

UNIT 11A

The Internet: Fundamentals

1

Computer Networks

- A computer network is a set of independent computer systems connected by telecommunication links.
- The Internet is the most widely used network.
- Technological innovation forever changing society
 - Equalizes access to information
 - Facilitates exchange of ideas, opinions

2

Communication Links

- Transmitted data (signals) propagate through physical links
 - Coaxial cable, twisted pair, fiber optic, wireless
 - Vary in transmission speed, error rate
- Data link established between two hosts
 - Data frame: unit of transmission
 - Transmission errors are detected and corrected

3

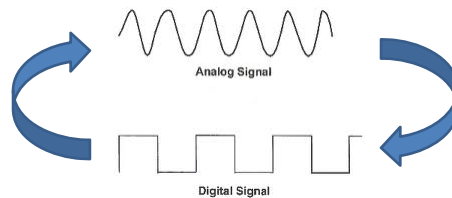
Communication Protocols

- Digital message formats and rules for exchanging those messages
 - signaling, authentication, error detection and correction capabilities.
- Protocols have to be agreed upon by the parties involved. To reach agreement a protocol may be developed into a technical standard.
- Standards Bodies
 - International Standards Organization (ISO), Internet Society, W3C

4

Communication Links

- In the early days of computing dial-up phone lines were used with low bandwidth (9,600 bps)



Modem (modulator - demodulator) encodes digital data to be represented as an analog signal and reconstructs a digital signal from an analog signal

5

Broadband Technologies

- Broadband refers to a communication bandwidth of at least 256 Kbps.
 - Digital subscriber line (DSL): Uses telephone lines but uses frequencies different from phone and transmits digital signals.
 - Cable modem: Uses cable TV lines. Some of the link capacity is used for data communications
 - Ethernet (up to 100 Gbps): Family of technologies for local area networks
 - Wireless broadband technologies

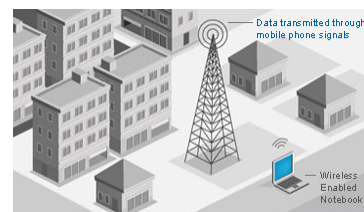
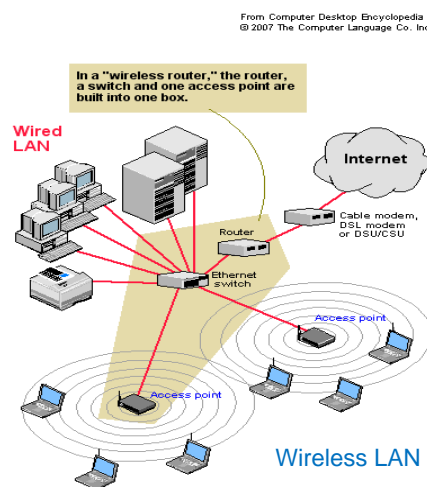
6

Wireless Data Communication

- Wireless data communication using radio, microwave, and infrared signals
 - Wireless local access network: user transmits messages to a local wireless base station referred to as a wireless router. Typically used in homes, coffee shops.
 - Wireless wide area access network: user transmits messages to a remote base station provided by a telecommunications company.

7

Examples



Wireless WAN

8

Wireless Local Access Standards

- Wi-Fi (Wireless Fidelity). Officially IEEE 802.11 wireless network standards.

- Wireless version of a wired local area network



- Bluetooth

- Low-power wireless standard for communication between devices close to each other



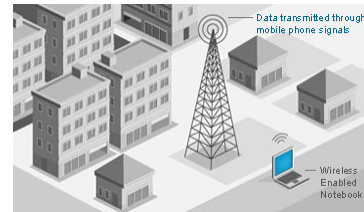
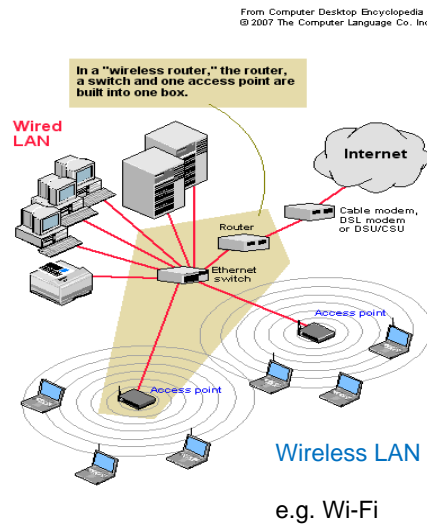
9

Wireless Wide Area Access Standards

- 3G (3rd generation mobile communication standards)
- 4G - Long Term Evolution (LTE)
 - anticipated to become the first truly global mobile phone standard
 - Currently 6-8Mbps on downlink and 2-3Mbps for uplink (roughly).

