Introduction to Computer Science

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What is Computer Science?

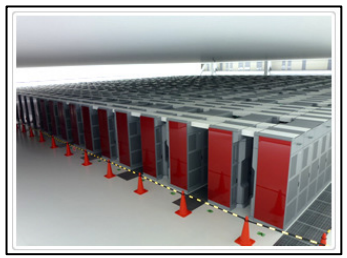
- A “computer” is a machine for manipulating data according to *a list of instructions* known as a program†
- Computer science
  - A discipline that seeks to build a scientific foundation for *computer design* and *information processing using computers*
- Question: is an abacus a computer?

† http://www.wikipedia.org

An Array of Computers

Super Computers

Cray-1 (1979): 80 MHz, 8 MB RAM, 2.4 GB disks



K computer (2011)†: Fujitsu, 705024 2GHz Sparc64 processors

Workstation/Desktop

Sun UltraSPARC IIi (2005): 650 MHz, 2 GB RAM, 80 GB HD

Intel Pentium 4 (2005): 3.4 GHz, 4 GB RAM, 300 GB HD

Notebook

Intel Core i5 (2011): 2.4 GHz, 8 GB RAM, 500 GB HD

Smart Phone/ Tablet

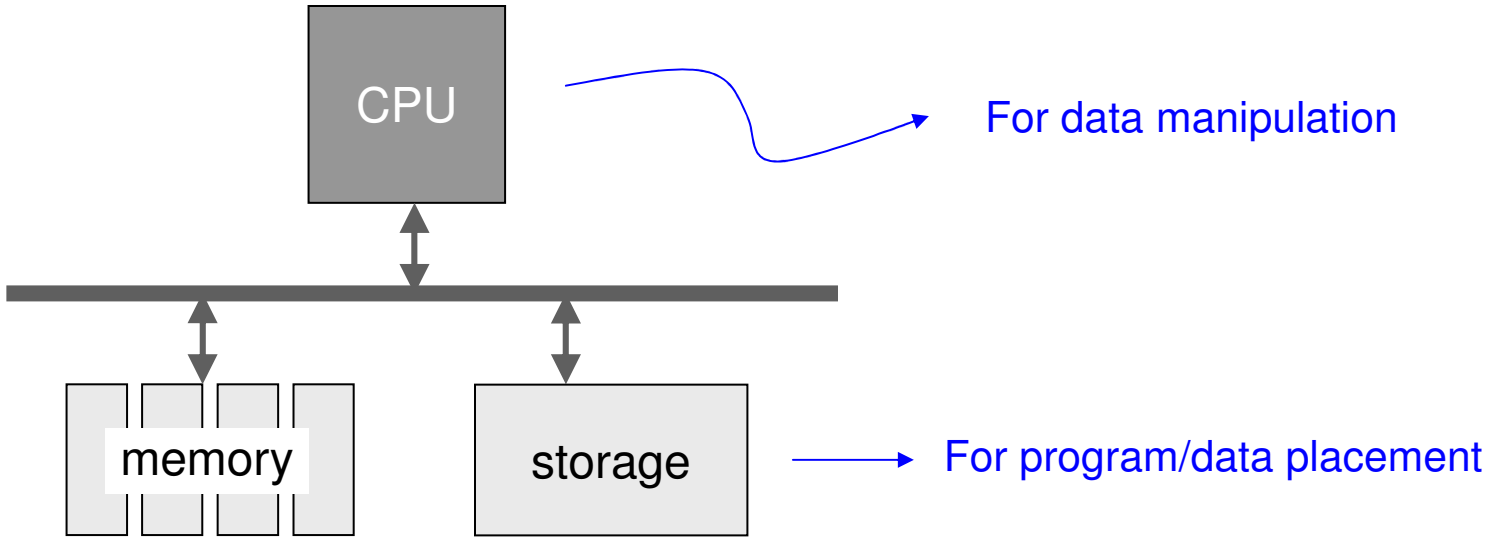
ARM-11 (2010): 436 MHz, 128 MB RAM, 16 GB Flash

ARM Cortex A8 (2010): 1 GHz, 256 MB RAM, 64 GB Flash

† http://www.top500.org/

Key Components of Computers

- Central Processing Unit (CPU)
- Volatile Memory (RAM)
- Non-volatile Storage (Harddisk, Flash)



Computing Systems

- A computer alone does not do anything!
- To complete some useful tasks, we need a "Computing System":

  A computing system is a precisely coordinated operation of ***hardware***, ***software***, and ***input data*** that produces proper ***output data***

Some Definitions

- Software: a collection of programs
- Program: an implementation of an algorithm and data structure using a particular language
  - Algorithm → a set of instructions that define how to carry out a task (by manipulating data)
  - Data structure → how the data is organized in memory and storage
- Hardware: CPU + memory + storage + I/O devices

Examples of “Programs”

- Task: compute the sum of one, two, and three.
  - Program 1 (written in the English language):

```
Compute the sum of one, two, and three.
```

