Chapter 1: Catalysts for Change

Organization of Chapter

- Introduction
- Milestones in computing
- Milestones in networking
- Milestones in information storage and retrieval
- Information technology issues

1.1 Introduction

Information Age

- Era characterized by unprecedented access to information
- Catalysts
  - Low-cost computers
  - High-speed communication networks

Samsung Galaxy S4
Product of the Information Age

Marian Stanca/Alamy

Advances in Past Two Decades

- Smartphones
- MP3 players
- Digital photography
- Email
- World Wide Web

Technology and Values

- Dynamic between people, technology
  - People adopt technology
  - Technology changes society

- Using technology can change people
  - Our experiences physically change our brains (e.g., London taxi drivers)
  - Experiences with technology can have psychological effects, too (e.g., effects of dependency on cell phones)

- Technologies solve problems, but may create new problems
  - Automobile
  - Refrigerator
  - Low-cost international communication

Amish Selectively Adopt New Technologies

AP Photos/The Indianapolis Star and News, Mike Fender

1.2 Milestones in Computing

Aids to Manual Calculating

- Tablet
  - Clay, wax tablets (ancient times)
  - Slates (late Middle Ages)
  - Paper tablets (19th century)
- Abacus
  - Rods or wires in rectangular frame
  - Lines drawn on a counting board
- Mathematical tables
  - Tables of logarithms (17th century)
  - Income tax tables (today)

Slate and Counting Board

© Science Museum Library/Science & Society Picture Library

Early Mechanical Calculators

- Calculators of Pascal and Leibniz (17th century)
  - Worked with whole numbers
  - Unreliable
- Arithmometer of de Colmar (19th century)
  - Took advantage of advances in machine tools
  - Adopted by insurance companies
- Printing calculator of Scheutzes (19th century)
  - Used method of differences pioneered by Babbage
  - Adopted by Dudley Observatory in New York
  - Completed astronomical calculations

Social Change → Market for Calculators

- Gilded Age (late 19th century America)
  - Rapid industrialization
  - Economic expansion
  - Concentration of corporate power
- New, larger corporations
  - Multiple layers of management
  - Multiple locations
  - Needed up-to-date, comprehensive, reliable, and affordable **information**

Calculator Adoptions → Social Change

- Fierce market
  - Continuous improvements in size, speed, ease of use
  - Sales increased rapidly
- "Deskilling" and feminization of bookkeeping
  - People of average ability quite productive
  - Calculators 6× faster than adding by hand
  - Wages dropped
  - Women replaced men

Feminization of Bookkeeping

Underwood Archives/Getty Images

Cash Register

- Store owners of late 1800s faced problems
  - Keeping accurate sales records for department stores
  - Preventing embezzlement from clerks
- Response to problems: cash register
  - Created printed, itemized receipts
  - Maintained printed log of transactions
  - Rang bell every time drawer was opened

Cash Register

The NCR Archive at Dayton History

Punched Card Tabulation

- Punched cards (late 19th century)
  - One record per card
  - Cards could be sorted into groups, allowing computation of subtotals by categories
- Early adopters
  - U.S. Bureau of the Census
  - Railroads
  - Retail organizations
  - Heavy industries

Tabulators → Data-processing Systems

- Data-processing system
  - Receives input data
  - Performs one or more calculations
  - Produces output data
- Punched cards
  - Stored input data and intermediate results
  - Stored output
  - On most sophisticated systems, also stored programs

IBM and the Holocaust

- Hitler came to power in Germany in 1933

- IBM CEO Watson ignored anti-Semitic violence, creation of concentration camps

- IBM expanded German subsidiary and sought contracts with German government

- Nazis used IBM machines to conduct censuses, generate lists of Jews

- Lists facilitated seizure of assets and deportation to camps

Precursors of Commercial Computers

- Atanasoff-Berry Computer: vacuum tubes
- ENIAC: externally programmed with wires
- EDVAC: program stored in memory
- Small-Scale Experimental Machine: CRT memory

