Teaching Assistants

- Albert Bachand
  abacha *AT* cs *DOT* mcgill *DOT* ca
  Office Hours: Wednesday 1 - 2 pm
  Location: McConnell Engineering, 321

- Hiba Yamani
  hiba *DOT* yamani *AT* mcgill *DOT* ca
  Office Hours: Friday 2 - 3 pm
  Location: McConnell Engineering, 110

History of Computing

Punched Cards

- early 1800s: Joseph-Marie Jacquard invented a way of automatically controlling the threads on a silk loom by recording patterns of holes in a string of cards.

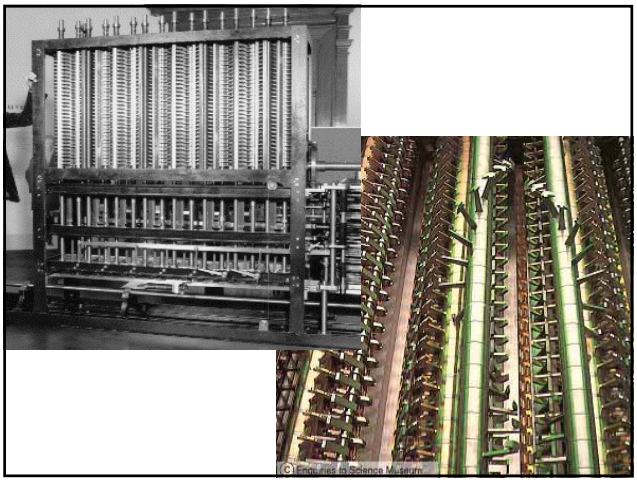
IBM 80-column punched card format.

Computer Re-Invented

- Computer (until 1940s): *Person* who worked out logarithmic and trigonometric tables

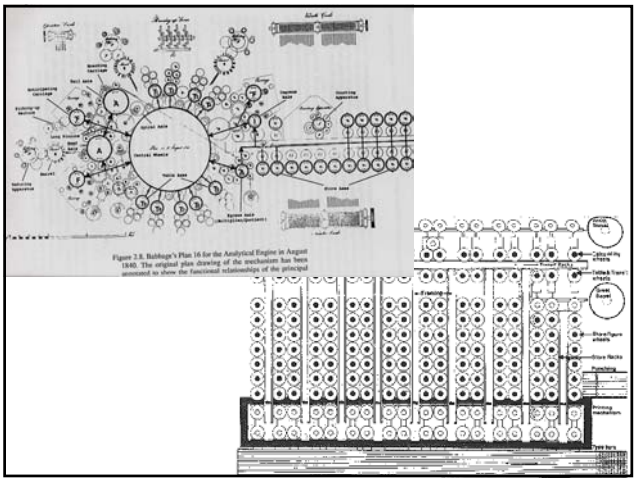
- 1822: Charles Babbage conceives the Difference Engine to automatically calculate these table

- Built in early 1990s: requires turning of crank 1000's of times!



Analytical Steam Engine

- 1830: Babbage conceives this machine
- Loops of Jacquard's punched cards to control an automatic calculator, which could make decisions based on the results of previous computations
- Construction beyond available technology

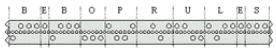


First "Programmer"

- Ada Augusta Byron, Countess of Lovelace (Lord Byron's daughter)
- Provided examples of how the Analytical Engine can be used to solve problems

Paper Tape

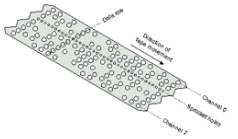
- 1857: Sir Charles Wheatstone introduces paper tape to store message in Morse Code (dashes and dots) to be telegraphed



Wheatstone's perforated paper tape

Paper Tape

- Used by designers of early computers
- Record data on a paper tape by punching rows of holes across the width of the tape
- The pattern of the holes in each data row represented a single data value or character
- Read by wires running under each channel; later by shining light



1-inch computer paper tape

Necessity is the Mother of Invention

- Population growth (USA)
  - 1790 4 million
  - 1840 17 million
  - 1870 40 million
  - 1880 50 million

    fear of not being able to enumerate the census in the 10 intervening years
  - 1890 63 million

Herman Hollerith

- Use Jacquard's punched cards to represent the census data, and to then read and collate this data using an automatic machine
- Extremely useful for a wide variety of statistical applications
- 1924: Hollerith's company changed its name to *International Business Machines*, or IBM.