  - Program 2 (written in the C language):

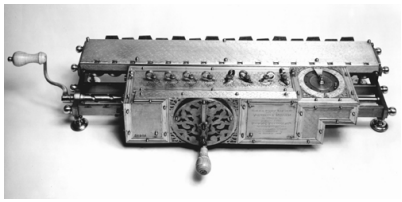
```
for (idx = 1, sum = 0; idx <= 3; idx++) sum += idx;
```

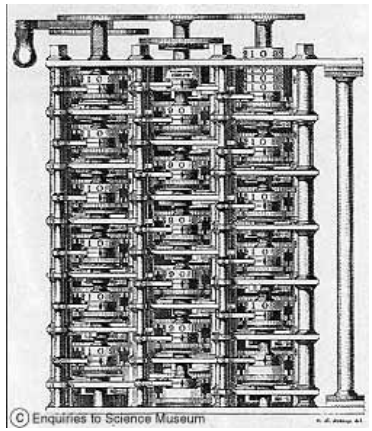
  - Program 3 (written in the x86 assembly language):

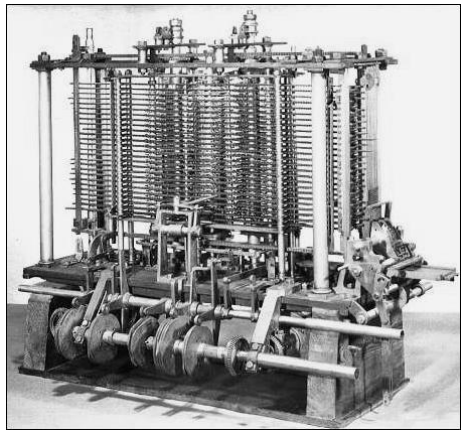
```
mov ax, 1
mov bx, 2
add ax, bx
inc bx
add ax, bx
```

Origins of Computing Machines

- Early computing devices†:
  - Gear-based machines (1600s-1800s):
    - Pascal's adding machine (1642)
    - Leibniz's calculator (1671)
    - Babbage's Difference Engine (1832) and Analytical Engine (1833)







† http://www.computerhistory.org/

Programmable vs. Hardwired

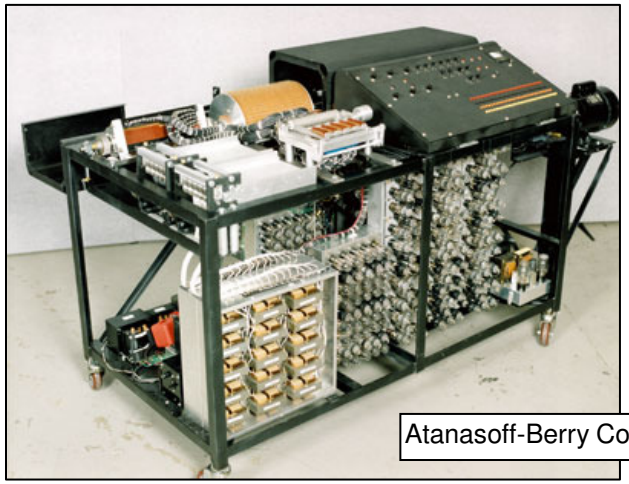
- Early computers based on gears are not “easily” programmable – the hardware must be modified in order to perform a different task
  - The concept of “programmable” computers was also invented in 1800’s (i.e. Analytical Engine)
  - “Programmable computers” is also refer to as “general-purpose computers”
- Today, hardwired (non-programmable) computing systems are as popular (if not more popular) as programmable computing systems

Origins of Programmable Machines

- Early data storage: punched cards
  - First used in Jacquard's loom (1801) to store patterns for weaving cloth
  - Also used to store programs in Babbage's Analytical Engine
    - Ada Byron, who wrote a "program" for this machine, was recognized as the first programmer in the world
  - In 1887, Herman Hollerith invented punch cards to store programs for computers, which were popular through the 1970's and are still used today for data input

Early Computers (1/2)

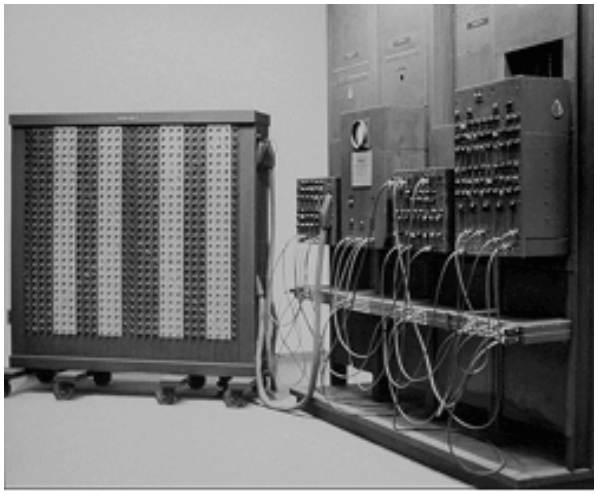
- Based on mechanical relays
  - 1940: Complex Calculator by Stibitz at Bell Laboratories
  - 1944: Mark I by Howard Aiken and IBM at Harvard
- Based on vacuum tubes
  - 1937-1941: ABC by Atanasoff & Berry at Iowa State U.
  - 1940s: ENIAC by Mauchly & Eckert at U. of Penn.



