Computer Science 1000: Part #8

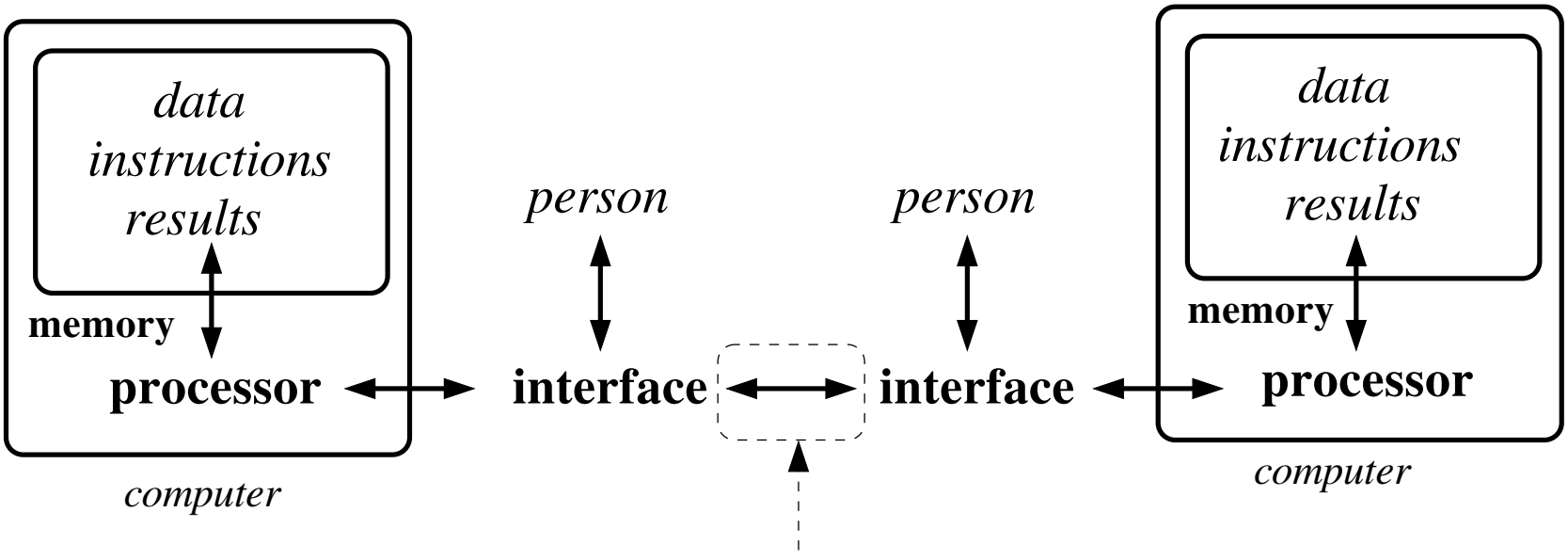
Computer Networks

BEGINNINGS

COMMERCIALIZATION

THE WORLD WIDE WEB

What *is* a Computer Network?



Computer Networks : Beginnings

J.C.R. Licklider
(1915-1990)

ADVANCED RESEARCH PROJECTS AGENCY

- Licklider established Information Processing Technologies Office (IPTO) at ARPA in 1962; provided funding to pursue long-range research, *e.g.*, HCI (GUI), computer graphics.
- Proposed “Intergalactic Computer Network” in 1963.

Computer Networks : Beginnings (Cont'd)

Bob Taylor
(1932–2017)

Larry Roberts
(1937–2018)

- 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.

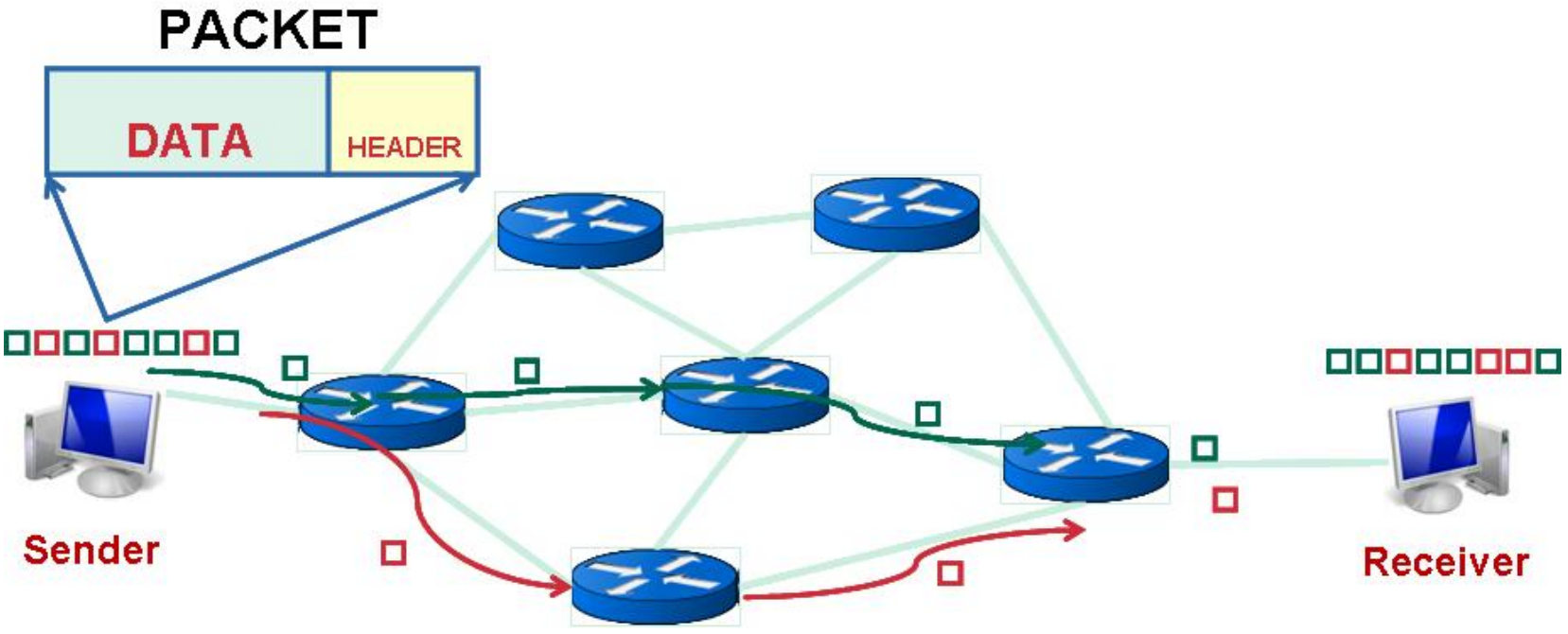
Computer Networks: Beginnings (Cont'd)