Harvard Mark I

- 1939-1944: First large-scale automatic digital computer
- Designed by Howard H. Aiken
- Constructed out of switches, relays, rotating shafts, and clutches, and was described as sounding like a "*roomful of ladies knitting*."
- Contained more than 750,000 components, was 50 feet long, 8 feet tall, and weighed approximately 5 tons!

Official Name: IBM Automatic Sequence Controlled Calculator (ASCC)

Marc I

- Performance:
  - Add or subtract 23 digit numbers in 0.3 seconds
  - Multiply them in 4 seconds
  - Divide them in 10 seconds
- Opinion:
  - "Only six electronic digital computers would be required to satisfy the computing needs of the entire United States."

Context

- Computers were typically only considered in the context of
  - scientific calculations and data processing for governments, large industries, research establishments, and educational institutions
- It was also widely believed that computers would only ever be programmed and used by experts and intellectual heroes ☺

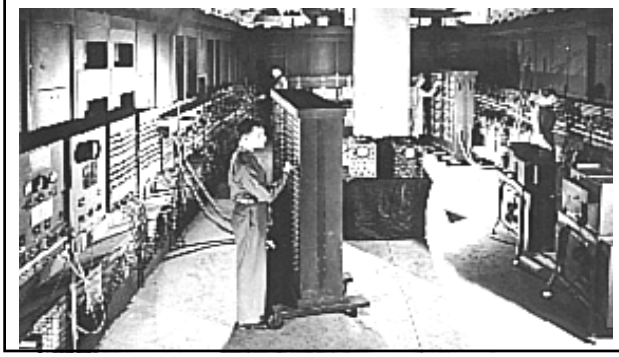
WWII

- Alan Turing worked as a cryptographer in Britain to break codes generated by the Nazi *ENIGMA* and *Geheimfernschreiber* machines
- *Special-purpose* electronic digital computer *COLOSSUS* as decoder
  - Made with 1,800 vacuum tubes (used to modify electric signal)

Electronic Numerical Integrator and Computer (ENIAC)

- *General-purpose* electronic digital computer (U. of Pennsylvania, 1943-1946) by Mauchly and Eckert
- Was a ***monster***: required 150 kilowatts of power, which was enough to light a small town
- 90% of ENIAC's down-time was attributed to locating and replacing burnt-out vacuum tubes
  - 50 tubes replaced per day!

ENIAC

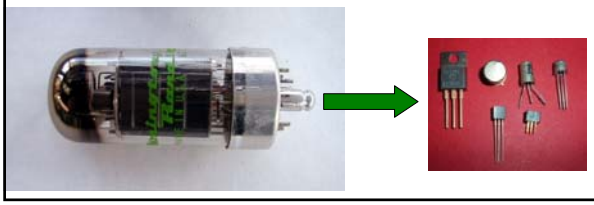


Electronic Discrete Variable Automatic Computer (EDVAC)

- ENIAC was hard-wired (didn't have any internal memory as such) and needed to be physically programmed by means of switches and dials
- EDVAC: 1944-1952
- First stored-program computer
- All subsequent digital computers based on this architecture

