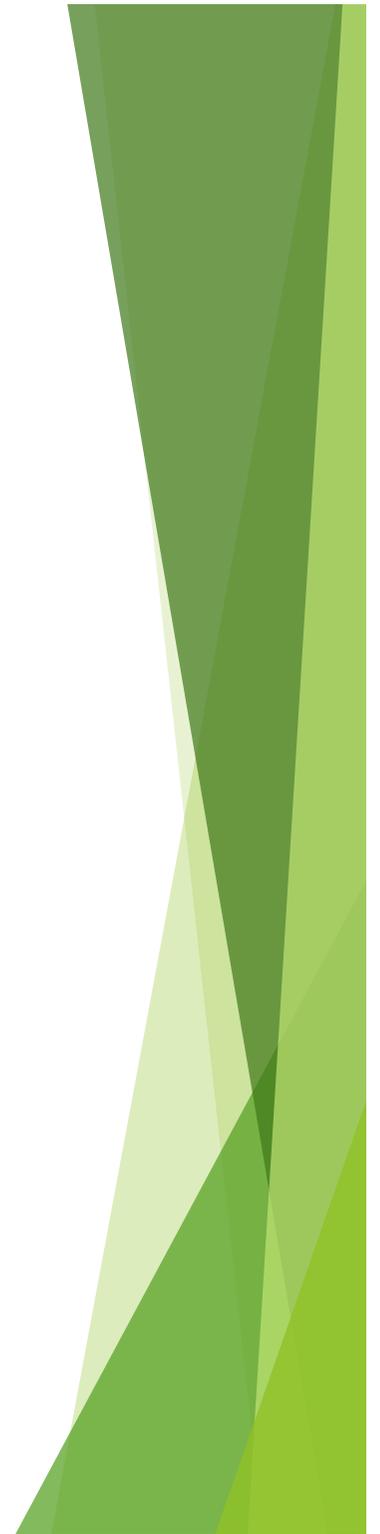
Connecting to the Internet

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



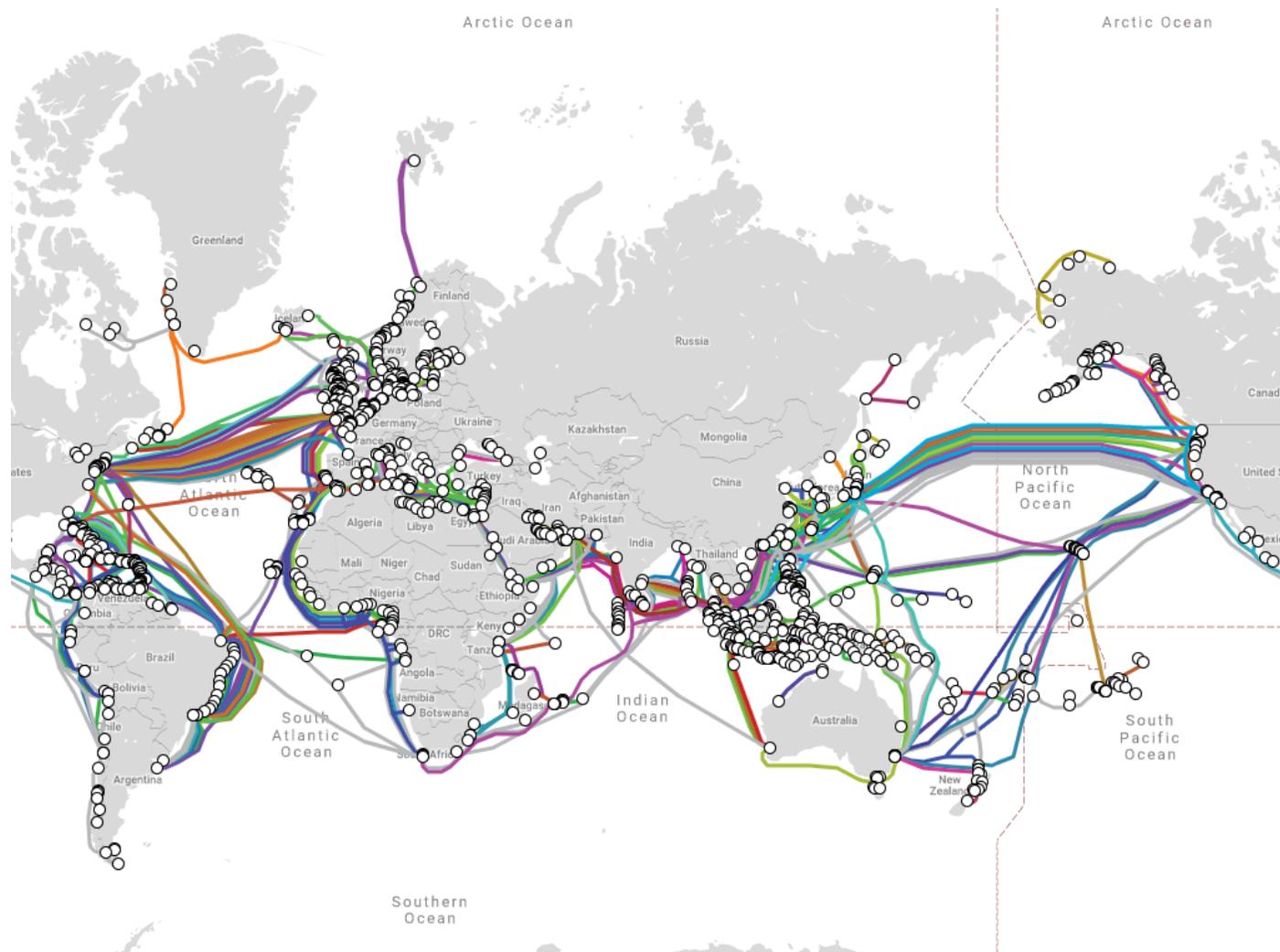
The Internet's backbone

- ▶ High-capacity fibre optic cables laid on land and under the sea
- ▶ Owned by companies who rent out capacity on the cables
