Computer Science 1510

Lecture 1

Lecture Outline

- Hardware / software
- Computer architecture, design

Hardware / software

- Hardware - the physical components that make up the computer.
- Software - the non-physical components, the instructions and rules that tell the hardware how to perform calculations and process data.
- This course focuses on writing software, that is, "programming".
- We will use two programming languages: Fortran and C.
- A programming language provides the vocabulary and grammar to write software.

Computer architecture

- Computer architecture refers to the design of a computer.

- Today's computers continue to be modelled after the framework developed by John von Neumann in the 1940's, called the von Neumann architecture:
  - Instructions and data are stored in memory.
  - Programs consist of a sequential list of instructions.
  - The central processing unit (CPU) performs all mathematical, logical, and data processing operations.

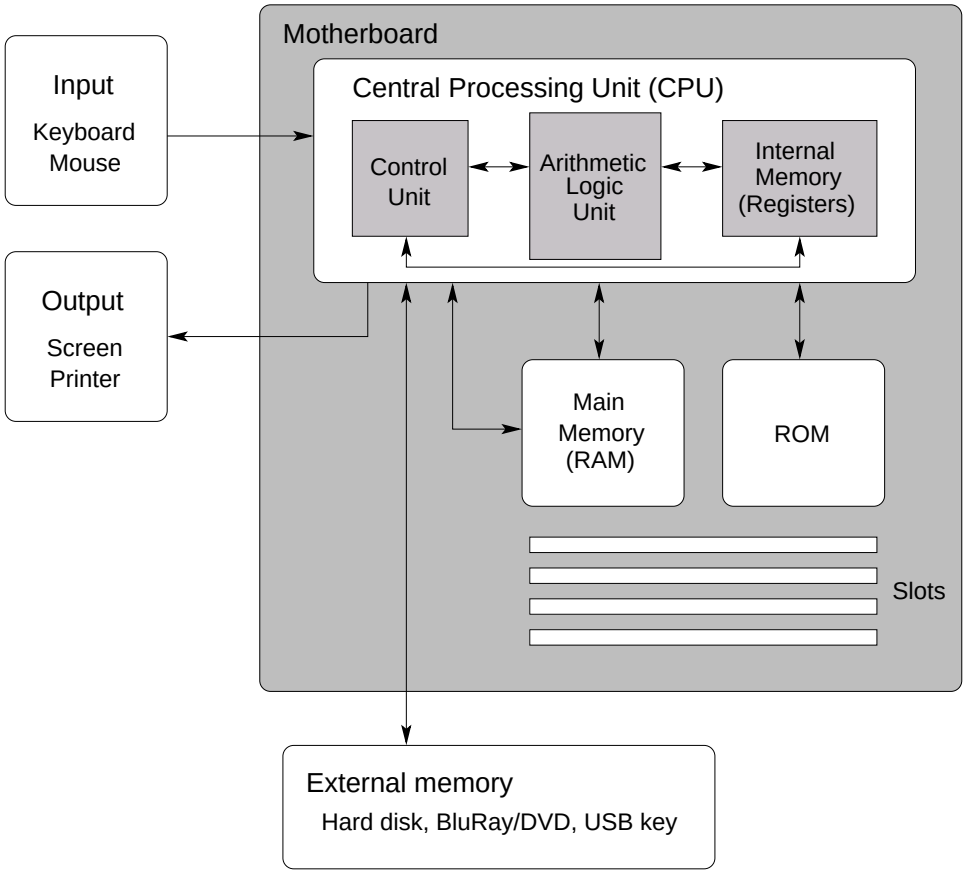
- Program instructions are fetched one at a time, decoded, and executed by the CPU.

The Motherboard

- The *motherboard* is a flat electronic board with wires (in the form of gold filaments) that connect the various components.

- All the other devices that make up the computer are connected to the motherboard.

- The memory and CPU reside on the motherboard.



The CPU

- The location where all mathematical, logical, and information processing operations are defined and executed.

- Examples:
  - Mathematical: addition, multiplication, etc.
  - Logical: $x > 10$? $x > 5$ AND $y < 0$?.
  - Information processing: moving data to a different location, sending data to an output device, receiving data from an input device.

- The CPU has limited memory, in the form of registers, that are used when executing an instruction.

- Results are stored in memory and/or sent to an output device (screen or printer, for example).

