

UNIT 11A

The Internet: Fundamentals

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1

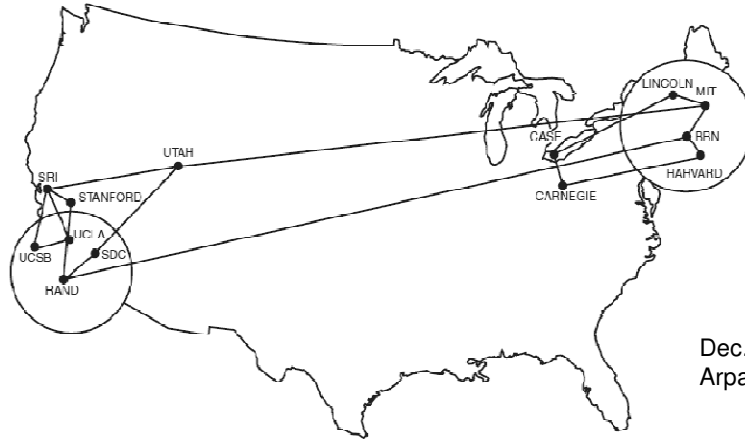
What is the Internet?

- The Internet is a system to deliver data (bits) from one computational device to another.
- No one entity controls/owns the Internet.
- The Internet is governed by protocols and standards that are commonly agreed to by developers of network software and applications.

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2

ARPANET to Internet



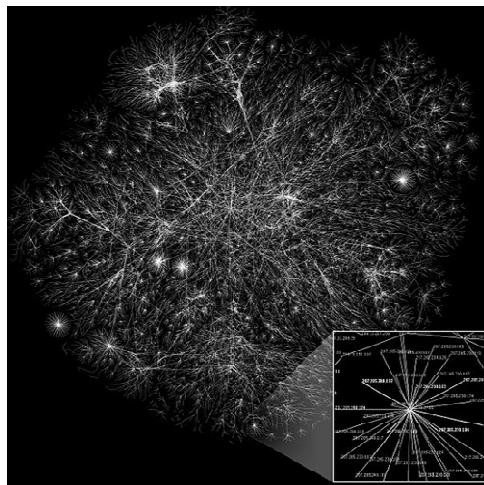
Dec. 1970
Arpanet

Source: Heart, F., McKenzie, A., McQuillan, J., and Walden, D., ARPANET Completion Report, Bull. Beranek and Newman, Burlington, MA, January 4, 1978.

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3

ARPANET to Internet



2000's
Internet Map
(small section)

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4

Structure of the Internet

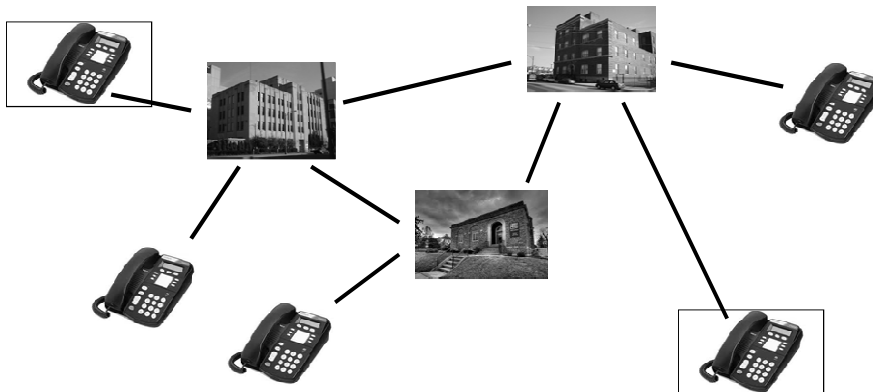
- Core
 - routers
 - gateways
 - Internet Service Providers (ISP's)
 - domain name servers
- Edges
 - individual users
 - private networks

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5

Circuit Switching

- Two network nodes (e.g. phones) establish a dedicated connection via one or more switching stations.



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6

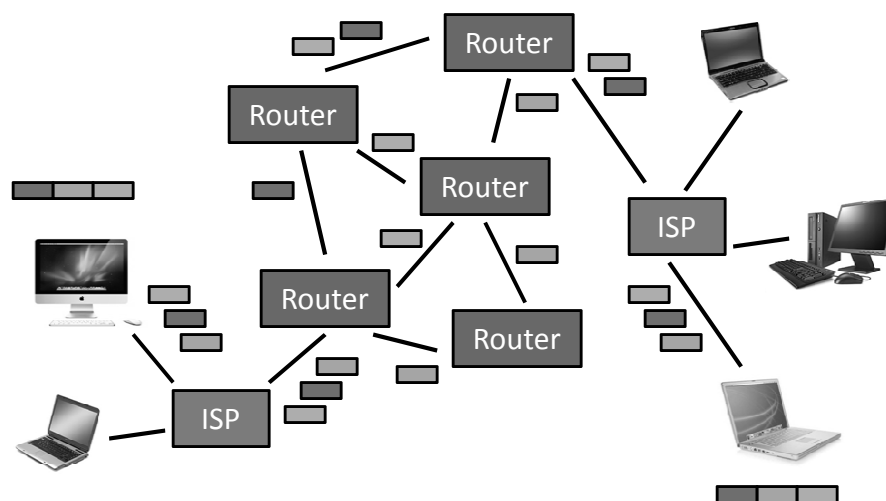
Packet Switching

- Two network nodes (e.g. computers) send messages by breaking the message up into small packets and sending each packet on to the network with a serial number and a destination address.
- Routers in the network use a buffer (queue) to hold packets until they can be routed toward their destination.
- Packets may be received at the destination in any order and may get lost and retransmitted. Serial numbers are used to put packets back into order at the destination.

