Principles of Programming

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Outline

- Syllabus
- First Program

Focus of the Course

- This is an intro to problem solving and programming class (that uses the C programming language)

- The focus is on
  - problem solving
  - the logic of programming
  - program design, implementation, and testing
  - the fundamentals of programming

Warnings

- Learning how to program takes a lot of time!
- It also requires a lot of patience.
- You cannot learn how to program by just reading the textbook. You have to spend long hours in front of the computer.
- If you want to learn how to program well you will have to take at least 2-3 other programming classes as well. This class alone is not enough!

- This class is not exclusively about writing code. It also emphasizes Problem Solving.

First Program

The C Programming Language

- A *programming language* specifies the words and symbols that we can use to write a program.
- A programming language employs a set of rules that dictate how the words and symbols can be put together to form valid *program statements.*

Note: The computer will always do what you tell it to do: not what you want it to do.

Reserved Words in C

auto break case chart const continue

default do double else enum extern

float for goto if int long register

return short signed sizeof static

struct switch typedef union

unsigned void volatile while

C Program Structure

```
#include <stdio.h>
main()
{
    //  comments about the program

    printf(“Hello World! \n”);


}
```

C Program Structure

```
#include <stdio.h>
main()
{




}
```

All programs must have a main function

C Program Structure

```
#include <stdio.h>
main()
{



}
```

main function body

Comments can be placed almost anywhere

Comments

- Comments in a program are called *inline documentation*
- They should be included to explain the purpose of the program and describe processing steps
- They do not affect how a program works
- C comments can take two forms:

```
// this comment runs to the end of the line

/*  this comment runs to the terminating
    symbol, even across line breaks        */
```

White Space

- **Spaces, blank lines, and tabs are called *white space***
- **White space is used to separate words and symbols in a program**
- **Extra white space is ignored**
- **A valid C program can be formatted many ways**
- **Programs should be formatted to enhance readability, using consistent indentation**

Identifiers

- *Identifiers* are the words a programmer uses in a program
- An identifier can be made up of letters, digits, the underscore character (`_`), and the dollar sign
- Identifiers cannot begin with a digit
- C is *case sensitive* - `Total`, `total`, and `TOTAL` are different identifiers

Hardware and Software

- **Hardware**
  - **the physical, tangible parts of a computer**
  - **keyboard, monitor, disks, wires, chips, etc.**
- **Software**
  - **programs and data**
  - **a *program* is a series of instructions**
- **A computer requires both hardware and software**
- **Each is essentially useless without the other**