The CPU

The execution cycle of the CPU consists of:

1. **Fetch:** The program instruction in the memory address stored in the *program counter* (PC) is fetched and stored in the *instruction register* (IR). Following the fetch, the PC points to the location in memory of the next instruction.
2. **Decode:** The current (encoded) instruction is decoded.
3. **Execute:** The control unit passes the decoded information to the appropriate unit of the CPU to execute the instruction. This could include reading values from registers, passing values to the ALU to perform mathematical or logic functions, and writing the result to a register. Note that the ALU accepts two values as input and produces a result that is stored in the *accumulator* (ACC). This result can then be transferred to RAM or disk.

Types of Memory

- A computer contains both primary and secondary storage.
- Primary storage, such as RAM (random access memory), is volatile, that is, the information is lost when the power is shut off.
- Other types of volatile memory include registers and cache.
- Secondary storage, such as hard disk, is nonvolatile, that is, the information is not lost when the power is shut off.
- ROM (read-only memory) is another type of nonvolatile memory.

ROM - Read Only Memory

- A type of non-volatile memory that is often used to store information for specific hardware.

- Motherboard ROM stores the BIOS (Basic Input and Output System) and the Boot procedure. The BIOS consists of routines that are aware of the data pathways within the motherboard and CPU. The Boot procedure is used when the computer is turned on.

- ROM is also found on peripheral cards (such as video/graphics cards) that interface with the motherboard using the slots.

RAM - Random Access Memory

- RAM is generally what people refer to simply as computer memory.
- Currently, personal computers normally contain 1 to 16 gigabytes of RAM.
- RAM is where information is stored temporarily.
- The time required to access information stored in RAM is independent of the location of the data within the memory.
- Program instructions are stored in RAM.

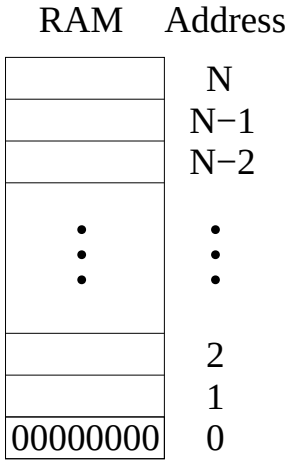
Memory Organization

- All information stored in a computer is stored in *binary* format.

- Each binary digit is called a *bit*, and each bit has two states, 1 or 0 ("on" or "off").

- A group of
  - 8 bits make up a *byte*,
  - 2^{10}=1024 bytes make up a *kilobyte*,
  - $2^{20} \approx 1$ million bytes is a *megabyte*,
  - $2^{30} \approx 1$ billion bytes is a *gigabyte*,
  - $2^{40} \approx 1$ trillion bytes is a *terabyte*.

- Consider RAM as organized into an array of bytes, where each location is numbered with an *address*.



The Bus

- The bus provides the means to transfer data between components in the computer (from RAM to the CPU for example).

- You can think of a bus as a series of wires, one for each bit.

- The bus connects all components connected to the motherboard.

The Clock

- A computer requires a clock to synchronize its activities.

- Each computer contains two clocks, a bus clock, and a CPU clock.

- It is the CPU clock speed that is normally advertised as the speed of a computer (ex. 2 GHz).

- At each tick of the clock one data operation occurs In the case of the bus, N bytes of information is moved from one location to another, where N is the width of the bus (ex. 4 bytes, "32-bit bus"). In the case of the CPU, one simple instruction is executed. [1]

- Clock speed is measured in Hertz (Hz) = number of ticks per second. 1GHz CPU = 1 billion ticks/second.

[1] Modern day processors can actually perform more than one operation per clock cycle. However, the operation of such processors is beyond the scope of this course.

Slots

- Peripheral devices are devices that are external to the motherboard (monitor, hard disk, speakers, etc.).

- These devices communicate with each other and the CPU via slots in the motherboard.

- Each slot accepts an integrated circuit card (sound card, video card, etc.), and each card is connected to both the motherboard and the peripheral device (via connectors that protrude through the back of the computer).

- Each card contains ROM that holds the translation necessary to convert encoded signals received via the bus to a format appropriate for the given peripheral.

Operating System

- The operating system is system software that performs tasks such as control of hardware devices, and resource management (memory, CPU time, bus access).

- The operating system provides an interface between the user and the computer.

- The operating system is stored in secondary memory.

- Operating systems are written in high-level programming languages like those used in this course.

- Examples of operating systems include UNIX, Linux, MS Windows, and MAC OS.