PH502: Scientific Programming Concepts

Irish Centre for High End Computing (ICHEC)

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Computing Machines

Fixed-program computer: Specific design to do a specific computation.

- Pascal's Calculator, 1642: First mechanical calculator. Invented by Blaise Pascal (1623-1662). It could add and subtract two numbers directly and multiply and divide by repetition.
- Difference Engine, 1834: The first mechanical computer. Designed by Charles Babbage (1791-1871). He couldn't finish but a working version was built in 1991. The Difference Engine was used to calculate tables of values from polynomials using the method of finite differences.
- Atanasoff-Berry Computer, 1941: The first electronic-digital computer. Created by John Vincent Atanasoff (1903-1995). It is designed to solve systems of linear equations.
- Turing Machine, 1948: Designed by Alan Turing (1912-1954). The "Turing Machine" is a good representation of the Central Processing Unit (CPU) today. He used his computing machines to break German enigma codes in WWII.

Turing Machine

- A tape divided into cells each of which contains a symbol
- A head that can read/write/erase the symbol and move the tape left and right at a time
- A state register that stores the state of the turing machine
- A finite table of instructions

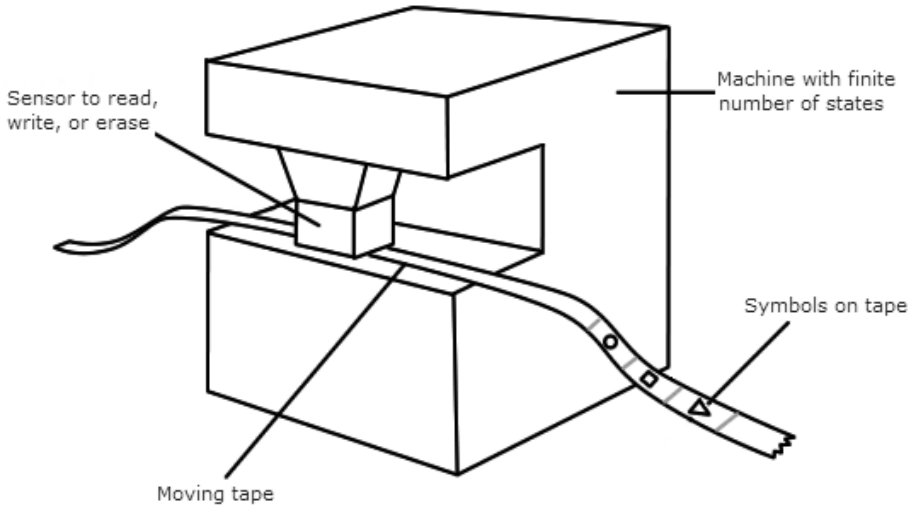
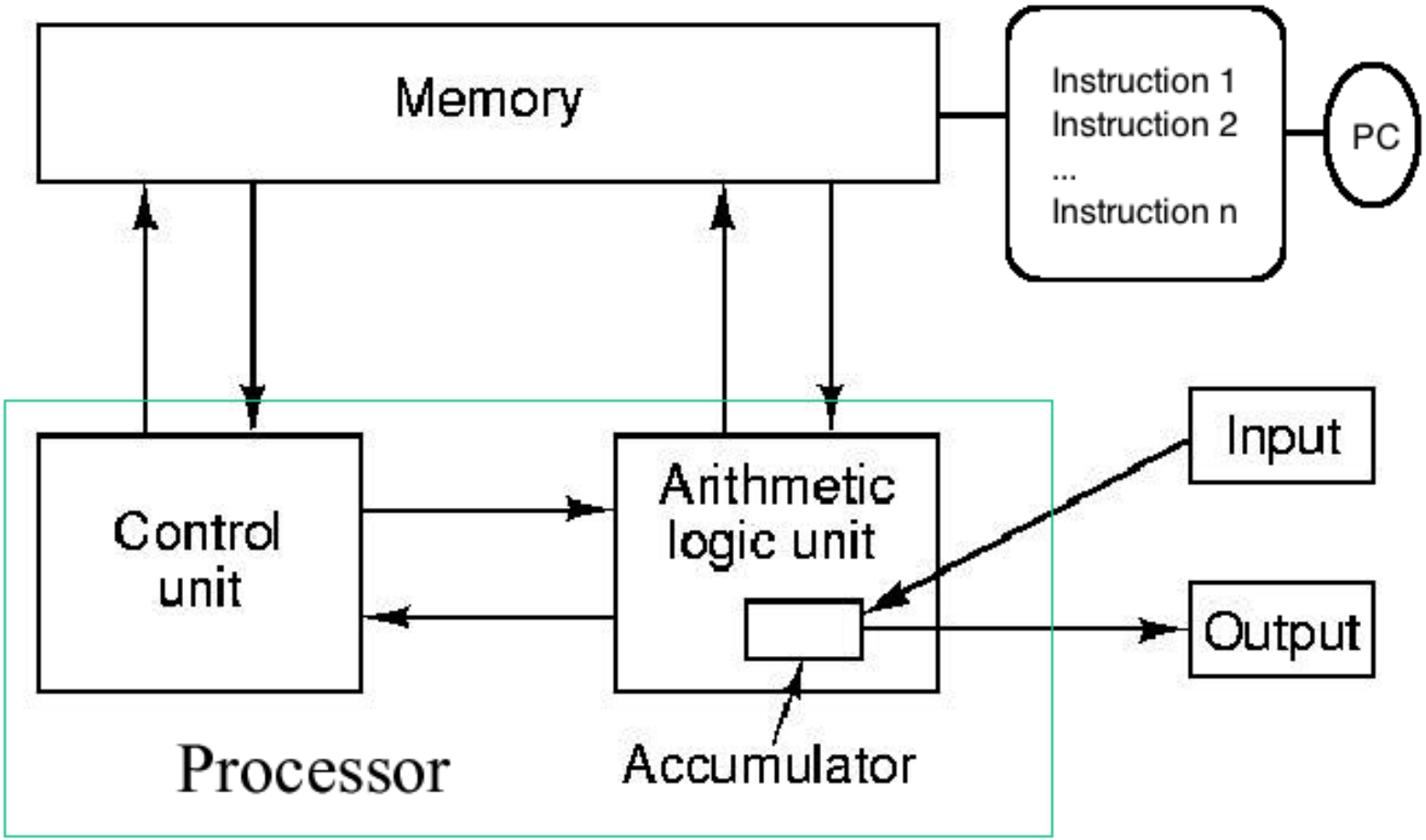