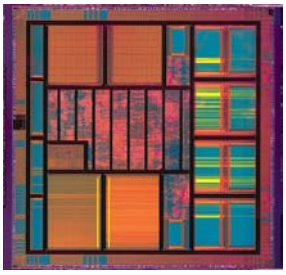
Transistors

- 1960s: Vacuum tubes replaced by transistors
- Computers became much smaller



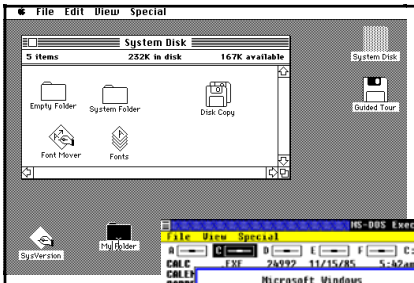
Integrated Circuits

- Integration of large numbers of tiny transistors into a small chip
- Mass production capability, reliability, and building-block approach to circuit design ensured the rapid adoption of standardized ICs

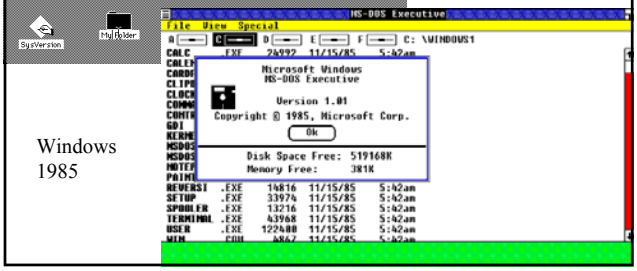


PC

- 1973-1981: First Personal Computers



Mac OS 1984



Windows 1985

Gaining Momentum

- In 1975, an IBM mainframe computer that could perform 10,000,000 instructions per second cost around $10,000,000
- In 1995, a computer video game capable of performing 500,000,000 million instructions per second was available for approximately $500

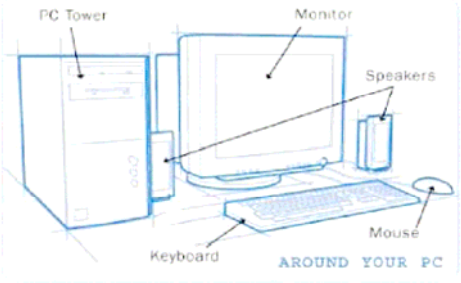
Credits

- http://www.maxmon.com/history.htm
- http://www.computinghistorymuseum.org/teaching/lectures/lectures.htm

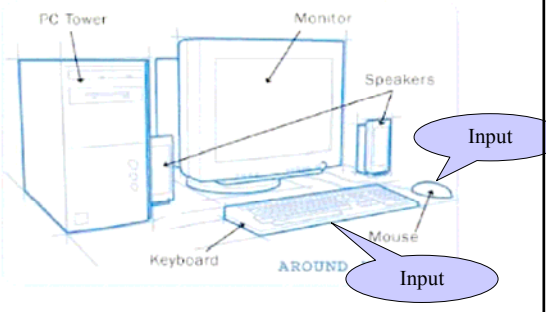
Time for a break!!!