Len Kleinrock
(1934–)

- Kleinrock developed mathematical theory 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.

- Packet switching independently developed by Paul Baran (1926-2011) at RAND and Don Davies (1923-2000) at NPL in the UK; called "packet switching" by Davies.

Computer Networks : Beginnings (Cont'd)



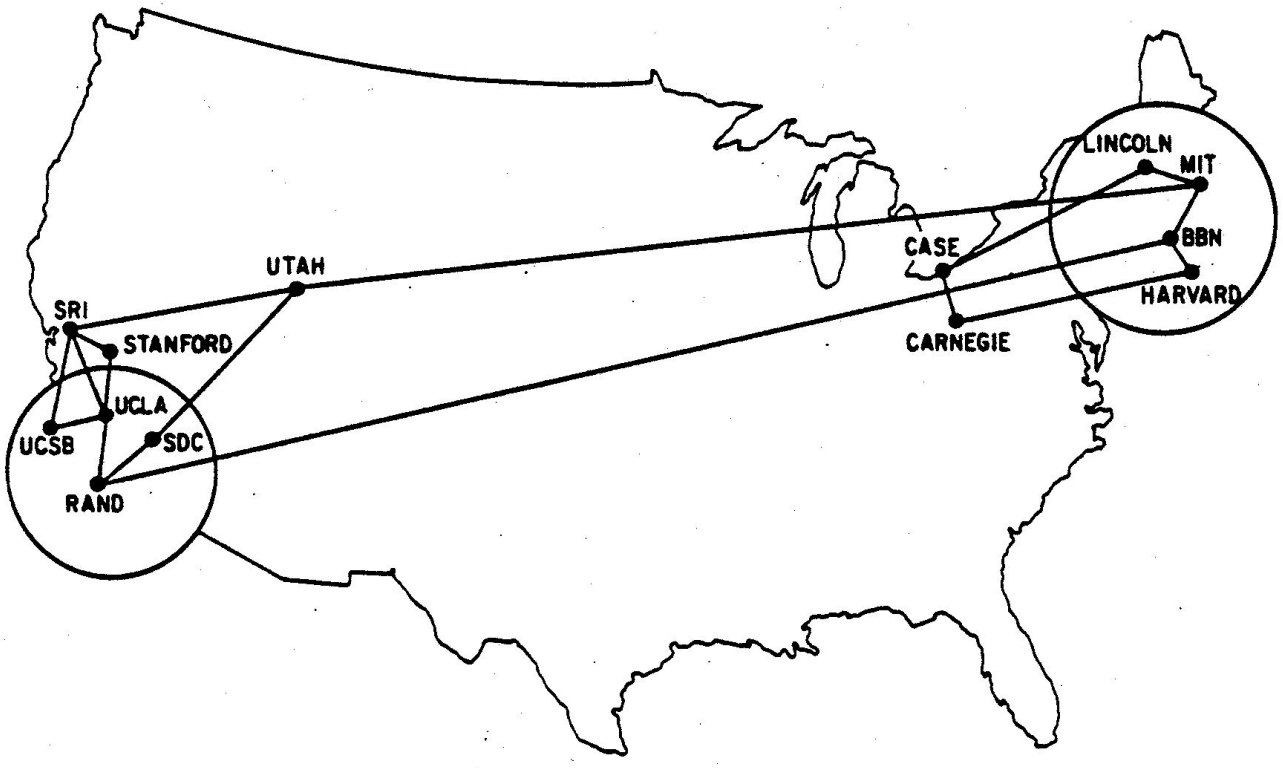
Computer Networks : Beginnings (Cont'd)

Interface Message Processor (IMP) (1969)

Computer Networks : Beginnings (Cont'd)