- ▶ They connect countries together to form the global Internet so are extremely important
 - ▶ Having multiple backbone cable connections provides extra capacity and redundancy

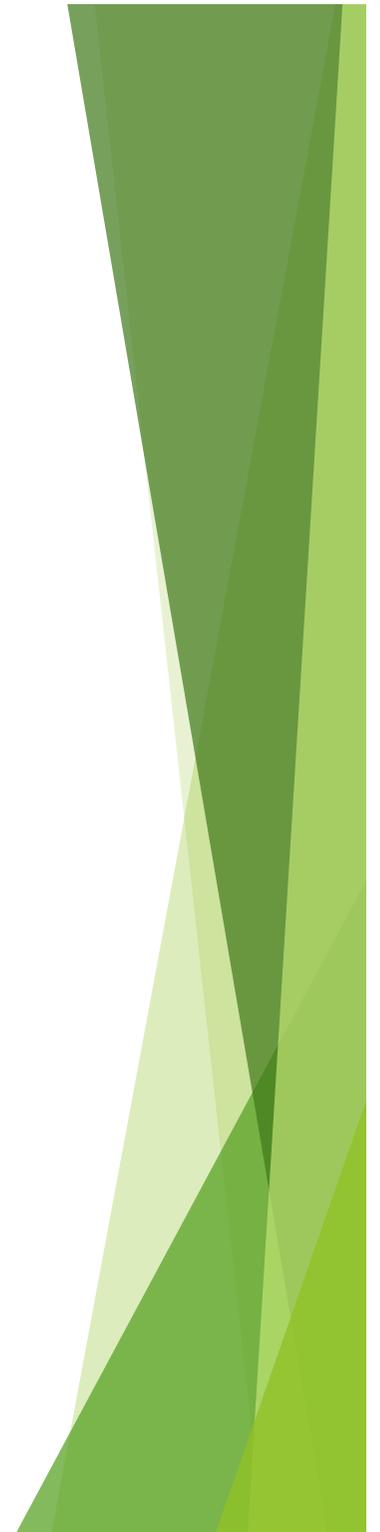
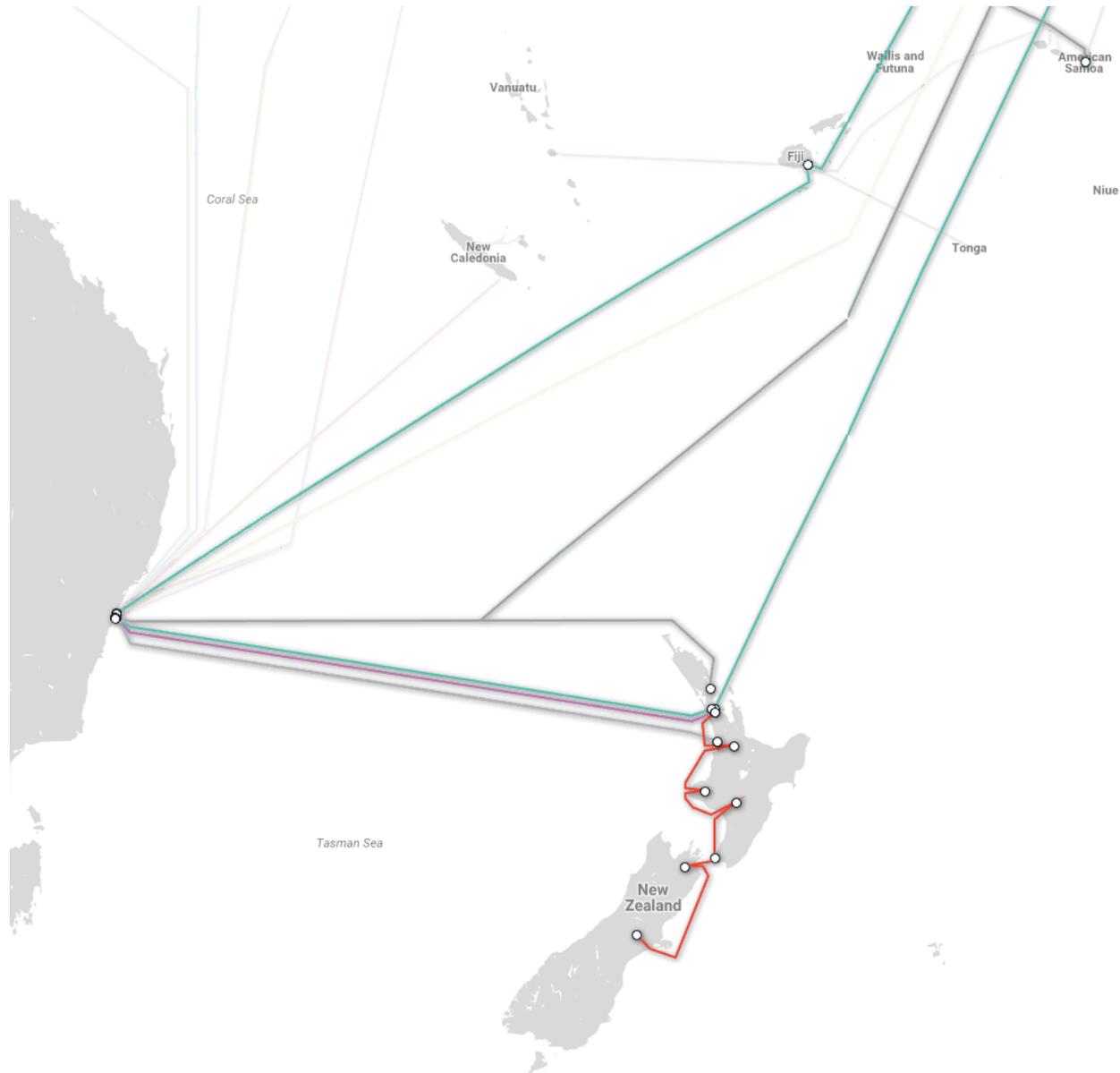