Computer Architecture

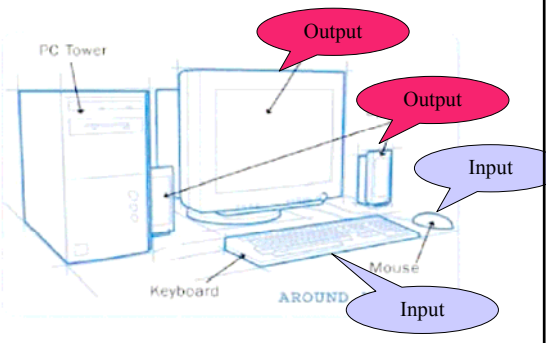
Your PC



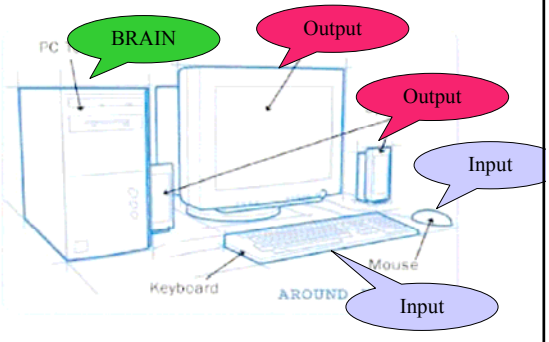
Your PC



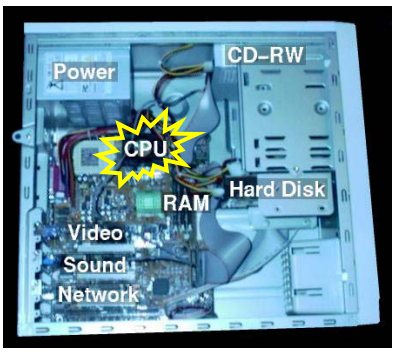
Your PC

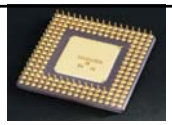


Your PC



Inside the BRAIN





CPU

The CPU is composed of 3 major parts:

- ALU (Arithmetic Logic Unit)
  - Arithmetic & Logical operations
- Registers
  - Storage areas for data and machine instructions operated on by the ALU
- Control unit
  - Acts as a coordinator between the ALU and registers

Fetch-Execute Cycle

1. Fetch Cycle: Control Unit *fetches* a program instruction from memory and *decodes* the instruction for subsequent processing
2. Execute Cycle: The ALU *executes* the required instruction and stores results into memory

Fetch Cycle

1. Look at the Program Counter (PC) to determine the location in memory where the next instruction is stored
2. Retrieve this instruction from program memory
3. Decode this instruction
4. After an instruction is fetched, increment the PC by the length of the instruction

Machine Instructions

MIPS32 Add Immediate Instruction

001000	00001	00010	0000000101011110
OP Code	Addr 1	Addr 2	Immediate value

Equivalent mnemonic: **addi $r1, $r2, 350**

Add the contents of the *register* r2 and 350 and store the result in the *register* r1

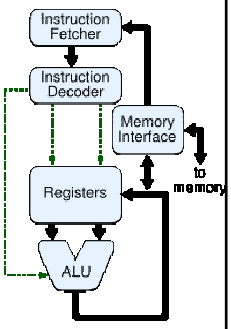
Machine Instructions

- Other kinds of instructions include:
  - Transferring data between registers or memory locations
  - Arithmetic or logical operations (use the ALU)
  - Control: test contents of a register and jump to a location

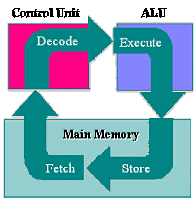
This is all a computer does!!!

Execute Cycle

1. Execute the instruction
   - Connects the various components of the computer so that the desired operation may be carried out
2. Write back the results (if any) of the execute step to some form of memory.



Fetch-Execute Cycle



- Fetch: get an instruction from Main Memory
- Decode: translate it into computer commands
- Execute: actually process the command
- Store: write the result to Main Memory

Computer Speed

- The CPU experiences high and low voltage changes, driven by the **clock** (vibrating quartz crystal).
- The clock operates with a predetermined **frequency** (such as 500MHz).
- Each time the clock changes, the computer's processor processes a machine instruction.
- A more accurate measurement would compare the **number of instructions per second** (MIPS: million instructions per second) as some computers use the clock ticks more efficiently than others.

Von Neumann Bottleneck

- The rate at which data can be transferred between the CPU and memory is much smaller than the rate at which the CPU itself can do the work
- Under some circumstances (when the CPU is required to perform minimal processing on large amounts of data), this gives rise to a serious limitation in overall effective processing speed

Assignment 1, Q7, File Formats

- A file format is a particular way to encode information for storage in a computer file
- E.g., text file is stored as ASCII