B E G I N N I N G S
C O M M E R C I A L I Z A T I O N
T H E W O R L D W I D E W E B
What is a Computer Network?

- **Processor**
- **Computer**
- **Interface**
- **Person**

Data, instructions, results flow between these components.
Licklider established Information Processing Technologies Office (IPTO) at ARPA in 1962; provided funding to pursue long-range research, e.g., HCI (GUI), computer graphics.

ARPAnet project proposed officially by IPTO director Taylor in 1968, with Roberts as chief engineer.

ARPAnet built to share data and computing resources – communication between human users not important.
Kleinrock invented and analyzed behavior of adaptive multi-route packet switching, *cf.*, static single-route dedicated communication line.

**Characteristics:**

- Distributed vs. centralized control.
- Any packet can go anywhere regardless of origin or destination.
- Message costs distributed over all network nodes.

Independently developed by Paul Baran (1926-2011) at RAND and Don Davies (1924-2000) at NPL in Britain; called “packet switching” by Davies.
Computer Networks: Beginnings (Cont’d)

Interface Message Processor (IMP) (1969)
ARPAnet (1969)
ARPAnet (1971)
ARPAnet (1972)
ARPAnet constructed by BBN in 1969 based on 50 kB/s lines linking four nodes (UCLA, SRI, UCSB, U. Utah). All network traffic at each node handled by an Interface Message Processor (IMP) which links network to one or more host computers.

First IMP-host testing done at UCLA in September 1969; first node-node testing done between UCLA and SRI in October 1969. Network testing and tuning follows, led by Kleinrock’s Network Measurement Center at UCLA.

BBN node added in March 1970; pioneers remote machine debugging and software uploading.

First public display of ARPAnet capabilities in Washington, DC at the International Conference on Computer Communications in 1972.
Resource-sharing proves too difficult for people to do; focus shifts to sharing files of data.

First e-mail software created by Tomlinson in 1971 as a “hack” combining cross-system file-sharing program and system-internal user mail program.

E-mail rapidly becomes dominant source of traffic on ARPAnet (75% by 1973).
• Wireless networking pioneered by Norm Abrahamson (1932–) in Hawaii as AlohaNet (operational in 1971).
Vint Cerf (1943–) and Bob Kahn (1938–) propose TCP/IP in 1974; allows easy communication between networks (inter-networking ⇒ internet).
The TCP/IP Layer Hierarchy:

- **Physical**  Direct bit-pipe between two computers.
- **Data Link**  Direct message pipe between two computers (framing and error correction)
- **Network**  Indirect message pipe between two computers
- **Transport**  Indirect message pipe between two programs running on different computers

Layer functions implemented by protocols, where a **protocol** is a mutually agreed-upon set of rules, conventions, and agreements for the efficient and orderly exchange of information.
Computer Networks : Commercialization

- Initial focus on ARPAnet-like Wide-Area Networks (WANs) quickly turned to Local-Area Networks (LANs).
- Initial LANs based on IMPs connecting host computers to ARPAnet.
- Metcalfe creates Ethernet LAN mechanism at PARC in 1974; leaves PARC to co-found 3COM in 1979.

Bob Metcalfe (1946–)
Computer Networks: Commercialization (Cont’d)
Initial commercial LANs designed for network-enabled computers like the SUN Workstation (1982; see above); subsequent LANs connected PCs via special hardware.
Computer Networks: Commercialization (Cont’d)

Acoustic Modem (late 1980s)
Local or regional commercial networks consisting of one or more central servers connected via modem to subscriber PCs emerged in the late 1970s.

Initial networks such as MicroNet (1978) and the Whole Earth ’Lectronic Link (WELL; 1984) relied on fanatic core subscribers (hobbyists and Deadheads, respectively).
Computer Networks: Commercialization (Cont’d)

Tim Berners-Lee (1955–) and Robert Cailliau (1947–)

- Berners-Lee and Cailliau develop first version of World-Wide Web (WWW) system in 1989–1991 at CERN in Switzerland; designed for sharing large-scale multimedia particle physics datasets.
Five components of WWW system: (1) content location specifier (URL), (2) web page creation language (HTML), (3) web page transmission protocol (HTTP), (4) web page distribution (server software), and (5) web page display (client-based web browser software).
• Basic WWW software available by free download from CERN starting in 1991.

• First commercial-grade web browser (Mosaic) created at UIUC in 1993; spun off as Navigator to Netscape (by creators) and Spyglass / Microsoft Internet Explorer (IE) (by UIUC) in 1994.

• Navigator free for individuals but sold for commercial use; IE bundled for “free” starting with Windows 98, prompting (successful) US federal anti-trust lawsuit in 1998.
Welcome to NCSA Mosaic, an Internet information browser and World Wide Web client. NCSA Mosaic was developed at the National Center for Supercomputing Applications at the University of Illinois in Urbana-Champaign. NCSA Mosaic software is copyrighted by The Board of Trustees of the University of Illinois (UI), and ownership remains with the UI.

Jan '97
The Software Development Group at NCSA has worked on NCSA Mosaic for nearly four years and we've learned a lot in the process. We are honored that we were able to help bring this technology to the masses and appreciate all the support and feedback we have received in return. However, this time has come for us to concentrate our limited resources in other areas of interest and development on Mosaic is complete.

All information about the Mosaic project is available from the homepages.

NCSA Mosaic Platforms:
- NCSA Mosaic for the X Window System
- NCSA Mosaic for the Apple Macintosh
- NCSA Mosaic for Microsoft Windows

World Wide Web Resources The following resources are available to help introduce you to cyberspace and keep track of its growth:
- A glossary of World Wide Web terms and acronyms
- An INDEX to Mosaic related documents
- NCSA Mosaic Access Page for persons with disabilities
- Mosaic and WWW related Tutorials
- Internet Resources Meta-Index at NCSA

Mosaic Web Browser (1993)
Google Chrome Web Browser (2008)
• First commercial web services are web content catalogs created by human indexers (Yahoo!; 1993); superseded by automated indexing services (Google; 1998).

• To make money, Yahoo! displays advertisements; Google pioneers search-triggered sponsored links.

• Many retail web services emerge in mid-1990s (Amazon (1995); eBay (1996)); companies provide 95%+ content.

• Overconfidence in technical and financial potential of first-generation web services and their business models results in Dot-Com Crash in early 2000.
Computer Networks: The World Wide Web (Cont’d)

Figure 14.1 A Typical Online Transaction in Nine Steps

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Computer Networks: The World Wide Web (Cont’d)
Retail sites use Web 2.0 to add user reviews of products; in tandem with user purchase data, allows automated recommendations.

Web 2.0 also underlies explosion in social media services (Facebook (2005); Twitter (2006)).

Semantic Web will allow much more accurate searches.

Future WWW will also enable massive interconnection of everyday devices (Internet of Things (IoT)) and utility-like availability of computing power, storage, and services (Cloud Computing).
And If You Liked This...

- MUN Computer Science courses on this area:
  - COMP 2006: Computer Networking
  - COMP 2100: Social Web Analysis
  - COMP 3300: Interactive Technologies
  - COMP 4759: Computer Networks
  - COMP 4768: Software Development for Mobile Devices

- MUN Computer Science professors teaching courses / doing research in this area:
  - Ed Brown
  - Rod Byrne
  - Yuanzhu Chen
  - Mark Hatcher