Atanasoff-Berry Computer (ABC)

Early Computers (2/2)

⇨ Mark I



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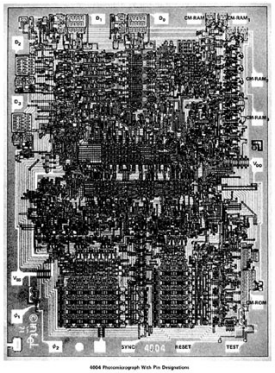
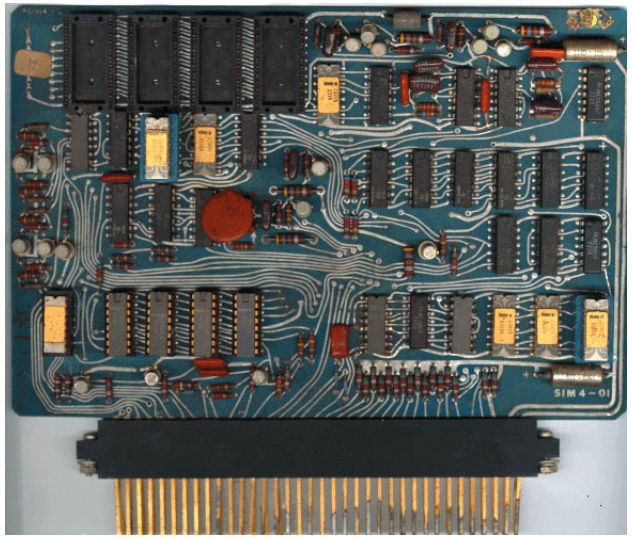
Microprocessors & Microcomputers

- The first microprocessor is Intel 4004 (1971)
- The first computer based on microprocessor is Intel SIM4-01



Intel 4004



Intel SIM4-01

Personal Computers (PC) (1/3)

- The definition of personal computers is quite vague:
  - Inexpensive general-purpose microprocessor-based computer for small scale computing tasks
- The first microprocessor used in a “PC” is 8008 (made in 1972), a descendent of 4004. The first PC based on 8008 is called Micral (made in 1973)
- The first high-level programming language available for PC is the BASIC interpreter written by Bill Gates and Paul Allen for Altair 8800 (a PC based on 8080) in 1975

Personal Computers (PC) (2/3)

- The first popular PC in Taiwan is the Apple II (1977), designed by Steve Wozniak of Apple Computers. The CPU was MOS 6502 (1 MHz).

- Today, most PCs are based on the x86 architecture. The first IBM PC was available in 1981. The CPU was the Intel 8088 (4.77MHz).

Personal Computers (PC) (3/3)

- The first real popular PC Operating Systems was CP/M – Control Program for Microcomputers, written by Gary Kildall in 1973 for the Intel 8080 processor.
- When IBM decided to make IBM PC, they first asked Gary Kildall to port the CP/M to the 8088 processor. However, he refused. Later, IBM turned to Microsoft for help. Microsoft bought QDOS from Seattle Computers and re-label it as MS-DOS for IBM.
- In fact, QDOS is simply a hackers' port of CP/M to x86 architecture

The Rise of the Open Source Spirit

- One of the most important software in computer history is the UNIX operating system by Ken Thompson and Dennis Ritchie in 1969.
  Its source code† is open to public with usage restrictions.

- In 1983, Richard Stallman from MIT launched the GNU project to create a free Unix-like operating system. In 1985, Free Software Foundation (FSF) is established.
- Linux (by Linus Torvalds) and the GCC toolchain (by Stallman) are both from the GNU project.

† The 1977 version of Unix is composed of about 9000 lines of assembly and C codes.

Computer Science Redefined

- The science of algorithms
  - All the intelligence of computers is embedded in algorithms
- Draws **domain knowledge** from other subjects, including
  - Mathematics
  - Engineering
  - Psychology
  - Business Administration
  - … etc.

Key Questions of Computer Science

- Which problems can be solved by algorithmic processes?
- How can discovery of algorithms be made easier?
- How can techniques of representing and communicating algorithms be improved?
- How can our knowledge of algorithms and technology be applied to provide better machines?
- How can characteristics of different algorithms be analyzed and compared?

Where Do We go from Here?

- ***Data Storage***
- ***Data Manipulation***
- ***Operating Systems***
- Networking and the Internet
- ***Algorithms***
- ***Programming Languages***
- ***Software Engineering***
- ***Data Abstractions***
- Database Systems
- ***Theory of Computation***