Programming the ENIAC

© CORBIS

First Commercial Computers

- Remington-Rand
  - Completed UNIVAC in 1951
  - Delivered to U.S. Bureau of the Census
  - Predicted winner of 1952 Presidential election
- IBM
  - Larger base of customers
  - Far superior sales and marketing organization
  - Greater investment in research and development
  - Dominated mainframe market by mid-1960s

CBS News Coverage of 1952 Presidential Election Featured UNIVAC Computer

Hagley Museum and Library. Accession number 1984.240

Programming Languages

- ## Assembly language
  - Symbolic representations of machine instructions
  - Programs just as long as machine language programs
- ## FORTRAN
  - First higher-level language (shorter programs)
  - Designed for scientific applications
- ## COBOL
  - U.S. Department of Defense standard
  - Designed for business applications

Time-Sharing Systems and BASIC

- Time-Sharing Systems
  - Divide computer time among multiple users
  - Users connect to computer via terminals
  - Cost of ownership spread among more people
  - Gave many more people access to computers
- BASIC
  - Developed at Dartmouth College
  - Simple, easy-to-learn programming language
  - Popular language for teaching programming

Transistor

- Replacement for vacuum tube
- Invented at Bell Labs (1948)
- Semiconductor
  - Faster
  - Cheaper
  - More reliable
  - More energy efficient

Integrated Circuit

- Semiconductor containing transistors, capacitors, and resistors
- Invented at Fairchild Semiconductor and Texas Instruments
- Advantages over parts they replaced
  - Smaller
  - Faster
  - More reliable
  - Less expensive

Fairchild Semiconductor Founders

Wayne Miller/Magnum Photos, Inc.

IBM System/360

- Before System/360
  - IBM dominated mainframe marked in 1960s
  - IBM computers were incompatible
  - Switch computers → rewrite programs
- System/360
  - Series of 19 computers with varying levels of power
  - All computers could run same programs
  - Upgrade without rewriting programs

IBM System/360

IBM/AP Photo

PEARSON

ALWAYS LEARNING

Microprocessor

- Computer inside a semiconductor chip

- Invented in 1970 at Intel

- Made personal computers practical

Antecedents to the Personal Computer

- *Whole Earth Catalog*
  - "Sort of like Google in paperback form" (Steve Jobs)
  - Stewart Brand saw "technology as a tool for individual and collective transformation" (Fred Turner)
- People's Computer Company
  - Educated people on how to use computers
  - People gathered around time-share computers
  - Culture promoted free exchange of software
- Homebrew Computer Club
  - Meeting place for hobbyists
  - Steve Wozniak created system that became Apple I

Steve Wozniak and Steve Jobs with Apple I Personal Computer

© Kimberly White/Corbis

PEARSON

ALWAYS LEARNING

Personal Computer

- Altair 8800
  - Gates and Allen created BASIC interpreter
  - Interpreter pirated at Homebrew Computer Club meeting
- Personal computers became popular
  - Apple Computer: Apple II
  - Tandy Corporation: TRS 80
- Businesses drawn to personal computers
  - Computer spreadsheet program: VisiCalc
  - IBM launches IBM PC

1.3 Milestones in Networking

Early Networking: Semaphore Telegraph Tower

Photo l'Adresse Musée de La Poste, Paris / La Poste

Electricity and Electromagnetism

- Volta invented battery (1799)
- Oersted: electricity creates magnetic field
- Sturgeon constructed electromagnet
- Henry: communication using electromagnets (1830)

Telegraph

- U.S. government funded first line
  - 40 miles from Washington, D.C. to Baltimore
  - Built by Samuel Morse in 1843-1844
- Private networks flourished
  - 12,000 miles of lines in 1850
  - Transcontinental line in 1861 put Pony Express out of business
  - 200,000 miles of lines by 1877
- Technology proved versatile
  - Fire alarm boxes
  - Police call boxes

Transcontinental Telegraph:
Pony Express Riders Lose Jobs

© North Wind Picture Archives / Alamy

Telephone

- Alexander Graham Bell
  - Constructed harmonic telegraph
  - Leveraged concept into first telephone
- Social impact of telephone
  - Blurred public life / private life boundary
  - Eroded traditional social hierarchies
  - Reduced privacy
  - Enabled first "online" communities