The Internet's backbone

- ▶ Go to www.submarinecablemap.com to see the undersea backbone cables

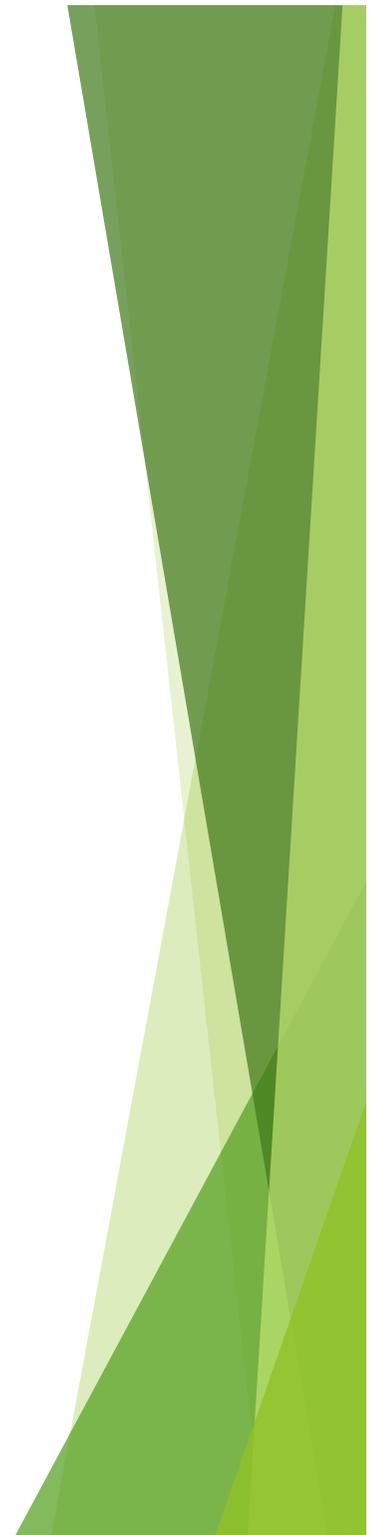


NZ's backbone cables



Answers

- ▶ What network model does the Internet use?
 - ▶ Packet-switched network
- ▶ What Internet protocol should your program use if it is time-sensitive?
 - ▶ UDP - user datagram protocol
- ▶ What is the name of the documents that describe the technical details of protocols?
 - ▶ RFCs - request for comments



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, organisations tasked with maintaining it need to ensure the Internet can handle the increased demand (eg. moving from IPv4 to IPv6)

