

CSC 121

Computers and Scientific Thinking

Fall 2005

History of Science and Computing

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Science and Computing



DYK?

- what is science?
- when did it originate? by whom?
- were the Middle Ages really the Dark Ages?
- what was the so-called Scientific Revolution?
- what is the scientific method?
- when were computers invented? by whom?
- when were computers accessible/affordable to individuals?
- when was the Internet invented? the Web?
- how did Bill Gates get so rich?

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Early science

science: a system of knowledge covering general truths or the operation of general laws especially as obtained and tested through scientific method (Merriam-Webster dictionary)

modern science traces its roots back to the Greek natural philosophers

- Thales (6th century B.C.) is considered by some to be the "first scientist"
 - he made observation/predictions about nature (weather, geography, astronomy, ...)
- Plato (4th century B.C.) proposed a grand theory of cosmology
 - claimed heavenly bodies move uniformly in circles, because of geometric perfection
 - believed observation was confused and impure, truth was found through contemplation
- Aristotle (4th century B.C.) proposed a coherent and common-sense vision of the natural world that stood for 2,000 years
 - studied and wrote on a cosmology, physics, biology, anatomy, logic, ...
 - placed greater emphasis on observation than Plato, but still not experimental
 - tutored Alexander the Great

Greek natural philosophy is sometimes called "pre-scientific", since it relied on contemplation or observation, but not experimentation

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Roman times → Middle Ages

Roman civilization built upon the tradition of Greek natural philosophy

- the Romans are better known for engineering than theoretical science
- Galen (2nd century) studied human anatomy and physiology
- Ptolemy (2nd century) tweaked the Plato/Aristotle cosmology to match observations of the planets

the fall of Rome (in 476) led to a discontinuity in western civilization

- in western Europe, population dropped, literacy virtually disappeared, and Greek knowledge was lost
- in eastern Europe, Greek knowledge was suppressed by orthodox Christianity in the Byzantine Empire (which finally fell in 1453)
- the only repositories of knowledge were monasteries and medieval universities (which started forming in the 12th century) **"DARK AGES?"**

medieval Islam became the principal heir to Greek science

- in the 7th-14th centuries, the Islamic Empire covered parts of Europe, northern Africa, the Middle East, and western Asia
- Greek writings were preserved and advanced by Islamic scholars
- the term "algorithm" is named after Persian scholar Muhammad ibn Musa al-Khwarismi

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Scientific Revolution

the Renaissance (15th-16th centuries) was instigated by the rediscovery of Greek science

- Greek and Latin texts were retrieved from monasteries & Islamic libraries
- Leonardo da Vinci (1452-1519) was artist, astronomer, geometer, engineer, ...
- Guttenberg's printing press made the broad dissemination of knowledge possible

the Scientific Revolution (16th-17th centuries) was brought about by a period of intellectual upheaval in Europe

- the Protestant Reformation, new World exploration, Spanish inquisition, ...
- the cultural environment allowed for questioning religious and scientific dogma

- the universe was viewed as a complex machine that could be understood through careful observation and experimentation

- Copernicus proposed a sun-centered cosmology (1543)
 - Kepler refined the heliocentric model, using elliptical orbits (1609)
- Galileo pioneered the use of experimentation to validate observational theories
 - considered the father of modern physics & the father of modern astronomy
- Newton described universal gravitation, laws of motion, classical mechanics (1687)

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Modern Science

the Scientific Revolution established science as the preeminent source for the growth of knowledge

- science became professionalized and institutionalized

the scientific method provides the common process by which modern science is conducted



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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 Scientific Revolution

- a mechanistic view of nature led to technological advances & innovation

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

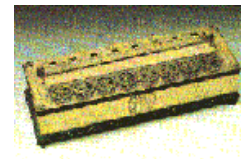
	Time Period	Defining Technology
Generation 0	1642–1945	Mechanical devices (e.g., gears, relays)
Generation 1	1945–1954	Vacuum tubes
Generation 2	1954–1963	Transistors
Generation 3	1963–1973	Integrated circuits
Generation 4	1973–1985	Very large scale integration (VLSI)
Generation 5	1985–????	Parallel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

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Generation 0: Mechanical Computers

1642 – Pascal built a mechanical calculating machine

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

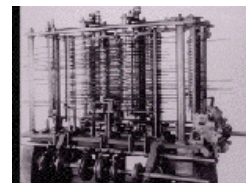


1805 – first programmable device, Jacquard loom

- wove tapestries with elaborate, programmable patterns
- pattern represented by metal punch-cards, fed into loom
- could mass-produce tapestries, reprogram with new cards

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

- expanded upon mechanical calculators, but programmable via punch-cards
- described general layout of modern computers
- never functional, beyond technology of the day



Generati on 0 (cont.)