Typewriter and Teletype

- Typewriter
  - Individual production of "type set" documents
  - Common in offices by 1890s
- Teletype
  - Typewriter connected to telegraph line
  - Popular uses
    - Transmitting news stories
    - Sending records of stock transactions

Radio

- **Pioneers**
  - Hertz generated electromagnetic waves
  - Marconi invented radio
- **First used in business**
  - Wireless telegraph
  - Transmit voices
- **Entertainment uses**
  - Suggested by Sarnoff
  - Important entertainment medium by 1930s
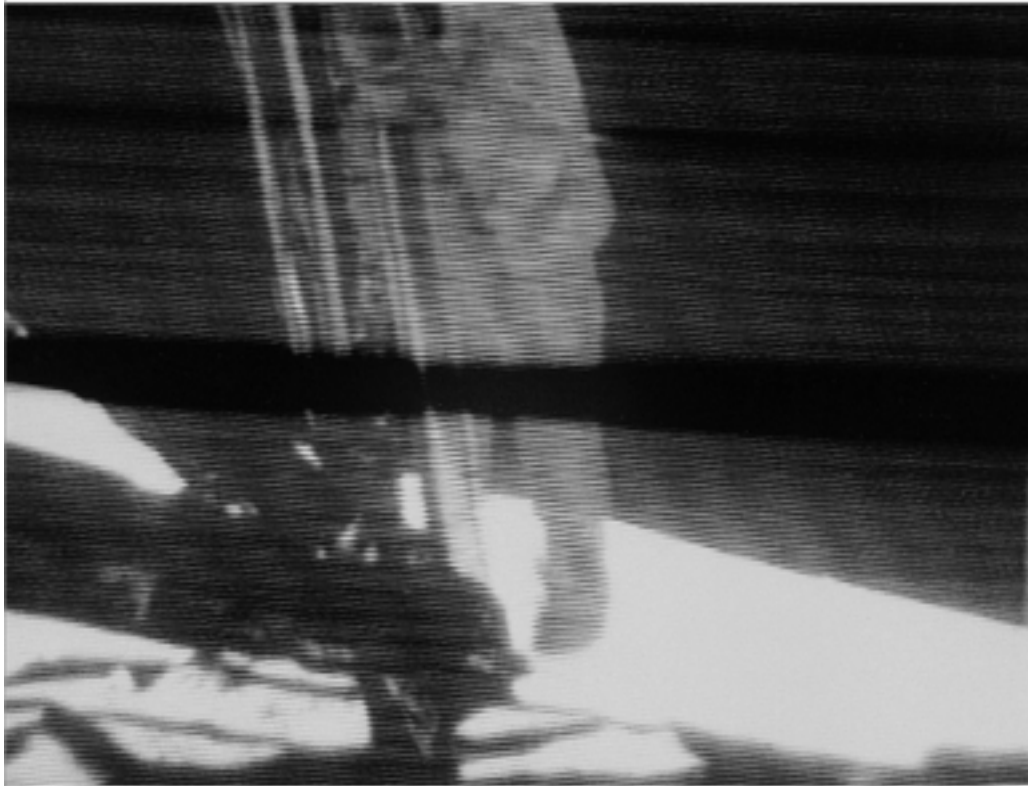
Orson Welles Broadcasts
War of the Worlds

© Bettmann/CORBIS

Television

- Became popular in 1950s
  - Price fell dramatically
  - Number of stations increased
- Social effects
  - Worldwide audiences
  - Networks strive to be first to deliver news
  - Impact of incorrect information; e.g., 2000 presidential election