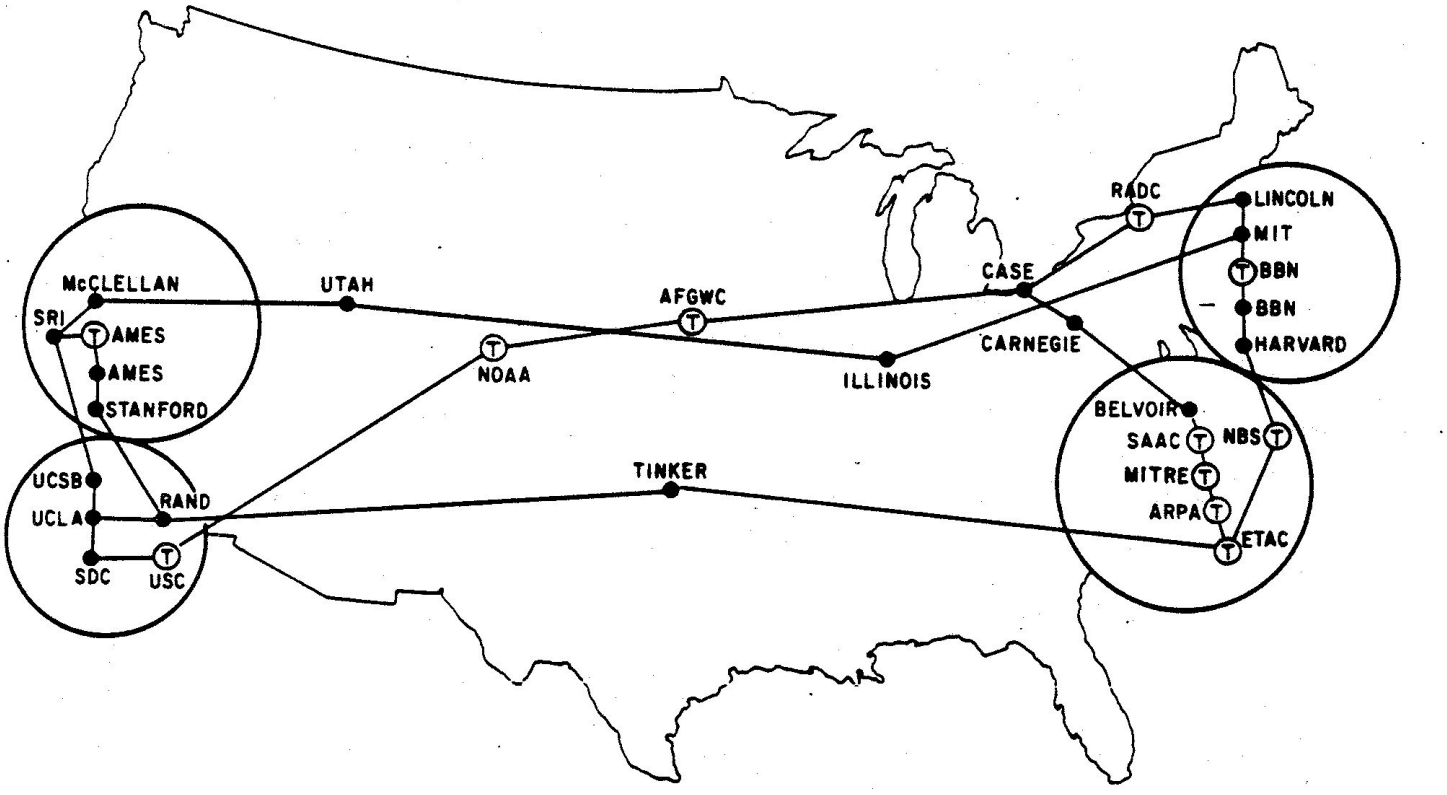
ARPAnet (1969)

Computer Networks : Beginnings (Cont'd)



ARPAnet (1971)

Computer Networks : Beginnings (Cont'd)



ARPAnet (1972)

Computer Networks : Beginnings (Cont'd)

- 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.

Computer Networks : Beginnings (Cont'd)

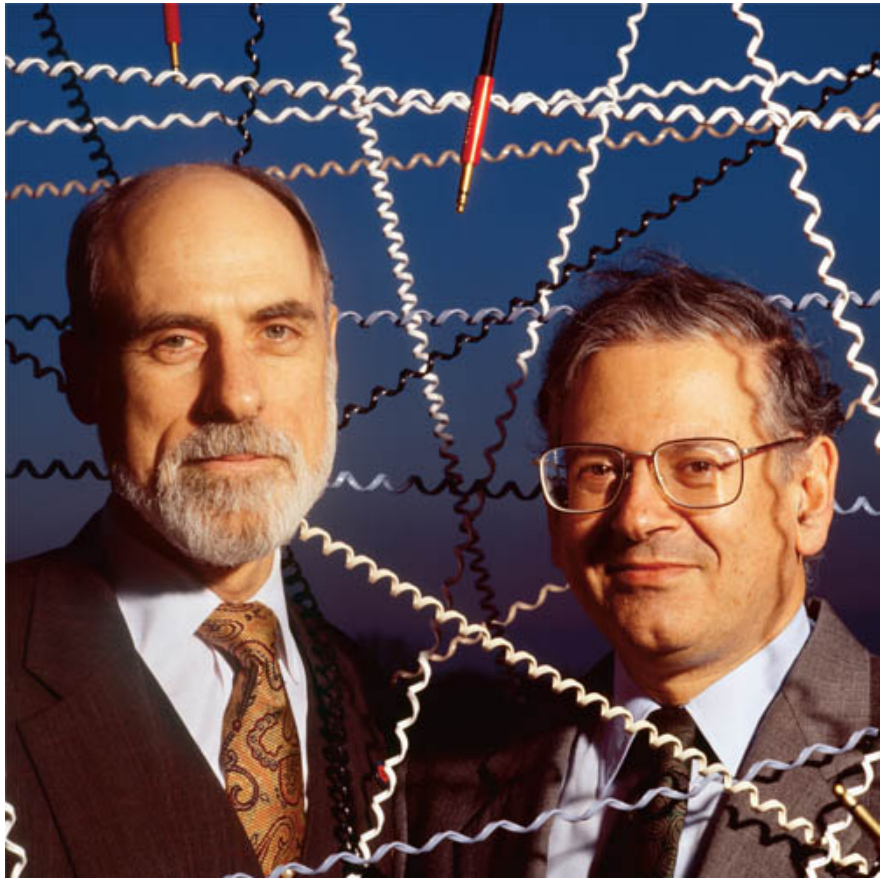
Ray Tomlinson
(1941–2016)

- 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).