Figure: A Turing Machine

Von Neumann Architecture

Stored-program computer: Designed to run any computation by interpreting a sequence of program instructions that are read into it.



Programming and Computer Architecture

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1. CPU: It performs virtually all computations; taking data from memory, executing it, and then returning the results back to memory.
2. Memory: It is the modifiable store but it also holds the data/program. Typically the size of memory will be in the order of 10GB.
   - Memory holds the executable code for different programs currently running on the machine, along with the executable code for the operating system itself. Each program has certain global variables associated with it and uses an area of memory called the stack, which holds all local variables and parameters. When a program completes execution, it releases its memory for reuse by other programs.
3. Disk: It is a permanent data/program store. The program resides on the disk initially, is loaded into the memory when executed. Objects saved to disk are called files. Disks are typically the order of a 1TB.

The disk is much bigger than the memory, so why load the program into memory?

It is a question of speed. Accessing information from the disk is about 10,000 times slower than the same information from memory.

Memory Addresses

- There are two subgroups of computer architecture: 32-bit and 64-bit.
- Bit: The smallest unit of information; has two settings (0 and 1).
  - 32-bit can store 2^{32} different values and 64-bit can 2^{64}.
- Memory is a long sequence of 0s and 1s; Memory size is generally measured in the number bytes of information a computer can store.
- Byte: A group of eight bits.

◦ 1 kilobyte=1024 bytes and 1 gigabyte=2^{30} bytes
Maximum memory size: The amount of memory that a computer can have is limited by its architecture.

$$\text{32-bit} \quad \frac{2^{32}}{(2^{10})^3} = 4\text{GB}$$

$$\text{64-bit} \quad \frac{2^{64}}{(2^{10})^3} = 2^{34} \simeq 1.7 \times 10^{10}\text{GB}$$