Hundreds of Millions Watch Moon Landing in 1969
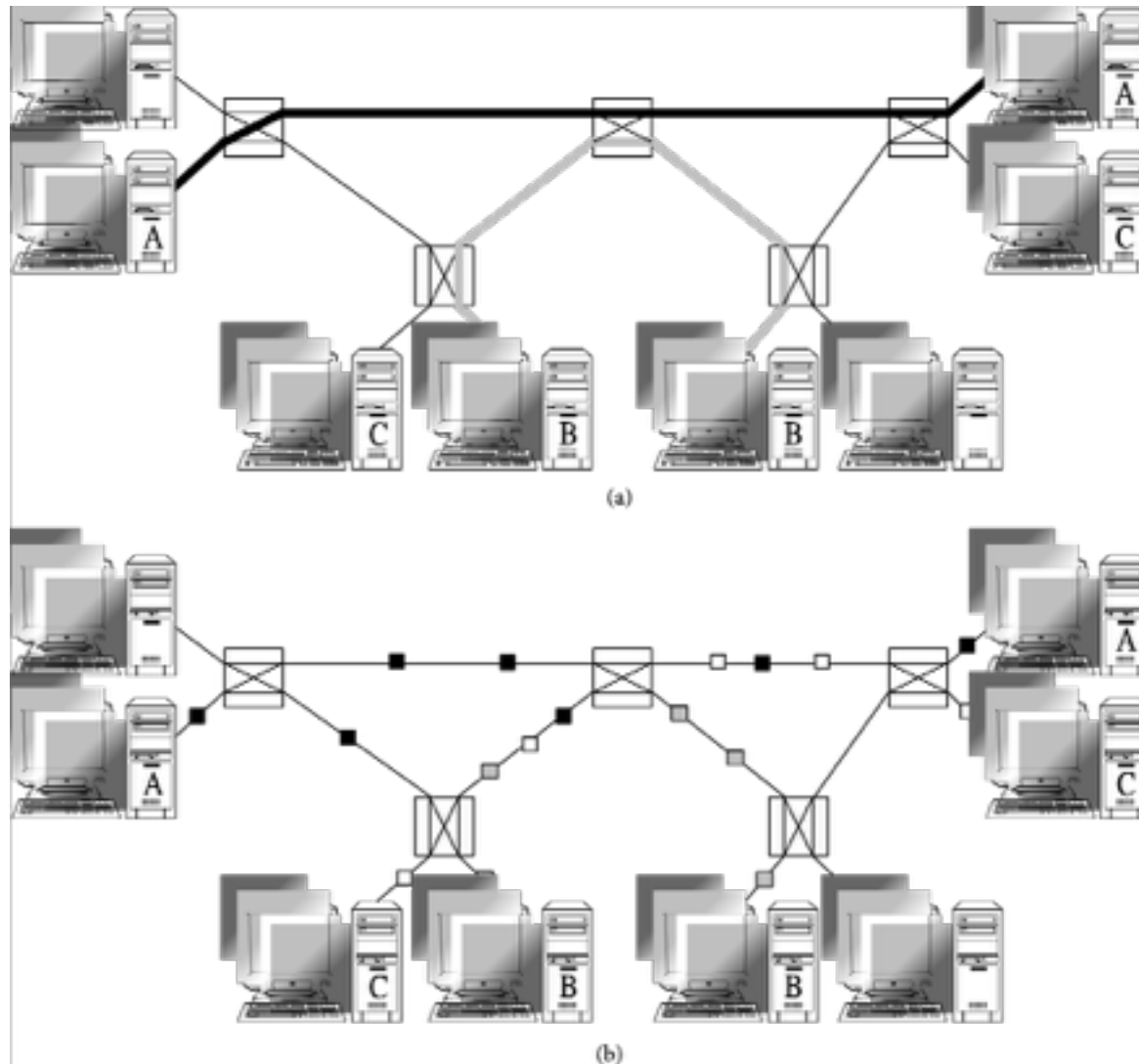

Courtesy of NASA

Remote Computing

- Stibitz and Williams built Complex Number Calculator at Bell Labs
- Bell Labs part of AT&T (phone company)
- Teletype chosen for input/output
- Allowed operator to be distant from machine
- Long-distance demonstration between New Hampshire and New York City