Computer Networks : Beginnings (Cont'd)

- Wireless networking pioneered by Norm Abrahamson (1932–2020) in Hawaii as AlohaNet (operational 1971).

Computer Networks : Beginnings (Cont'd)



- Vint Cerf (1943–) and Bob Kahn (1938–) propose TCP/IP in 1974; allows easy communication between networks (inter-networking $\Rightarrow$ internet).

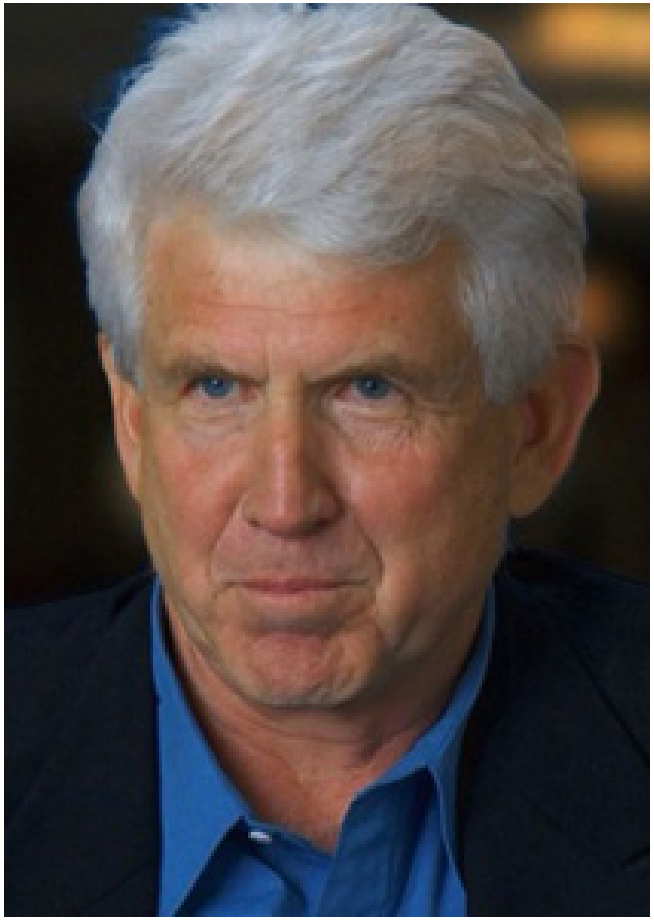
Computer Networks : Beginnings (Cont'd)

- 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.

