A Balanced Introduction to Computer Science, 2/E

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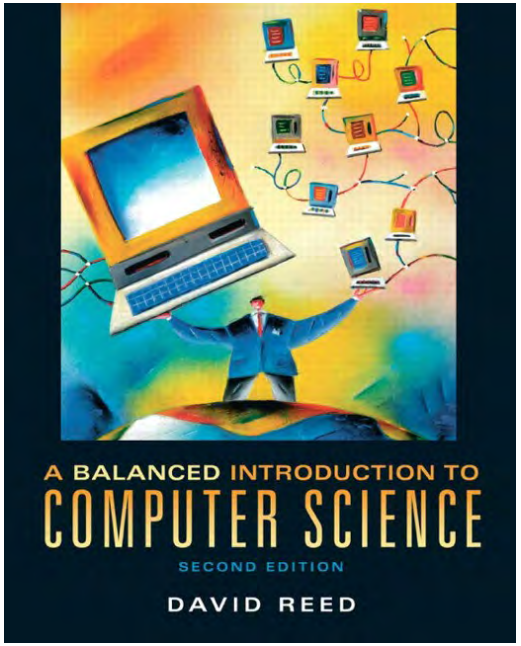


Chapter 6

The History of Computers

History of computing

calculating devices have been around for millennia (e.g., abacus ~3,000 B.C.)

modern "computing technology" traces its roots to the 16-17th centuries

- as part of the "Scientific Revolution", people like Kepler, Galileo, and Newton viewed the natural world as mechanistic and understandable
- this led to technological advances & innovation

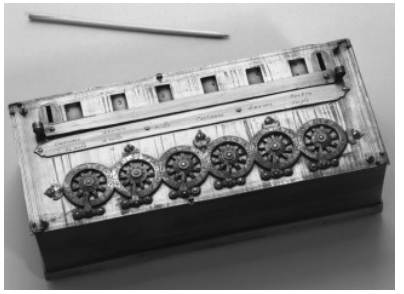
from simple mechanical calculating devices to powerful modern computers, computing technology has evolved through technological breakthroughs

	Time Period	Defining Technology
Generation 0	1642–1945	Mechanical devices (e.g., gears, relays)
Generation 1	1945–1954	Vacuum tubes
Generation 2	1954–1963	Transistors
Generation 3	1963–1973	Integrated circuits
Generation 4	1973–1985	Very large scale integration (VLSI)
Generation 5	1985–????	Parallel processing and networking

Generation 0: Mechanical Computers

1642 – Pascal built a mechanical calculating machine

- used mechanical gears, a hand-crank, dials and knobs
- other similar machines followed



1805 – the first programmable device was Jacquard's loom

- the loom wove tapestries with elaborate, programmable patterns
- a pattern was represented by metal punch-cards, fed into the loom
- using the loom, it became possible to mass-produce tapestries, and even reprogram it to produce different patterns simply by changing the cards

mid 1800's – Babbage designed his "analytical engine"

- its design expanded upon mechanical calculators, but was programmable via punch-cards (similar to Jacquard's loom)
- Babbage's vision described the general layout of modern computers
- he never completed a functional machine – his design was beyond the technology of the day

Generation 0 (cont.)

1890 – Hollerith invented tabulating machine

- designed for tabulating 1890 U.S. Census data
- similar to Jacquard's loom and Babbage's analytical engine, it stored data on punch-cards, and could sort and tabulate using electrical pins
- using Hollerith's machine, census data was tabulated in 6 weeks (vs. 7 years for the 1880 census)
- Hollerith's company would become IBM

1930's – several engineers independently built "computers" using electromagnetic relays