ARPANET

- DoD created ARPA in late 1950s
- Licklider conceived of "Galactic Network"
- Decentralized design to improve survivability
- Packet-switching replaced circuit switching

Circuit-switched v. Packet-switched Networks

(a)

(b)

Email

- Creation
  - Tomlinson at BBN wrote software to send, receive email messages
  - Roberts created email utility
- Current status
  - One of world's most important communication technologies
  - Billions of messages sent in U.S. every day

Internet

- Kahn conceived of open architecture networking

- Cerf and Kahn designed TCP/IP protocol

- Internet: network of networks communicating using TCP/IP

NSFNET

- Created by National Science Foundation

- Provided access grants to universities

- Encouraged commercial subscribers for regional networks

- Banned commercial traffic on NSFNET Backbone

- Private companies developed long-distance Internet connections

- After private networks established, NSF shut down NSFNET Backbone

Broadband

- Broadband
  - High-speed Internet connection
  - Makes feasible transfer of very large files (e.g., video)
  - Growth in file-swapping growth parallels growth in broadband
- Typical broadband speeds
  - South Korea (#1): 14.0 megabits/second
  - Japan (#2): 10.8 megabits/second
  - United States (#8): 7.4 megabits/second

Wireless Networks

- Cell phones
  - Appeared in 1973, weighed 2 ½ pounds
  - Now weigh a few ounces and also support texting and broadband Internet access
- Public access wireless local area networks
  - Proposed in 1993
  - Hotspot: wireless Internet access point
  - Wi-Fi most common hotspot technology

1.4 Milestones in Information Storage and Retrieval

Greek Alphabet

- True alphabet: letters for both consonant and vowel sounds

- 750 BC: Greeks developed first true alphabet with 24 characters

- Simple, efficient way of transforming spoken words into written form

- Oral culture transitioned to written culture

Codex and Paper

- Codex
  - Rectangular pages sewn together on one side
  - Replaced papyrus scrolls as way of storing books
  - Allowed quicker access to particular passages
  - First produced by hand, then by wood engraving
- Paper
  - Invented by Chinese, brought to Europe in late Middle Ages
  - By 15th century replaced parchment for pages in less expensive codices

Gutenberg's Printing Press

- Based on movable metal type
- Church principal customer of early publishers
- Powerful mass communication tool
- Printing press's impact on Reformation
  - More than 300,000 copies of Luther's publications
  - Protestants out-published Catholics by 10-to-1 in the middle 16th century

Newspapers

- Newspapers: Stimulated free expression
- Governments responded
  - Licensing
  - Censorship
- Impact on American Revolution
  - Newspapers helped unify colonies
  - Swayed public opinion toward independence

Hypertext

- Vannevar Bush envisioned Memex
- Ted Nelson
  - Coined word hypertext
  - Proposed creation of Xanadu
- Douglas Engelbart
  - Directed construction of NLS (oNLine System)
  - Demonstrated windows, email, mouse, videoconferencing

Douglas Engelbart Rehearses for "The Mother of All Demos"