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7

Packet Switching



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8

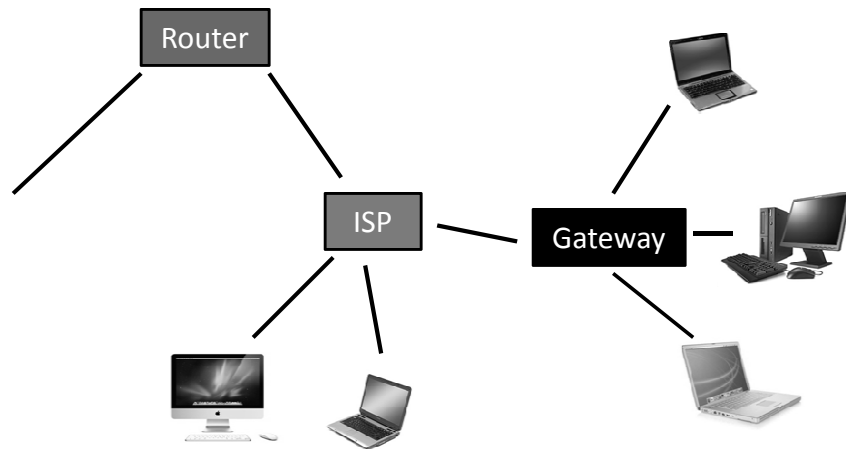
IP Addresses (IPv4)

- Computers on the internet are assigned an IP Address
____ . ____ . ____ . ____
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.
→ supports up to 2^{32} computers on the network at the same time
- ISPs can reassign IP addresses dynamically.

Network Address Translation (NAT)

- To accommodate more users on the Internet, NAT is used.
- The gateway assigns an additional code called a port for each user. Packets are tagged with the port.
- The gateway knows where to route the messages on the private network, but all messages from that private network share the same single IP address.

Network Address Translation (NAT)



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11

IPv4 Address Assignment

- The original IPv4 had several classes of addresses:
 - 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 addr
Accommodates up to 2^8 unique IP addresses in a company or location.

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12

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 address part (so there can only be 32 machines on that network).
- IPv6 also follows classless routing, but the standard subnetwork size is 64-bits (which allows using the MAC address manufactured into each ethernet card as the local part. Normally 48-bit prefixes of IPv6 are assigned to individual organizations, allowing each organization to have a 65,535 subnetworks with up to 2^{64} machines per subnetwork.

New IP (IPv6)

- IPv6 uses 128-bit addresses
 - supports 2^{128} unique computer addresses
 - = 3.4×10^{38}
- 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.

ISPs

- An Internet Service Provider (ISP) is a company that provides access for users to the Internet.
 - AT&T, Comcast, EarthLink, Verizon, etc.
 - access can be provided via copper cable, wireless transmission, fiber optic cable, etc.
 - In rural areas, an ISP may be a company providing Internet services by satellite.
 - Universities (like CMU) and big companies (like Google and Microsoft) are their own ISPs.

Internet Protocol (IP)

- A *protocol* is a standard for communicating messages between networked computers.
- An IP address in each packet determine the intended destination of the packet.
- A domain name server translates machine names to equivalent IP addresses to make it easier for users to indicate message destinations.
 - Example: www.cnn.com, unix.andrew.cmu.edu, employees.verizon.net

Transfer Control Protocol (TCP)

- TCP is the main protocol used on the Internet to transmit messages using packets.
 - used for the web, email and file transfer
- TCP can detect if a packet is lost, delivered out of order or duplicated.
- TCP is optimized for accurate delivery rather than timely delivery.
 - For streaming data, other protocols are used (e.g. UDP) where packet loss is not as critical.

TCP and “Handshaking”

- The process of two parties determine that each has received the other’s transmission correctly is called *handshaking*.
 - Alice sends several packets to Bob using TCP.
 - Each packet includes parity information so Bob can check its accuracy.
 - When Bob receives a packet, if it is ok, Bob sends an acknowledgement packet back to Alice.
 - If Bob is missing a packet, he can send a request for a retransmission of the packet.
 - If Alice doesn’t get an acknowledgement within a set period of time, she can retransmit the packet.

Routers

- Routers are considered to be very simple devices whose sole purpose is to route data traffic.
- The end-to-end principle in the Internet
- Routers only implement IP by routing packets. It is up to the end units to run the more involved TCP to check for transmission errors, omissions and duplications.

Fault Tolerance

- The Internet is subject to faults at individual nodes. The protocols are designed to allow data traffic to be rerouted if nodes go down or become too overloaded.
 - World Trade Center Attack (9/11/2001)
 - New Orleans & Hurricane Katrina (2005)
 - Hanchung earthquake (2006)
 - Qatar Internet blackout (2008)