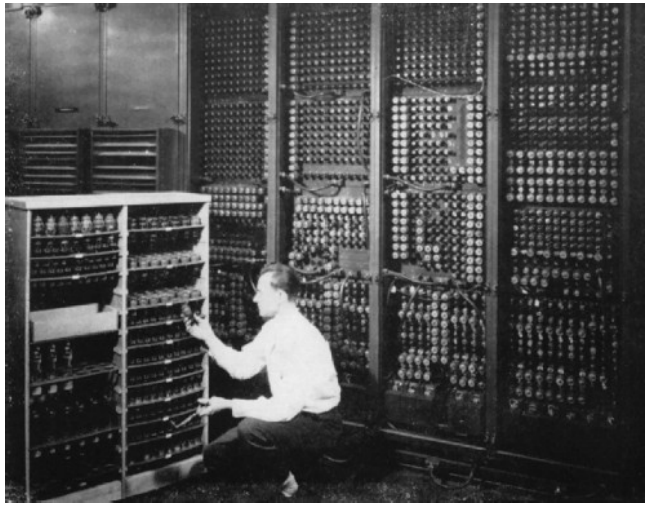
- an electromagnetic relay is physical switch, which can be opened/closed via electrical current
- Zuse (Nazi Germany) – his machines were destroyed in WWII
- Atanasoff (Iowa State) – built a partially-working machine with his grad student
- Stibitz (Bell Labs) – built the MARK I computer that followed the designs of Babbage
  - limited capabilities by modern standards: could store only 72 numbers, required 1/10 sec to add, 6 sec to multiply
  - still, 100 times faster than previous technology

Generation 1: Vacuum Tubes

mid 1940's – vacuum tubes replaced relays

- a vacuum tube is a light bulb containing a partial vacuum to speed electron flow
- vacuum tubes could control the flow of electricity faster than relays since they had no moving parts
- invented by Lee de Forest in 1906

1940's – hybrid computers using vacuum tubes and relays were built



COLOSSUS (1943)

- first "electronic computer", built by the British govt. (based on designs by Alan Turing)
- used to decode Nazi communications during the war
- the computer was top-secret, so did not influence other researchers

ENIAC (1946)

- first publicly-acknowledged "electronic computer", built by Eckert & Mauchly (UPenn)
- contained 18,000 vacuum tubes and 1,500 relays
- weighed 30 tons, consumed 140 kwatts

Generation 1 (cont.)

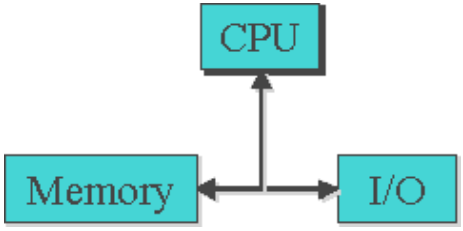
COLOSSUS and ENIAC were not general purpose computers

- could enter input using dials & knobs, paper tape
- but to perform a different computation, needed to reconfigure

von Neumann popularized the idea of a "stored program" computer

- Memory stores both data and programs
- Central Processing Unit (CPU) executes by loading program instructions from memory and executing them in sequence
- Input/Output devices allow for interaction with the user

virtually all modern machines follow this
von Neumann Architecture
(note: same basic design as Babbage)



programming was still difficult and tedious

- each machine had its own machine language, 0's & 1's corresponding to the settings of physical components
- in 1950's, assembly languages replaced 0's & 1's with mnemonic names
  e.g., `ADD` instead of `00101110`

Generation 2: Transistors

mid 1950's – transistors began to replace tubes

- a transistor is a piece of silicon whose conductivity can be turned on and off using an electric current
- they performed the same switching function of vacuum tubes, but were smaller, faster, more reliable, and cheaper to mass produce
- invented by Bardeen, Brattain, & Shockley in 1948 (earning them the 1956 Nobel Prize in physics)

some historians claim the transistor was the most important invention of the 20th century

computers became commercial as cost dropped

high-level languages were designed to make programming more natural

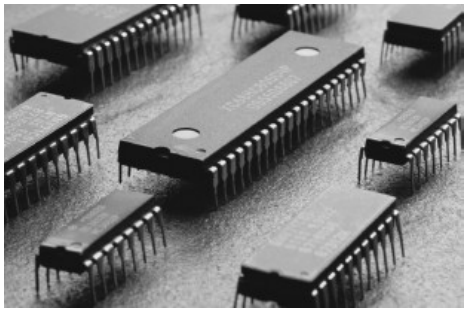
- FORTRAN (1957, Backus at IBM)
- LISP (1959, McCarthy at MIT)
- BASIC (1959, Kemeny at Dartmouth)
- COBOL (1960, Murray-Hopper at DOD)

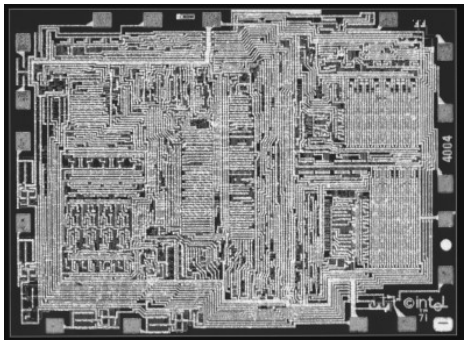
the computer industry grew as businesses could afford to buy and use computers