Courtesy of SRI

Graphical User Interface

- Xerox PARC (Palo Alto Research Center)
  - Alan Kay saw Doug Engelbart demo in 1968
  - Alto personal computer (early 1970s)
  - Bit-mapped display, keyboard, and mouse
- Apple Computer
  - Steve Jobs visited Xerox PARC in 1979
  - Macintosh (1984)
  - Bit-mapped display, keyboard, and mouse
- Microsoft Windows (1990)
  - Released in May 1990
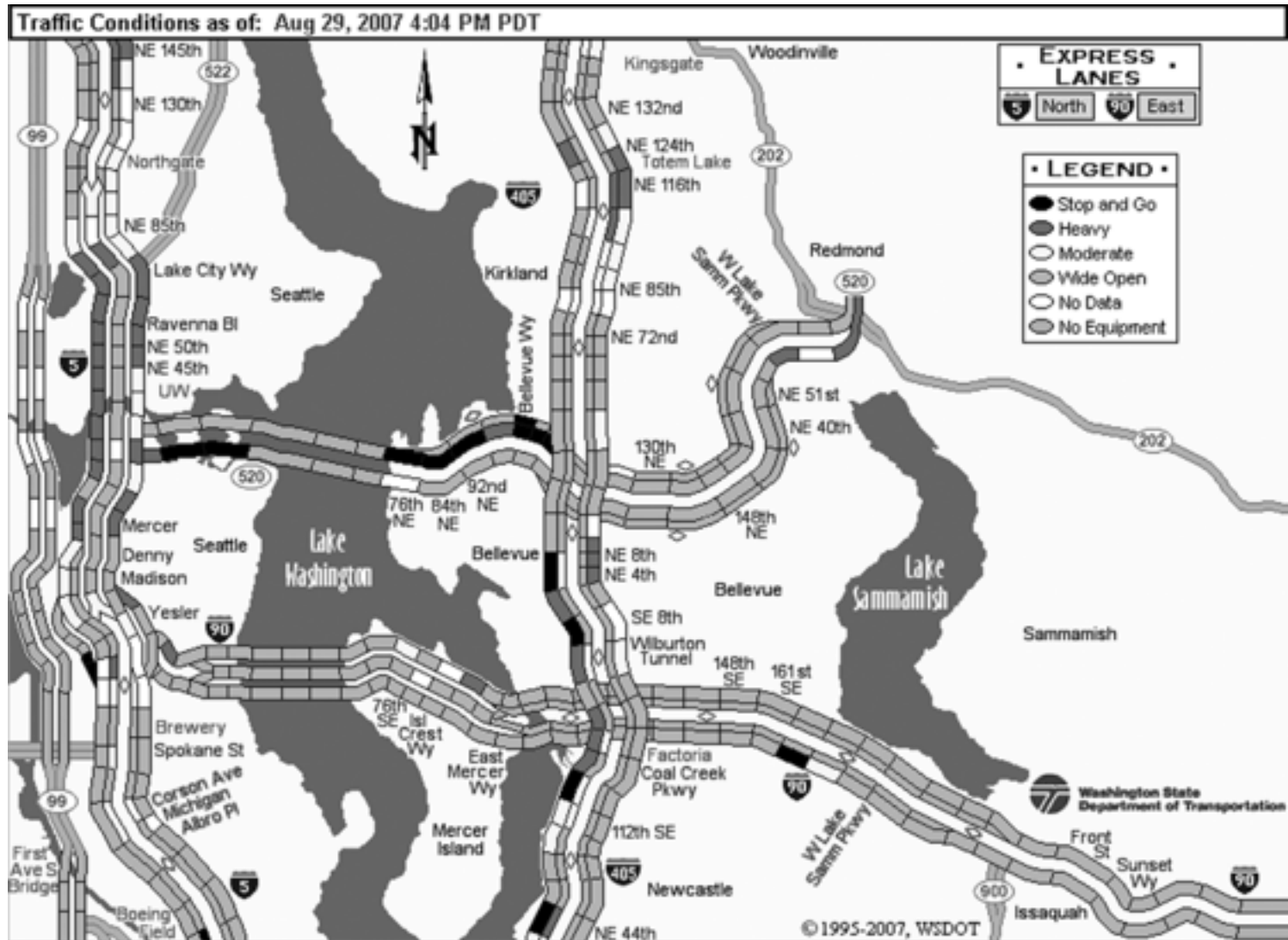 - Quickly became dominant graphical user interface

Single-Computer Hypertext Systems

- Peter Brown at University of Kent
  - Guide (1982)
  - Released versions for Macintosh and IBM PC
- Apple Computer
  - HyperCard (1987)
  - Hypertext system based on "stacks" of "cards"
  - Links represented by buttons
  - Basis for best-selling games Myst and Riven

World Wide Web

- First browser built at CERN in Switzerland
  - Tim Berners-Lee: WorldWideWeb (1990)
  - Berners-Lee created Web protocols
  - Protocols based on TCP/IP → general

- Later browsers
  - Mosaic
  - Netscape Navigator
  - Netscape Mozilla
  - Microsoft Internet Explorer (most popular)