10

Examples



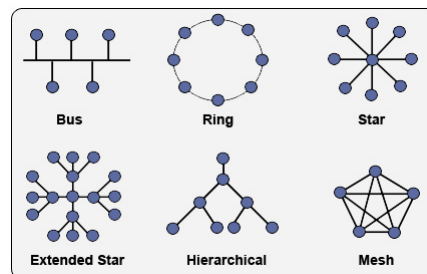
Wireless WAN

e.g. 3G, 4G

11

Local Area Networks

Local area networks connects devices that are in close proximity such as computers, printers, and storage devices.



A local area network can be built using different topologies.

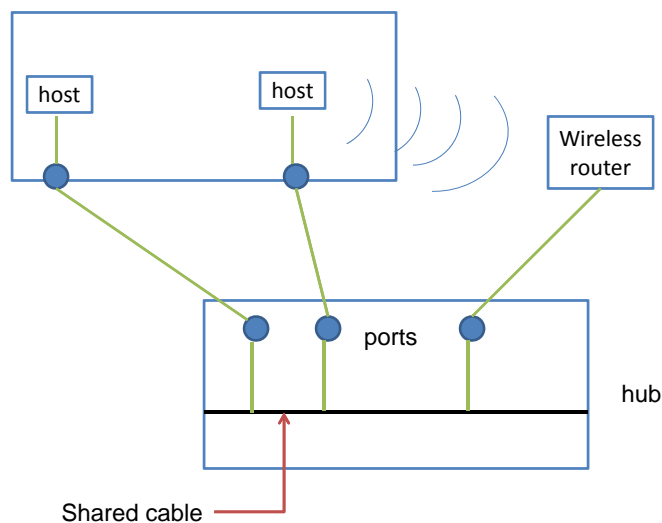
12

Local Area Network (LAN)

- Ethernet is the most widely used technology for building local area networks (LAN)
 - Uses the bus topology: To send a message a node places the message, including the destination address on the cable . Each node looks at the destination address to see if it is the intended recipient.
 - The Ethernet first developed by Xerox in the early 1970s. Ethernet later became a generic term.

13

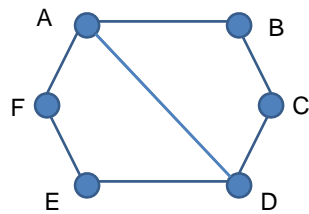
Example Ethernet LAN



14

Wide Area Network (WAN)

- Wide area networks connect devices that are not in close proximity.
 - Typically, directed point-to-point lines as opposed to shared lines as in LANs, and selective switching of messages
 - They cross public property so users must purchase telecommunications services.



A message from A to C could go through
 A -> B -> C, or
 A -> D -> C, or

15

Inter-networks

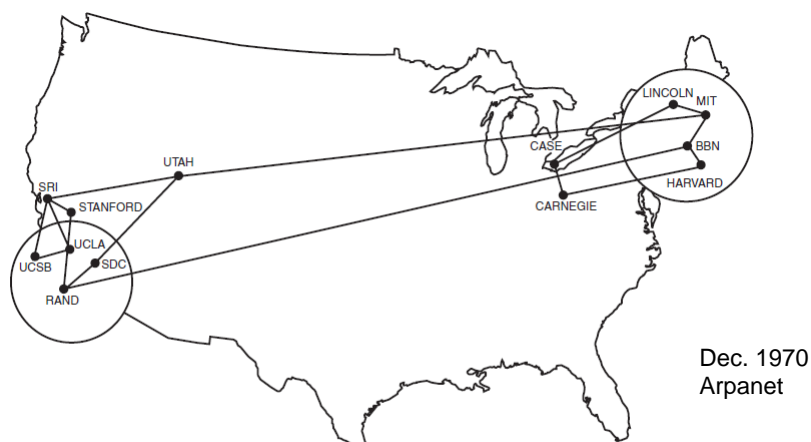
- Real-life networks are a mix of both network types.
- An inter-network allows different networks to cooperate
 - Routers transmit messages between two distinct types of networks.