Eckert-Mauchly (1951), DEC (1957)

IBM became market force in 1960's

Generation 3: Integrated Circuits





mid 1960's - integrated circuits (IC) were produced

- Noyce and Kilby independently developed techniques for packaging transistors and circuitry on a silicon chip (Kilby won the 2000 Nobel Prize in physics)
- this advance was made possible by miniaturization & improved manufacturing
- allowed for mass-producing useful circuitry

1971 – Intel marketed the first *microprocessor*, the 4004, a chip with all the circuitry for a calculator

1960's saw the rise of Operating Systems

- recall: an operating system is a collection of programs that manage peripheral devices and other resources
- in the 60's, operating systems enabled time-sharing, where users share a computer by swapping jobs in and out
- as computers became affordable to small businesses, specialized programming languages were developed

  Pascal (1971, Wirth), C (1972, Ritche)

Generation 4: VLSI

late 1970's - Very Large Scale Integration (VLSI)

- by the late 1970's, manufacturing advances allowed placing hundreds of thousands of transistors w/ circuitry on a chip
- this "very large scale integration" resulted in mass-produced microprocessors and other useful IC's
- since computers could be constructed by simply connecting powerful IC's and peripheral devices, they were easier to make and more affordable

Year	Intel Processor	Number of Transistors[4]
2006	Core 2 Duo	291,000,000
2000	Pentium 4	42,000,000
1999	Pentium III	9,500,000
1997	Pentium II	7,500,000
1993	Pentium	3,100,000
1989	80486	1,200,000
1985	80386	275,000
1982	80286	134,000
1978	8088	29,000
1974	8080	6,000
1972	8008	3,500
1971	4004	2,300

(Intel Research. "Silicon—Moore's Law." October 2006.)

Generation 4: VLSI (cont.)

with VLSI came the rise of personal computing

- 1975 - Bill Gates & Paul Allen founded Microsoft
  Gates wrote a BASIC interpreter for the first PC (Altair)
- 1977 - Steve Wozniak & Steve Jobs founded Apple
  went from Jobs' garage to $120 million in sales by 1980
- 1980 - IBM introduced PC
  Microsoft licensed the DOS operating system to IBM
- 1984 - Apple countered with Macintosh
  introduced the modern GUI-based OS (which was mostly developed at Xerox)
- 1985 - Microsoft countered with Windows

Richest People in the World (Forbes.com, 3/8/07)	
1. Bill Gates	$56 billion
2. Warren Buffet	$52 billion
3. Carlos Slim Helu	$49 billion
4. Ingvar Kamprad	$33 billion
5. Lakshmi Mittal	$32 billion
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19. Paul Allen	$18 billion

1980's - object-oriented programming began

- represented a new approach to program design which views a program as a collection of interacting software objects that model real-world entities
- Smalltalk (Kay, 1980), C++ (Stroustrup, 1985), Java (Sun, 1995)

Generation 5: Parallelism/Networks

the latest generation of computers is still hotly debated

- no new switching technologies, but changes in usage have occurred

high-end machines (e.g. Web servers) can have multiple CPU's

- in 1997, highly parallel Deep Blue beat Kasparov in a chess match
- in 2003, successor Deep Junior played Kasparov to a draw

Year	Computers on the Internet[5]	Web Servers on on the Internet[6]
2006	439,286,364	88,166,395
2004	285,139,107	52,131,889
2002	162,128,493	33,082,657
2000	93,047,785	18,169,498
1998	36,739,000	4,279,000
1996	12,881,000	300,000
1994	3,212,000	3,000
1992	992,000	50

("Internet Domain Survey." Internet Software Consortium, July 2006.

"Netcraft Web Server Survey." Netcraft, July 2006.)

most computers today are networked

- the Internet traces its roots to the 1969 ARPANet
  - mainly used by government & universities until the late 80s/early 90s
- the Web was invented by Tim Berners-Lee in 1989
  - designed to allow physics researchers to share data and documents
  - not popular until 1993 when Marc Andreessen developed a graphical browser (Mosaic)
  - Andreessen would go on to found Netscape, and Internet Explorer soon followed