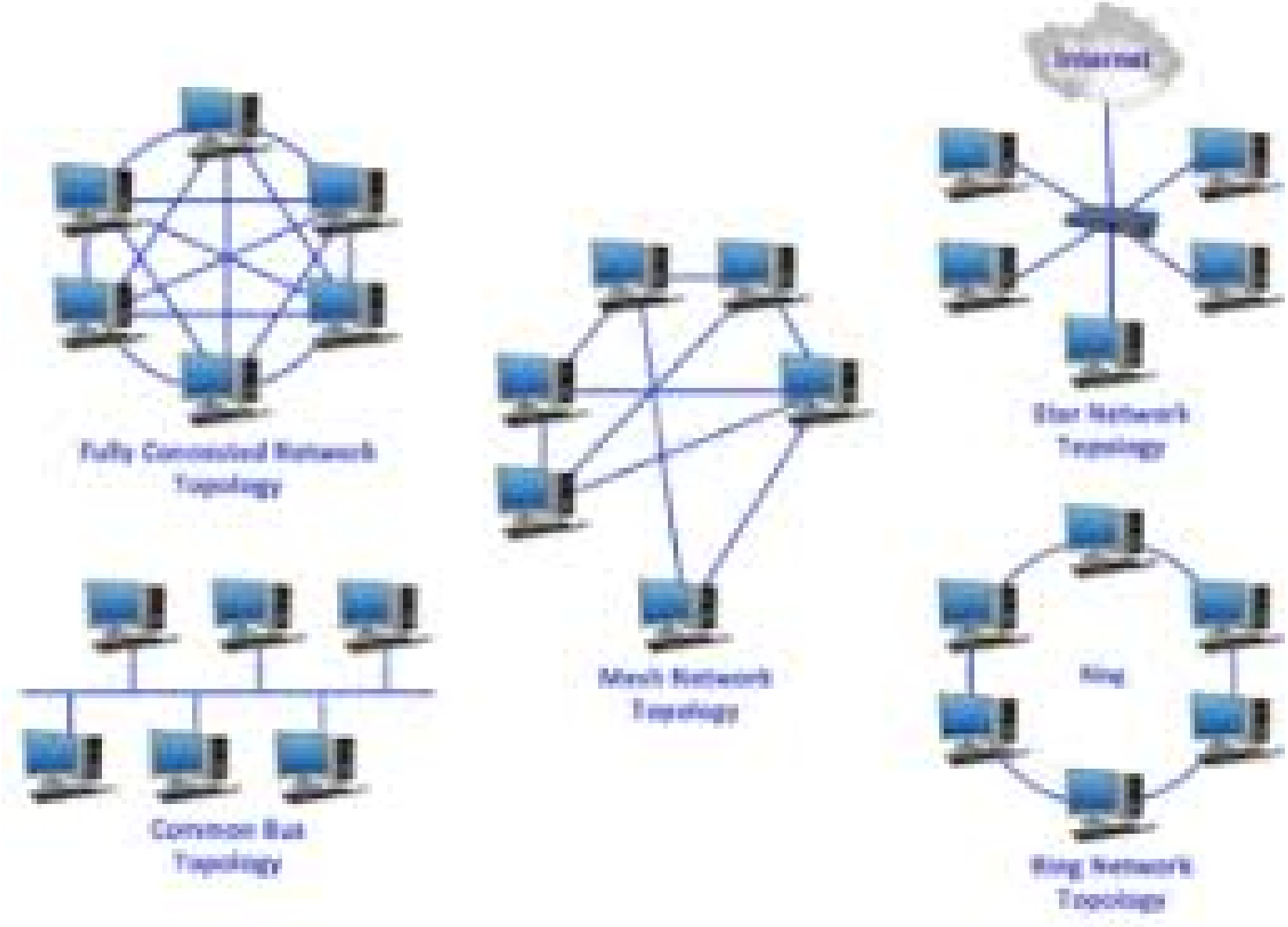
Computer Networks : Commercialization



Bob Metcalfe (1946–)

- 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.

Computer Networks : Commercialization (Cont'd)



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)

Computer Networks : Commercialization (Cont'd)

- 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).

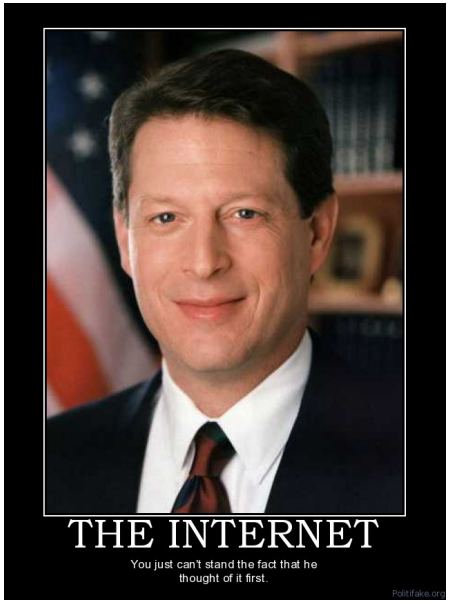
Computer Networks : Commercialization (Cont'd)

Computer Networks : Commercialization (Cont'd)

- National commercial networks established starting in early 1980s. Some like Compuserve (1969) based on surviving business-oriented computer utilities from the late 1960s; others like Prodigy (1984) created by retail and computer business partnerships (Sears / IBM).
- Initial networks joined by subscriber-purchased "starter kits"; later networks like America On-Line (AOL) (1989) pioneered free trial periods.

Computer Networks : Commercialization (Cont'd)

Rick Boucher (1946–)



Al Gore (1948–)

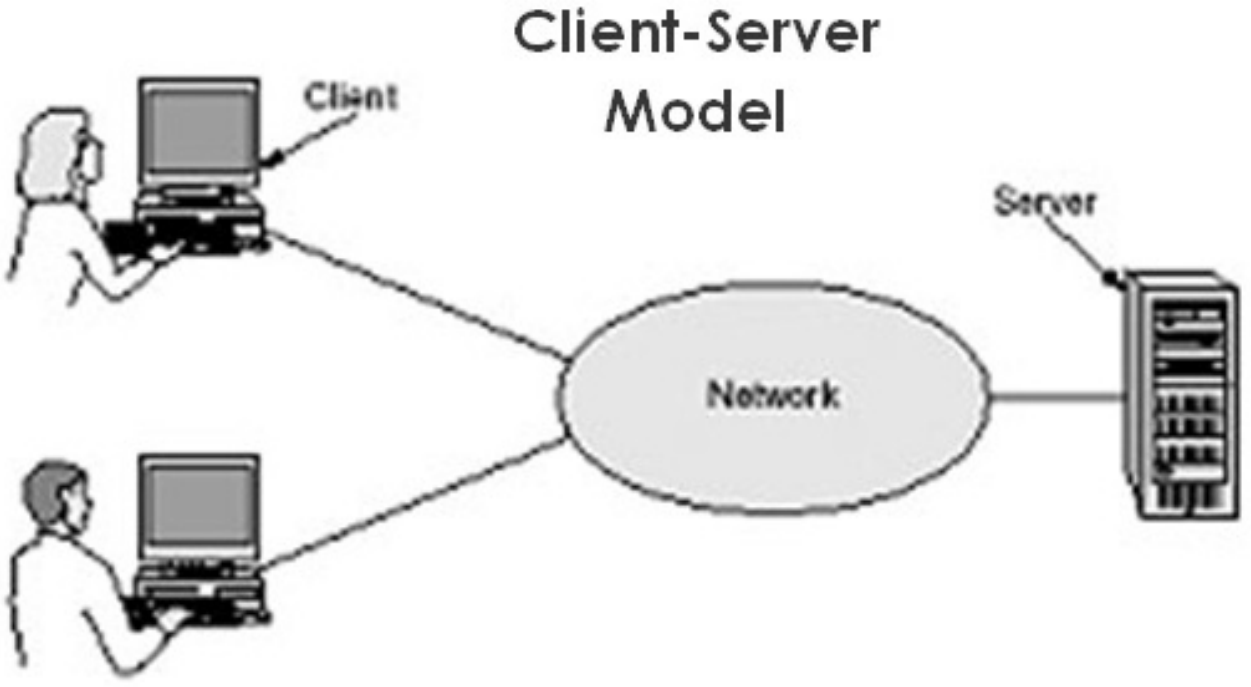
- Effective commercial national network usage enabled by government-funded high-performance national network upgrades (Gore; 1991; "information superhighway") and amended commercial-usage rules of government- created networks (Boucher; 1992).

