

What is a Computer?

A Brief and Rough Description

- Hardware
- Software
- Computers versus Humans:
Machine Intelligence versus
Human Intelligence

Hardware - 1

- In the old days a *Computer* was a human that was given the task of performing a list of calculations using some kind of mechanical calculator.
- *Electronic Computers* made their appearance during WW-II. Machines that did the job of human computers much faster.
- Several early designs – the one that won was the *Electronic Digital Computer* that solved problems by manipulating numerical digits.
- Eventually, human computers disappeared and the word *Computer* became a synonym for *Electronic Digital Computer*.

Hardware - 2

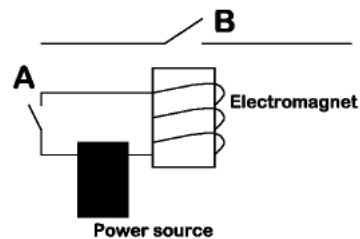
- The key ingredient in the circuitry of an electronic digital computer is an element consisting of a switch in a circuit that can be turned on and off by the current in another circuit.
- Originally, such elements were electromechanical relays or vacuum tubes and computers tended to be quite bulky.
 - One of the early IBM computers, the *Selective Sequence Electronic Calculator* (SSEC), built in 1948, consisted of 20,000 relays and 12,500 vacuum tubes and occupied 25X40 feet floor space.
 - This machine was used to calculate the tables of moon positions that were used 20 years later in the *Apollo* mission.

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Hardware - 3



When switch A closes, the electromagnet is activated and it causes switch B to close.

The word **bug** for a computer malfunction has its origins in the days of relays. On September 9, 1945 a moth was stuck between the contacts of a relay and Grace Hopper (1906-1992), one of the computer pioneers, logged the incident as a *bug*.

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Hardware - 4

- In the late 1950's transistors were introduced and computer size went down, while memory and speed went up.
- Then came integrated circuits, devices that could have millions of transistors on a small piece of silicon and computers have been getting more powerful and cheaper every year.
- The *Computer Revolution* was made possible by technology that could make switching circuits that were very small, very fast, and very cheap.

Hardware - 5

- Switching circuits can perform logical and numerical operations provided that all the elements of the computation are **binary**, having only one of two possible values, 0 (open switch) or 1 (closed).
- The word **bit** refers a single switch that can open (0) or closed (1). The word **byte** refers to a set of **eight bits**. A **kilobyte** is 1024 bytes.
- A machine with one **megabyte** of memory contains 1024x1024x8 switches, over eight million of them.

Hardware - 6

- **Alan Turing's** (1912-1954) Insight: Any problem that can be expressed by mathematical and logical operations can be solved (at least approximately) by a device using only switching circuits.
- Turing went on to supervise the building of one of the first computers in order to break the German communication codes during War World II.
- Sadly, Turing was hounded to death because he was gay.
- He has been honored by the establishment of the Turing Award, equivalent to a Nobel for Computer Science and Technology,

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Hardware to Software

- The collection of switching circuits is part of the computer **hardware**.
- It is possible to wire such circuits together to perform particular operations. Such circuits are usually called **special purpose hardware**.
- However, most computers rely on another property of switching circuits, that the connectivity of their basic elements can be modified by information stored in some of those elements. That makes the computers to be **programmable** by software.

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Software - 1

- Most modern computers are designed according to principles developed by the American-Hungarian mathematician **John von Neumann** (1903-1957) who wrote a paper on programmable machines around 1945.
- Von Neumann had a computer built at the Institute of Advanced Studies at Princeton. The engineer for the project was *Julian Bigelow* (1913 - 2003) and the technician was *Leon Harmon* (1922-1982).

Software - 2

- A **program** consists of sets of instructions and data for the computer to process.
- The term **software** is used to describe the collection of programs run on a computer and it has been coined to contrast with hardware.
- Most modern computers use special purpose hardware for basic operations, such as addition and multiplication of numbers, and rely on everything else on software.

Software - 3

- Early days(WW-II and soon after): Programming in *Machine Language*, the binary codes of the instructions.
- Next stage: Programming in *Assembly Code*, letter/number combinations that corresponded directly to the binary code. (Circa 1950 –1970 but still used in special circumstances.)
- Modern times: *Programming languages* where the code has a human-friendly form. Another program, called a *compiler*, has to be used to translate the code into machine language, strings of 1's and 0's that control the switching circuits of the machine.

Software - 4

- The first programming languages were **FORTRAN** (for scientific applications) and **COBOL**(for commercial applications), both developed in the late 1950's.
- FORTRAN was developed at IBM by a team led by John W. Backus (1924-2007)
- COBOL was invented by Grace Hopper who also wrote the compiler for it.
- Usually, the machine code generated by the compilers of programs written in such languages is not as efficient as hand-coded instructions, so Assembly Code continued to be used for applications where speed was important.

Software - 5

- Eventually (after 1980), FORTRAN and COBOL were superseded by others such as *Algol*, *C*, *C++*, *Java*, etc that made programming even easier.
- Example: a piece of code to compute the amount of the sales tax in a retail store checkout computer:

```
tax_rate = 0.08;  
...  
sales_tax = tax_rate*total_purchase;
```
- The * symbol stands for multiplication. (This line of code could be from any of several languages such as C, C++, Java, etc.)

Software - 6

- Compilers have improved so much that very rarely there is a need for writing programs in Assembly Code.
- But: Old languages cannot be forgotten because there still programs written in them running.
 - **Y2K issue:** Make sure that computers would shift from 1999 to 2000 correctly. Many of the business programs that had to be checked were old programs written in COBOL.
- Usually there are several layers of software running on a computer. The **Operating System**, for example *Linux* or *Windows*, interacts directly with the hardware and on top of that there are **Application Programs (apps!)** that interact with the operating system.

Computer Intelligence versus Human Intelligence

- **The machine itself has no intelligence - the intelligence comes from the software, programs that are written by humans.** (Even when special purpose hardware is used, it must also be designed by humans.)
- What is often referred to as "machine (or artificial) intelligence" are programs that are supposed to replicate human thinking and cognition.
- It would be more accurate to say that we are discussing "**Computer Programs Replicating Human Thinking and Cognition versus Real Humans**" rather than "**Computers versus Humans**" but we opt for brevity.

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Computers and Text - 1

- In addition to solving mathematical problems, computers can be used to manipulate text because each letter or other symbol can be given a numerical code so that a piece of text is reduced to a string of numbers.
- From typing letters, to browsing the web, to reading a book on *Kindle*, all these operations use the text processing capabilities of computers.
- When you type on your personal computer, each key stroke generates a code corresponding to the letter on the key. You can actually change the code by specifying a different language. For example, in *Microsoft Word* the key that produces the code the **j** in English will produce the code for **ξ** in Greek.

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Computers and Text - 2

- Codes for a few letters and symbols in the most commonly used system (ASCII).

Key	Numerical Code	
	Decimal	Binary
space	32	00 100 000
A	65	01 000 001
a	97	01 100 001
1	49	00 110 001

Note: The code is the same regardless of the size or the font.