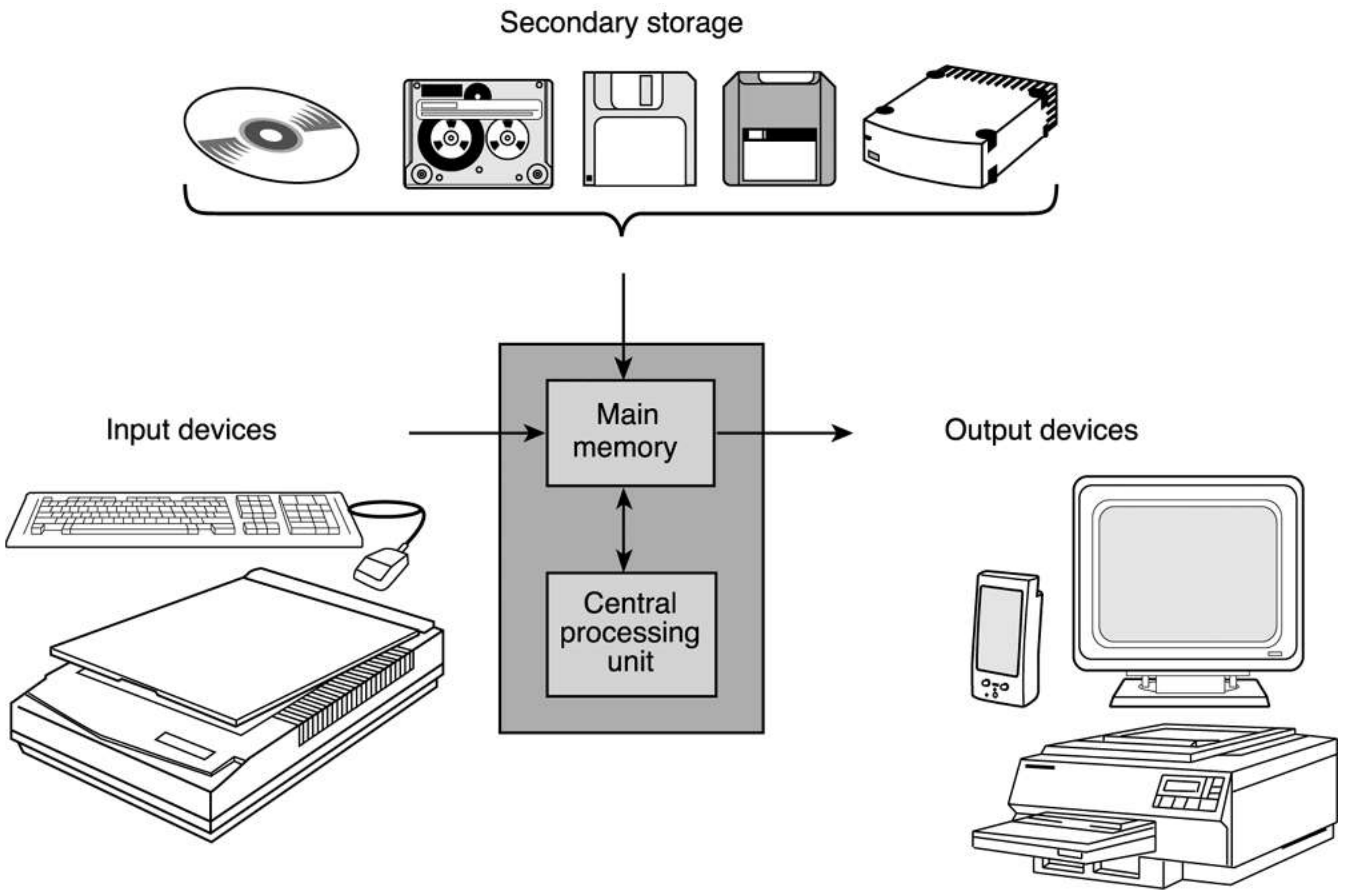
Software Categories

- **Operating System**
  - **controls all machine activities**
  - **provides the user interface to the computer**
  - **manages resources such as the CPU and memory**
  - **Windows XP, Unix, Linux, Mac OS**
- **Application program**
  - **generic term for any other kind of software**
  - **word processors, missile control systems, games**
- **Most operating systems and application programs have a *graphical user interface* (GUI)**

A Computer Specification

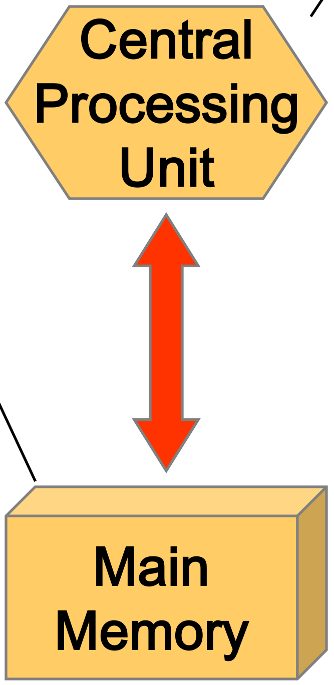
- Consider the following specification for a personal computer:
  - 2.8 GHz Pentium 4 Processor
  - 512 MB RAM
  - 80 GB Hard Disk
  - 48x CD-RW / DVD-ROM Combo Drive
  - 17” Video Display with 1280 x 1024 resolution
  - 56 Kb/s Modem
- What does it all mean?

Components of a Computer



[Figure 1.3 in the textbook]