1890 – Hollerith invented tabulating machine

- used for 1890 U.S. Census
- stored data on punch-cards, could sort and tabulate using electrical pins
- finished census in 6 weeks (vs. 7 years)
- Hollerith's company would become IBM



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

- physical switch, open/close via electrical current
- Zuse (Nazi Germany) – destroyed in WWII
- Atanasoff (Iowa State) – built with grad student
- Stibitz (Bell Labs) – followed design of Babbage

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Generati on 1: Vacuum Tubes



mid 1940's – vacuum tubes replaced relays

- glass tube w/ partial vacuum to speed electron flow
- faster than relays since no moving parts
- invented by de Forest in 1906



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

COLOSSUS (1943)

- built by British govt. (Alan Turing)
- used to decode Nazi communications

ENIAC (1946)

- built by Eckert & Mauchly at UPenn
- 18,000 vacuum tubes, 1,500 relays
- weighed 30 tons, consumed 140 kwatts

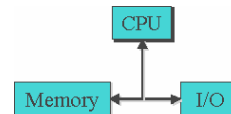
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Generati on 1 (cont.)

- 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



- 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

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Generati on 2: Transistors

- mid 1950's – transistors began to replace tubes
- piece of silicon whose conductivity can be turned on and off using an electric current
 - smaller, faster, more reliable, cheaper to mass produce
 - invented by Bardeen, Brattain, & Shockley in 1948 (won 1956 Nobel Prize in physics)



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 buy
Eckert-Mauchly (1951), DEC (1957)
IBM became market force in 1960's

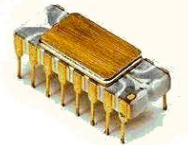
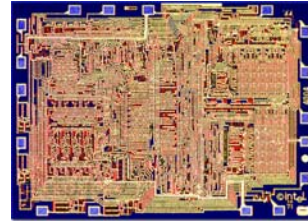
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Generati on 3: Integrated Ci rcui ts

integrated circuit (IC)

- as transistor size decreased, could package many transistors with circuitry on silicon chip
- mass production further reduced prices

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



1960's saw the rise of Operating Systems

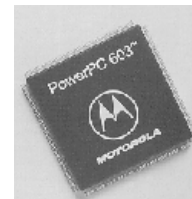
- an operating system is a collection of programs that manage peripheral devices and other resources
- allowed for time-sharing, where users share a computer by swapping jobs in and out
- as computers became affordable to small businesses, specialized programming languages were developed
Pascal (1971, Wirth), C (1972, Ritchie)

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Generati on 4: VLSI

Very Large Scale Integration (VLSI)

- by late 1970's, could fit hundreds of thousands of transistors w/ circuitry on a chip
- could mass produce powerful microprocessors and other useful IC's
- computers finally affordable to individuals



Year	Intel Processor	Number of Transistors ⁴
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

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Generati on 4: VLSI (cont.)



late 1970's saw the rise of personal computing

- Bill Gates & Paul Allen founded Microsoft in 1975
Gates wrote BASIC compiler for the first PC (Altair)
Gates is now richest person in the world, Allen is #7
<http://evan.quuxuum.org/bgnw.html>
- Steve Wozniak and Steve Jobs founded Apple in 1977
went from garage to \$120 million in sales by 1980
- IBM introduced PC in 1980
Microsoft provided the DOS operating system
- Apple countered with Macintosh in 1984
introduced the modern GUI-based OS
- Microsoft countered with Windows in 1985

object-oriented programming began in the 1980's

- Smalltalk (Kay, 1980), C++ (Stroustrup, 1985)

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Generati on 5: Paral l e l i sm/Networks

high-end machines (e.g. 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	Web Servers on the internet
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
1990	313,000	
1988	56,000	
1986	5,089	
1984	1,024	
1982	235	
1969	4	

most computers today are networked

- Internet born in 1969, connected 4 computers (UCLA, UCSB, SRI, & Utah)
mainly used by govt. & universities until late 80's/early 90's
- Web invented by Tim Berners-Lee at CERN in 1989
designed to allow physics researchers to share data and documents
not popular until 1993 when Andreessen developed graphical browser (Mosaic)
Andreessen would go on to found Netscape, and Internet Explorer soon followed

stats from NetCraft & Internet Software Consortium

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