Computer Networks : The World Wide Web

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.

Computer Networks : The World Wide Web (Cont'd)

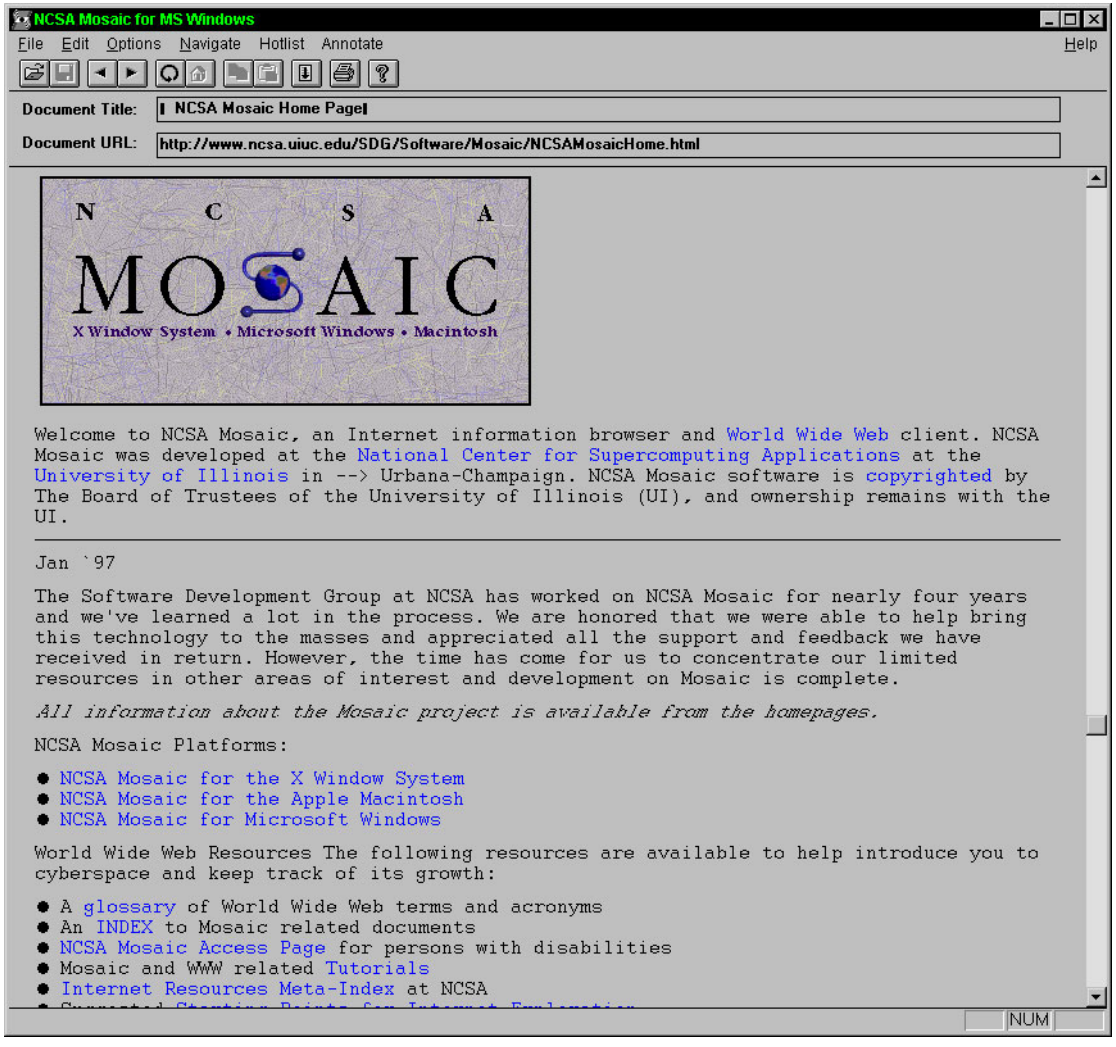


- Five components of WWW system: (1) content location specifier (URL), (2) web page creation language (HTML), (3) web page transmission protocol (HTTP), (4) web page distribution (server software), and (5) web page display (client-based web browser software).

Computer Networks : The World Wide Web (Cont'd)