16

What is the Internet?

- The Internet is a “system” to deliver data from one computational device to another, using internetworking.
 - Designed to connect any types of network
- 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.¹⁷

ARPANET to Internet

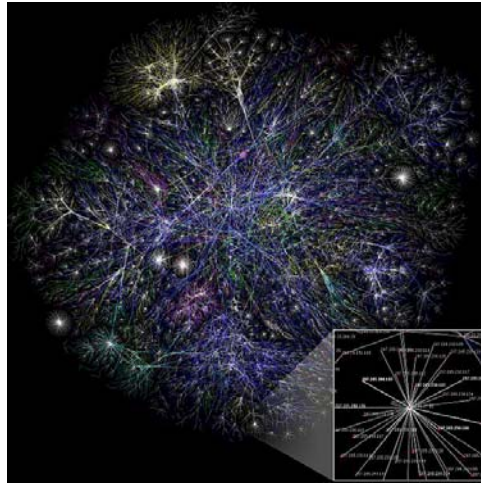


Source: Heart, F., McKenzie, A., McQuillan, J., and Walden, D., ARPANET Completion Report, Bolt, Beranek and Newman, Burlington, MA, January 4, 1978.

15110 Principles of Computing, Carnegie Mellon University - CORTINA

18

ARPANET to Internet



2000's
Internet Map
(small section)

15110 Principles of Computing, Carnegie
Mellon University - CORTINA

19

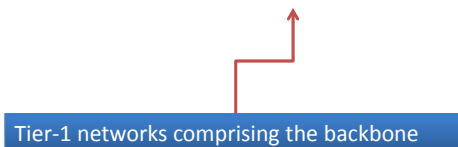
Internet Service Providers (ISPs)

- An Internet Service Provider (ISP) is a company that provides access for users to the Internet.
 - AT&T, Comcast, EarthLink, Verizon, etc.
- Access occurs through a WAN owned by ISP.
 - 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.

20

Internet Backbone

- ISPs are hierarchical, interconnected in multiple tiers
 - Individuals or companies connect to local ISPs
 - Local ISPs connect to regional ISPs
 - Regional IPS connect to international ISPs



21

Net Neutrality

- The principle of net neutrality advocates no restrictions by ISPs or governments on consumers' access to networks that participate in the Internet.

Net neutrality means simply that all like Internet content must be treated alike and move at the same speed over the network. The owners of the Internet's wires cannot discriminate. This is the simple but brilliant "end-to-end" design of the Internet that has made it such a powerful force for economic and social good.

– Lawrence Lessig and Robert W. McChesney (Washington Post, June 8, 2006)

22

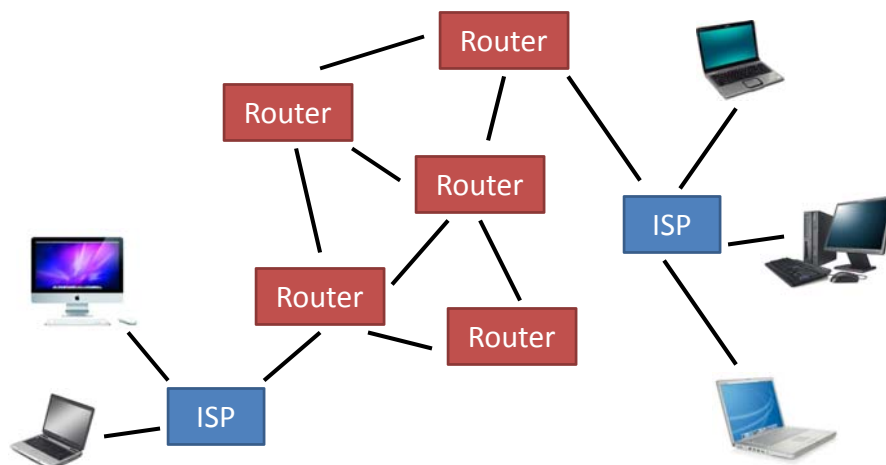
Structure of the Internet

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

15110 Principles of Computing, Carnegie
Mellon University - CORTINA

23

Structure of the Internet



15110 Principles of Computing, Carnegie
Mellon University - CORTINA

24

Design Goals

In order of priority:

1. Continue despite loss of networks or gateways
2. Support multiple types of communication service
3. Accommodate a variety of networks
4. Permit distributed management of Internet resources
5. Cost effective
6. Host attachment should be easy
7. Resource accountability

Source: Dave Andersen, CMU 15-744

25

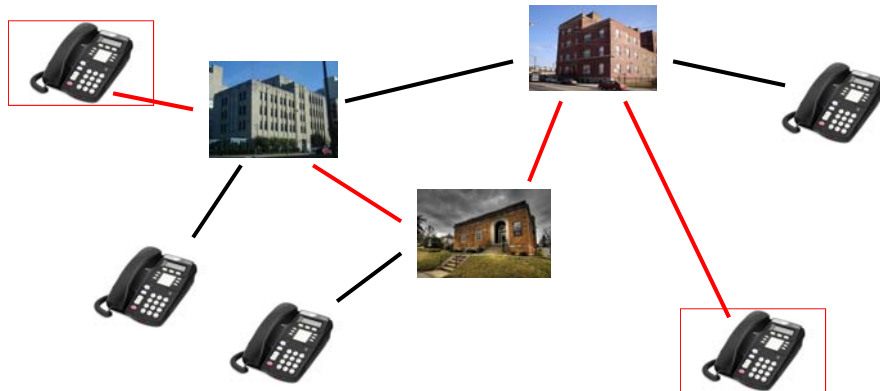
Some Key Design Decisions

- Limit on message size? NO
- Packet-switching or circuit-switching?

26

Circuit Switching

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



15110 Principles of Computing, Carnegie Mellon University - CORTINA

27

Circuit Switching

- Reliable, uninterruptible connections
- High cost per connection
- Adding new nodes requires bigger switches

28

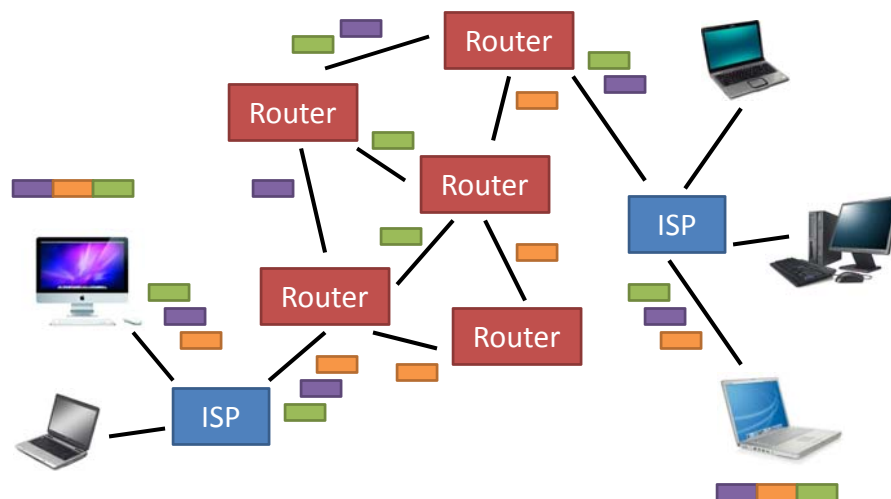
Packet Switching

- 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.

15110 Principles of Computing, Carnegie
Mellon University - CORTINA

29

Packet Switching



15110 Principles of Computing, Carnegie
Mellon University - CORTINA

30

End-to-end Principal

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

31

Governing the Internet

- Internet Society: a range of partners from non-profit agencies, local and global NGOs, academia, technologists, local councils, federal policy and decision makers, business (www.isoc.org)
- Subcommittees the Internet Architecture Board (IAB) and the Internet Engineering Task Force (IETF) established network protocol standards.
 - RFC (Request for Comments): someone posts a proposal and it goes through comments and revisions.

32

Rest of the Week

- Closer look at the Internet protocol stack
- Security over the Internet
- Recommended reading: Blown to Bits
Chapter 5 and the Appendix

33