Traffic Information on the Web

Traffic Conditions as of: Aug 29, 2007 4:04 PM PDT

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Search Engines

- Crawler-based engines (Google, AltaVista)
  - Programs called spiders follow hyperlinks and visit millions of Web pages
  - System automatically constructs Web page database
- Human-assisted engines (Open Directory)
  - Humans build Web page database
  - Web page summaries more accurate
  - Far fewer Web pages in database
- Hybrid systems (MSN Search)

1.5 Information Technology Issues

Information Technology

- Definition:
  - Devices used in creation, storage, manipulation, dissemination of data, sound, and/or images
- Examples
  - Tablets, smartphones, laptop computers
- People making greater use of IT
  - Costs keep falling
  - Capabilities keep rising

IT Issues (1/3)

- Email
  - Easy way to keep in touch
  - Spam has become a real problem
- Web
  - Free access to huge amounts of information
  - Harmful consequences of some sites
- CDs, MP3s
  - Free or cheap copies readily available
  - May be unfair to musicians
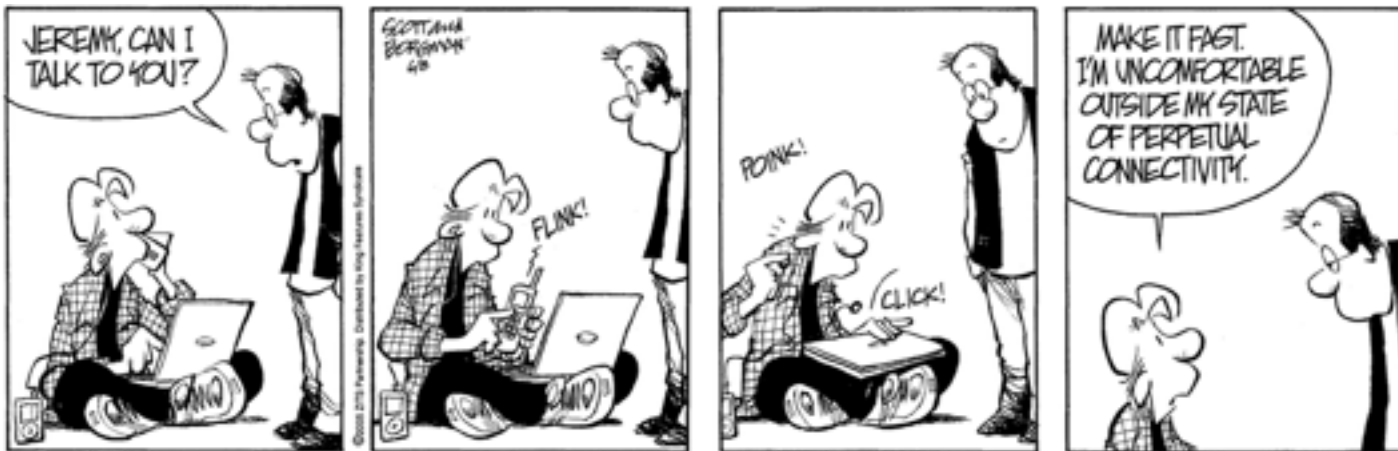
IT Issues (2/3)

- Credit cards
  - Convenience over cash and checks
  - Increases possibility of identity theft
  - Who owns information about transactions?
- Loan applications
  - Based on credit history, not personal interview
  - Lower interest rates, but less flexibility
- Telecommuting
  - Saves time, allows more flexible work hours
  - Do teleworkers get overlooked for promotions?

IT Issues (3/3)

- Improved global communication network
  - Allows companies to sell to entire world
  - Allows companies to move jobs out of U.S.
  - Should IT consumers be concerned about working conditions in factories in developing countries?

- World Wide Web
  - A conduit for democratic ideas?
  - Another tool for totalitarian governments?

Summary

- Revolutionary discoveries are rare; change is usually incremental

- Information technology has long history

- Social conditions give rise to new technologies

- Adoption of technologies can change society

- Rate of technological change accelerating

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