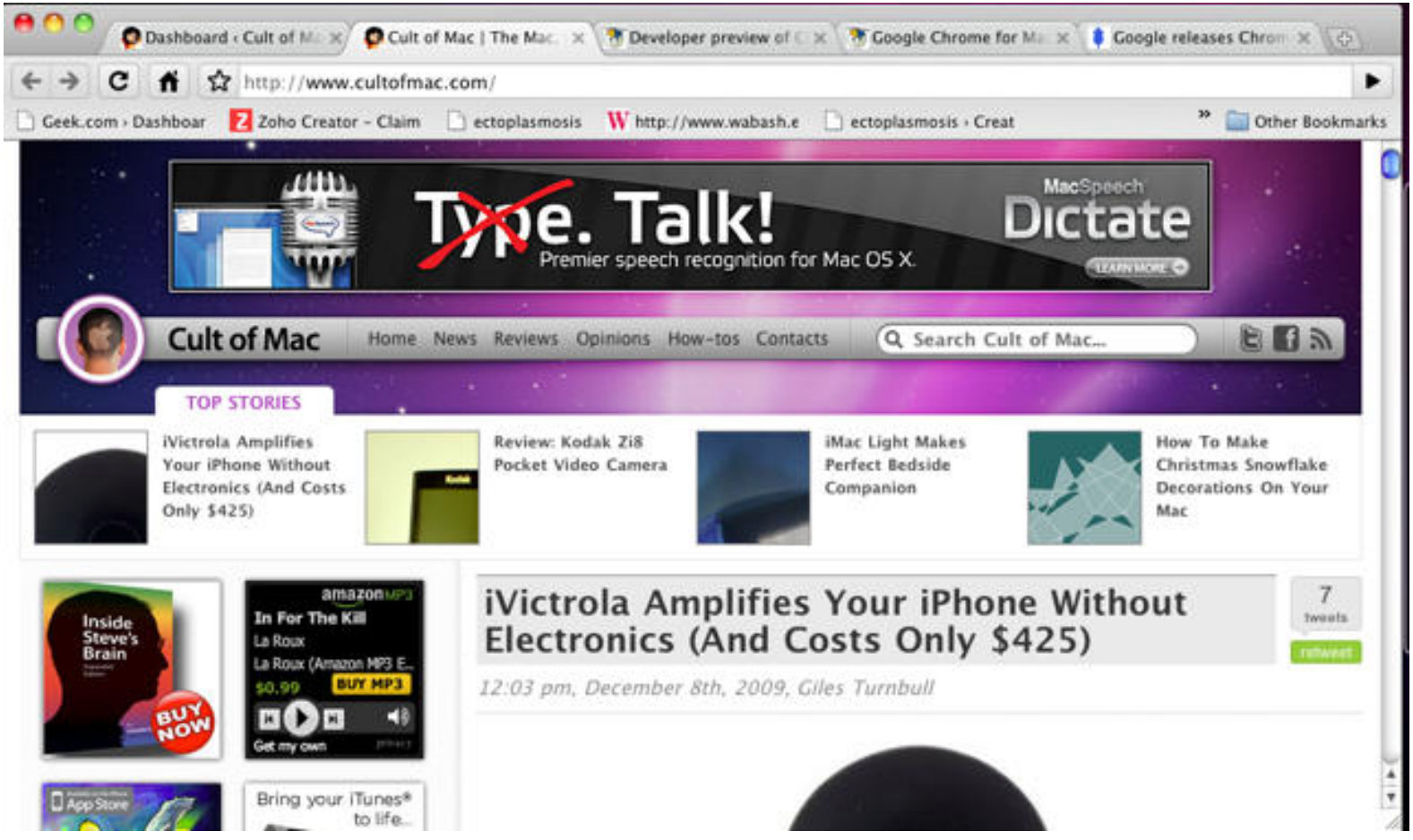
- Basic WWW software available by free download from CERN starting in 1991.
- First commercial-grade web browser (Mosaic) created at UIUC in 1993; spun off as Navigator to Netscape (by creators) and Spyglass / Microsoft Internet Explorer (IE) (by UIUC) in 1994.
- Navigator free for individuals but sold for commercial use; IE bundled for "free' starting with Windows 98, prompting (successful) US federal anti-trust lawsuit in 1998.

Computer Networks : The World Wide Web (Cont'd)



Mosaic Web Browser (1993)

Computer Networks : The World Wide Web (Cont'd)



Google Chrome Web Browser (2008)

Computer Networks : The World Wide Web (Cont'd)

- 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)

