Introduction to Computing

MCS1101B

Lecture 1

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Outline of the Course

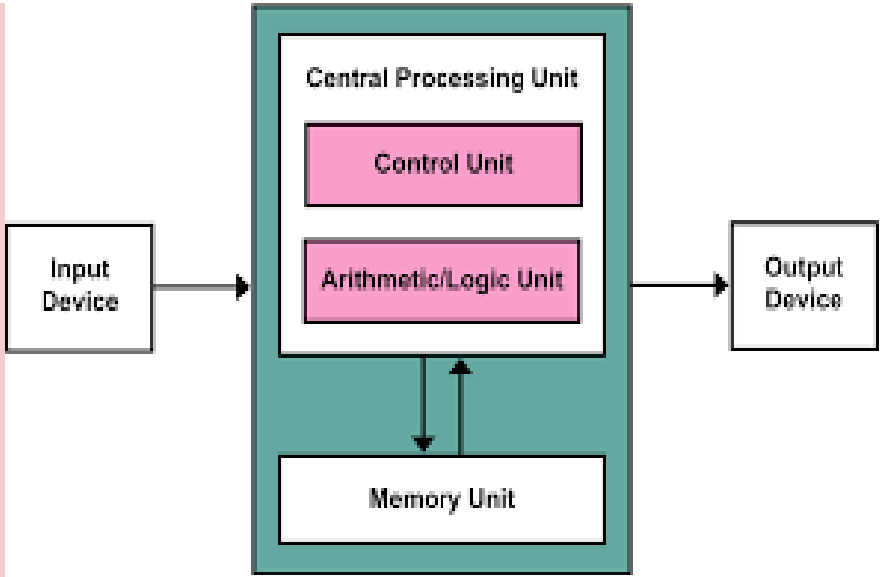
- Broad overview
  - Basic prerequisites of computation
  - Computation using the language **C**
  - Computation using the language **Python**
- Course webpage
  - https://soumadip.github.io/courses/I2C
- Reference books
  - Let Us C by Yashavant Kanetkar.
  - The C Programming Language by B. W. Kernighan and D. M. Ritchie.
  - A Book on C: Programming in C by Al Kelley and Ira Pohl

Computation

- What is computation?
  - The typical definition: The action of mathematical calculation
- Why computation is needed?
  - Almost everything requires computation in one form or the other
  - e.g. shopping, grades, rocket science, cellphone…
  - It can take many and any form - from printing a letter to predict who will win the World Cup to determine the number of atoms in the universe to …
- Properties of computation
  - They are mostly boring monotonous tasks
  - No real thinking is required once you know exactly what formula to use and when to use
- The role of computer programs
  - It is the tool using which we can automate computation

How do Computers Compute?

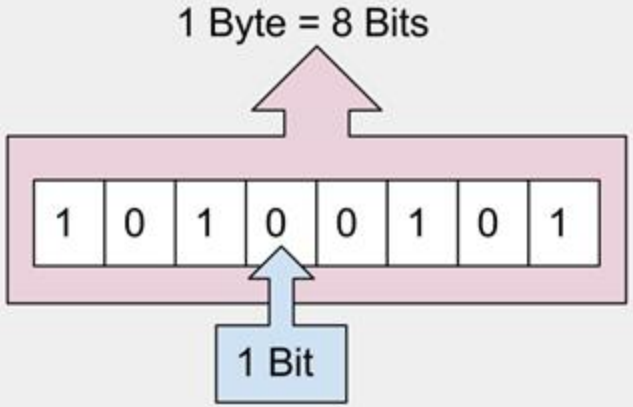
- It uses its brain - similar to humans
  - It's called a CPU (Central Processing Unit)
- Broadly a typical CPU consists of
  - ALU (Arithmetic and Logic Unit)
  - CU (control Unit)
  - Note: Modern CPUs are much more advanced and has more components, but let's ignore that for the moment …
- It needs some input(s)
  - Keyboard, mouse, camera, etc.
- It produces some output(s)
  - Monitor, printer, speaker, etc.



The Von Neumann Architecture

How do Computers Store Data?

- It uses memory - similar to humans
- Different types of memory aka. storage
  - Primary memory - RAM (Random Access Memory)
  - Secondary memory - Hard disk, SSD
  - Other types of storages - ROM (Read Only Memory), Pen-drive, Floppy disk, etc.
- The unit of computer memory
  - It's called a bit
  - It can store either a 0 or a 1
  - 8 bits constitute a byte
  - …refer to the image →
- Each memory location has an *unique address*



1 byte	= 8 bits
1 kilobyte	= 1024 bytes
1 megabyte	= 1024 kilobyte
1 gigabyte	= 1024 megabyte
1 terabyte	= 1024 gigabyte

What can a Computer store?

- Only 0s and 1s can be stored in computer memory (i.e. bits)
  - So, basically numbers
- But, it can store anything (image, text, videos), right?
  - How does it do it?
  - This is where files/structures come into the picture
- Computer interprets sequence of numbers in many different
  - But how do a computer know how to interpret something
  - This is where computer programs come into the picture
  - Subsequently computer programmers follow; that means you, in the near future, hopefully :-)

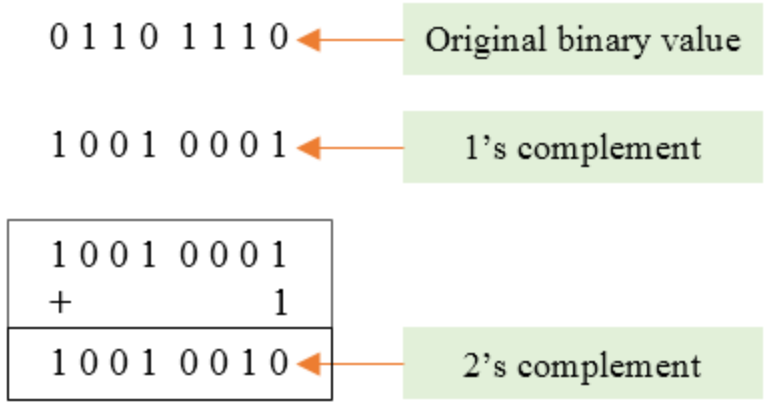
So, how do Computers Store Numbers?

- The binary number system
  - By using 0 and 1
  - The base (radix) is 2
- Why binary?
- How do you get a binary number?
  - Think how decimal numbers work : 103 = 1 * 10^2 + 0 * 10^1 + 3 * 10^0
  - So, 103 = 1 * 2^6 + 1 * 2^5 + 0 * 2^4 + 0 * 2^3 + 1 * 2^2 + 1 * 2^1+ 1 * 2^0 = 1100111
  - 150 = ?2
- So, what is the maximum number a byte can hold?

Binary Operations

- **Arithmetic operations**: Addition, Subtraction, Multiplication, Division
- **Logical operations**: And, Or, Xor, Not
- **Complements**: 1's complement, 2's complement

X	Y	X&Y	X|Y	X^Y	~(X)
0	0	0	0	0	1
0	1	0	1	1	1
1	0	0	1	1	0
1	1	1	1	0	0



Data

- What is data?
  - It can be anything - a number, a character, a set, an image, etc.
  - A **meaningful data** is an information
- For a computer
  - At the smallest, it is a bit
  - Predefined interpretation of collection of bits constitutes different data types
- Basic types of data
  - Integer
  - Real numbers
  - Alphabets
  - Special symbols
  - … anything else?

Programming and Software

Computer needs to be programmed to do tasks

- **Programming** is the process of writing instructions in a language that can be understood by the computer so that a desired task can be performed by it
- **Program**: sequence of instructions to do a task, computer processes the instructions sequentially one after the other
- **Software**: programs for doing tasks on computers

Computers understand machine language (set of instructions) which are different strings of 0s and 1s only

- They are hard to remember
- So, names are given to these instructions e.g. ADD, START,COPY, etc.

Machine Language and Programming

Instruction Set

- **Start**
- **Read M**
- **Write M**
- **Load Data, M**
- **Copy M1, M2**
- **Add M1, M2, M3**
- **Sub M1, M2, M3**
- **Compare M1, M2, M3**
- **Jump L**
- **J_Zero M, L**
- **Halt**

Program

```
0: Start
1: Load 33, 10
2: Load 24, 11
3: Add 10, 11, 12
4: Halt
```

Problems with Programming using Instruction Set

- Different CPU can have different instruction sets
  - Need to write same code multiple times
- They are, still, hard to remember
- Solution: *High level programming languages* e.g. C, C++, Java, etc.
  - Does not depend on CPU
  - There is a **compiler** that converts the high level language to low level machine language that computers can understand

Programming Levels

High-Level Program

```
Variables x, y;
Begin
Read (x);
Read (y);
If (x = y) then Write (x)
           else  Write (y);
End.
```

Low-Level Program

```
0: Start
1: Compare 20, 21, 22
2: J_Zero 22, 5
3: Write 20
4: Jump 6
5: Write 21
6: Halt
```

Steps of Programming

- **Step 1**: Write the program in a high-level language
  - In your case, **C**
- **Step 2**: Compile the program using a compiler
  - C compiler - **gcc**
- **Step 3**: Run the program
  - i.e. ask the computer to execute it

So, Let Us C

- Make sure you have a laptop with you
  - Or else, you are paired with a friend who has one.
- You need to have a C compiler installed in your computer
  - I prefer **gcc** - The GNU Compiler Collection
  - You can find “how to install gcc” tutorials all over the internet for your operating system
- To write a code
  - You will need any text editor
  - You may choose one with syntax highlighting e.g. sublime text(mac), notepad++(windows), gedit(linux), vi, emacs, … there are many
- To compile a code
  - You need to open a terminal and execute the following: gcc <filename>.c
  - <filename> is basically the name you have given to your text file
  - The .c extension is optional,but you **should always** use it while naming a c file

Anatomy of Programming

- You have a problem to solve
  - You take steps to solve the problem
- What are these steps, really?
  - Represent the problem formally
  - Take a decision
    - Some tasks based on the decision
    - Evaluate outcomes
  - Repeat until problem is solved.