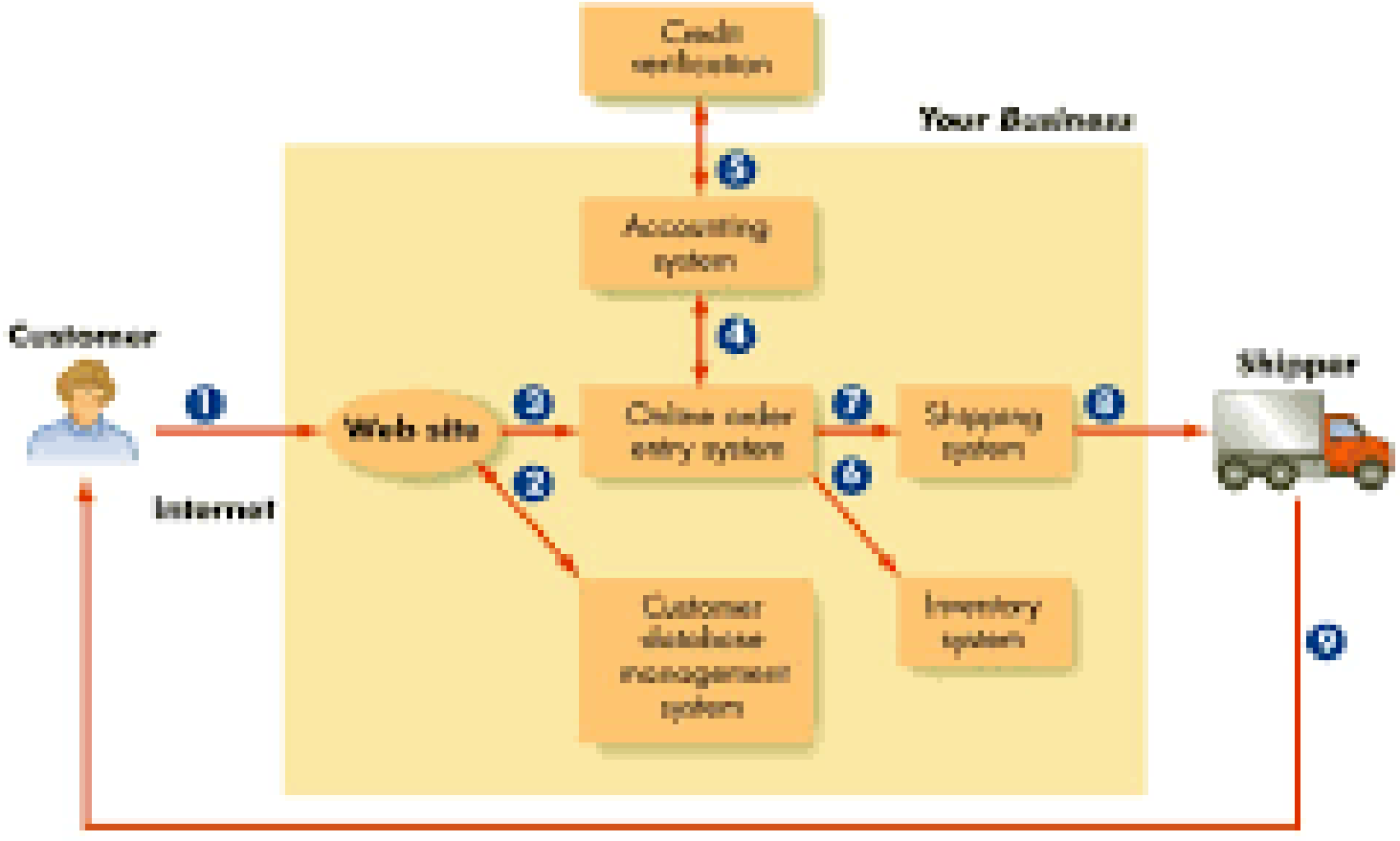
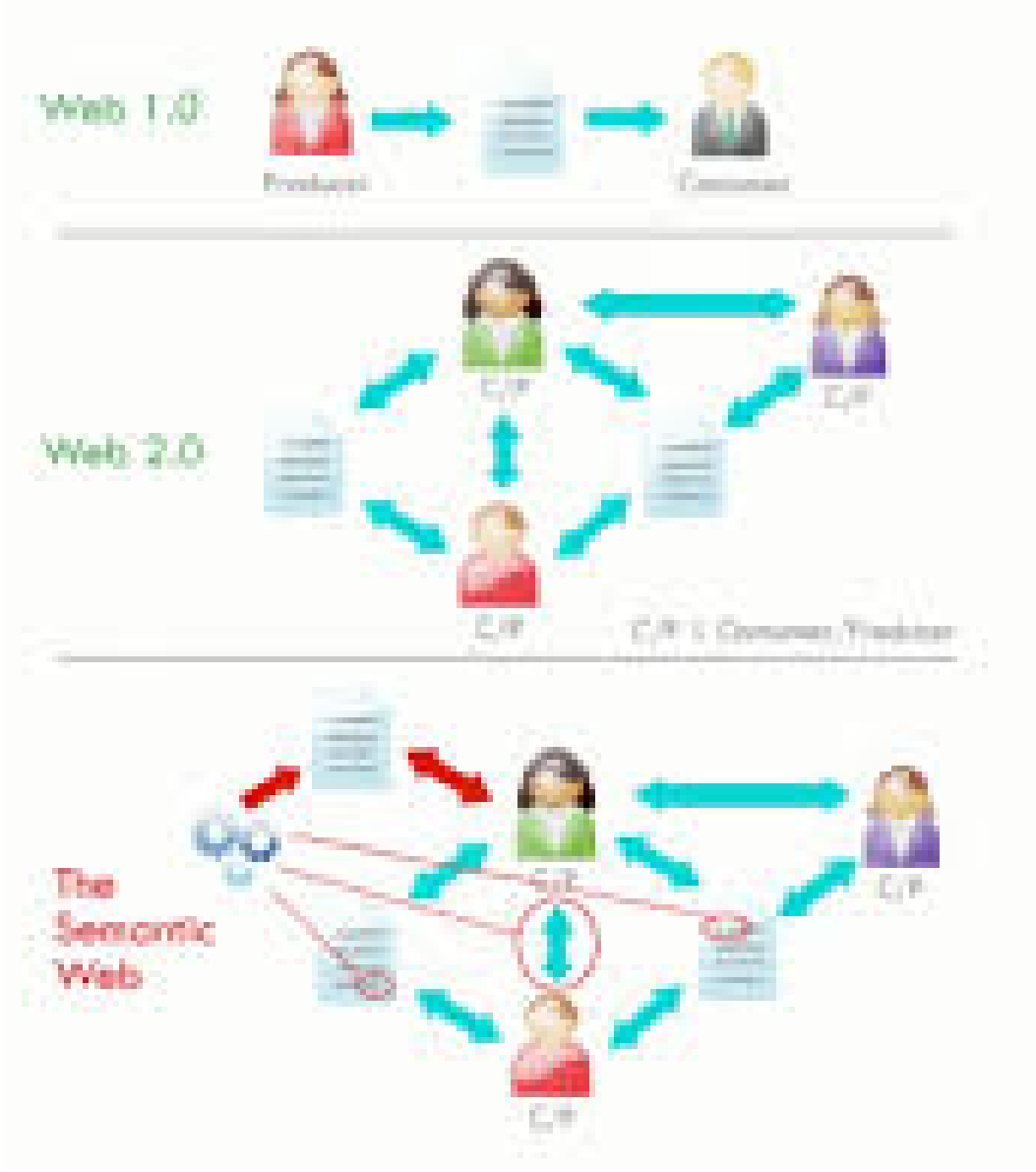


Figure 14.1 A Typical Online Transaction in Nine Steps

Computer Networks : The World Wide Web (Cont'd)



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 3100: Web Programming
  - COMP 3300: Interactive Technologies
  - COMP 4759: Computer Networks
  - COMP 4768: Software Development for Mobile Devices
- MUN Computer Science professors teaching courses / doing research in in this area:
  - Ed Brown
  - Mark Hatcher
  - Amilcar Soares
  - Qiang Ye