The Customary First C Code

- The preprocessor
- A function definition
- *Start of the function*
- *A comment*
- *A function call*
- *A return value*
- *End of the function*

```c
#include <stdio.h>


int main (void)
{
    /* my first program in C */
    printf ("Hello, World! \n");
    return 0;
}
```

```c
#include <stdio.h>

int main()
{
    /* my first program in C */
    printf("Hello, ");
    printf("World! \n");
    return 0;
}
```

```c
#include <stdio.h>

int main()
{
    int a;
    a = 10;
    printf (“%d\n”, a);
    return 0;
}
```

```c
#include <stdio.h>

int main()
{
    int a, b;
    a = 10;
    b = 20;
    printf (“%d %d\n”, a, b);
    return 0;
}
```

```c
#include <stdio.h>

int main()
{
     int a = 10, b = 20, x;
     printf (“a = %d, b = %d\n”, a, b);

     if (a > b)
     {
         x = a;
     }
     else
     {
         x = b;
     }
     printf (“The larger value is %d\n”, x);
     return 0;
}
```

```c
#include<stdio.h>

int main()
{
        float c, f;
        f = 212;
        c = 5 * (f - 32) / 9;
        printf ("Fahrenheit %f : Celsius value is %f \n", f, c);
}
```

```c
#include<stdio.h>

int main()
{
        float c, f;
        scanf ("%f", &f); //take a keyboard input
        c = 5 * (f - 32) / 9;
        printf ("Fahrenheit %f : Celsius value is %f \n", f, c);
}
```

Structure of a C Program

- They are a collection of functions
- Exactly one special function called “main” which must be present
- Each function has statements
  - e.g. declaration, assignment, condition check, looping
  - Statements are executed one by one

The C Character Set

- A-Z
- a-z
- 0-9
- Special Characters

  ! # % ^ & * ( ) - _ + = ~ [ ] \ | ; : ‘ “ { } , . < > / ? blank

  A C program should not contain anything else.

Things One Might Use in C Programming

- Variables
- Constants
- Expressions
  - Arithmetic, Logical, Assignment
- Statements
  - Declaration, Assignment,
  - Control Structures - conditional branching, looping
- Arrays
- Pointers
- Functions
- Structures

Variables

- Very important concept for programming
- An entity that has a value and is known to the program by a name
- Can store any temporary result while executing a program
- Can have only one value assigned to it at any given time during the execution of the program
- The value of a variable can be changed during the execution of the program

Variables (contd.)

- Variables stored in memory
- Remember that memory is a list of storage locations, each having a unique address
- A variable is like a bin
  - The contents of the bin is the value of the variable
  - The variable name is used to refer to the value of the variable
  - A variable is mapped to a location of the memory, called its address

Constants (Read-only variables)

- Sometimes you need to have some values that remain the same throughout a program
  - e.g. universal constants, limits, ranges of data, etc.
- In that case you can use a constant type indicator to enforce that property
- Prevents accidental change of the value

Data Types of Variables or Constants

- Each variable has a type,
  - It indicates what type of values the variable can hold
- Four common data types in C
  - int - can store integers (usually 4 bytes)
  - float - can store floating point numbers (usually 4 bytes)
  - double - can store floating point numbers (usually 8 bytes)
  - char - can store a character (1 byte)
- A keyword called const is used to declare a read-only variable

Variable Declaration

- Must declare a variable (specify its type and name) before using it anywhere in your program
- All variable declarations should be at the beginning of the main() or other functions
- A value can also be assigned to a variable at the time the variable is declared.
  - int speed = 30;
  - char flag = ‘y’;

Variable Naming

- Sequence of letters and digits
- First character must be a letter or ‘_’ No special characters other than ‘_’
- No blank in between
- Names are case-sensitive (max and Max are two different names)
- Examples of valid names:
  - i rank1 MAX max Min _abc class_rank
- Examples of invalid names:
  - a’s fact rec 2sqroot class,rank

C Keywords

- Used by the C language, cannot be used as variable names
- Examples:
  - int, float, char, double, main, if else, for, while. do, struct, union, typedef, enum, void, return, signed, unsigned, case, break, sizeof, ...
  - There are others, see textbook

In The Next Class…

- You will learn more about printf and scanf functions
- You will learn more about operators
  - Logical operators
  - arithmetic operators
  - Special operators
- You will learn about expressions
- You will learn more about control structures
  - Conditional branching
  - Looping
- You will be introduced to pointers and array