CPU and Main Memory



Chip that executes program commands

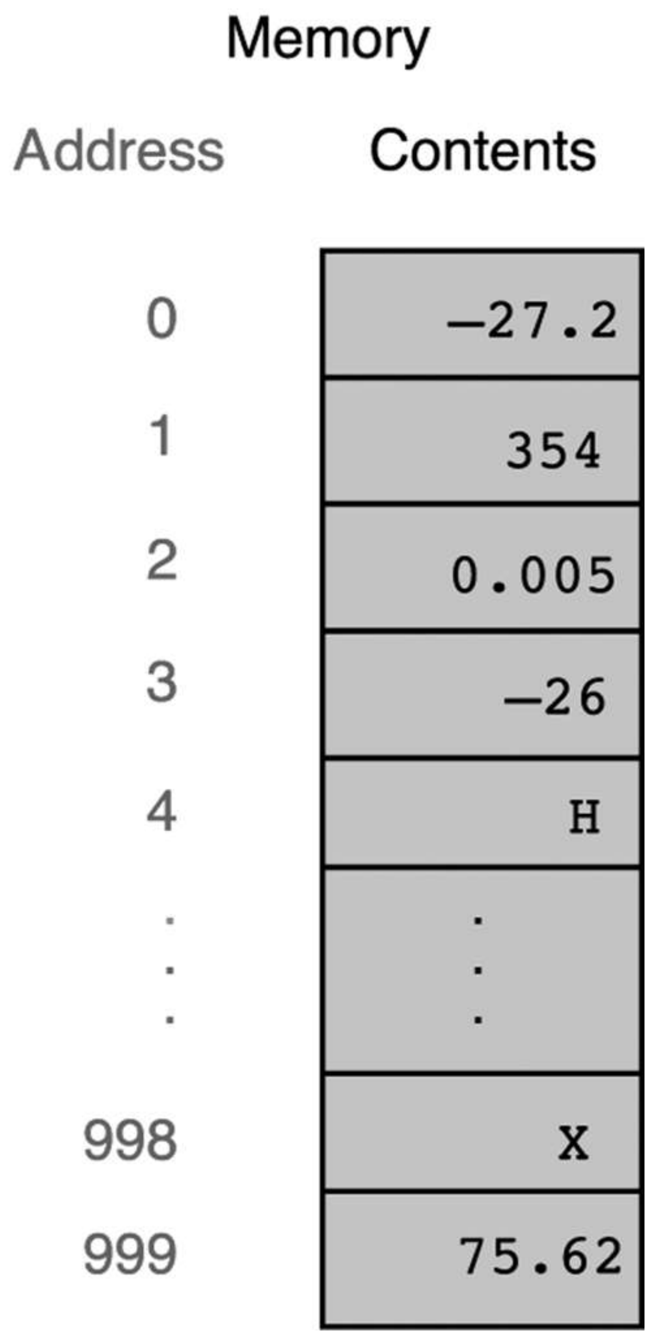
Intel Pentium 4
Sun ultraSPARC III

Primary storage area for programs and data that are in active use

Synonymous with RAM

RAM is volatile memory

Start-up instructions are burnt into ROM



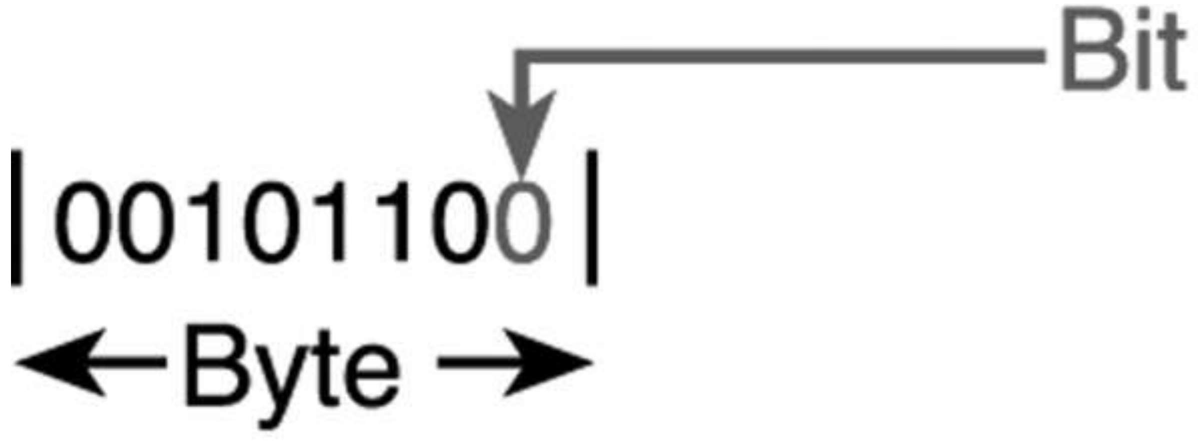
Most modern computers are byte-addressable

Memory Analogy

Memory Analogy

Memory Analogy

Relationship Between a Byte and a Bit

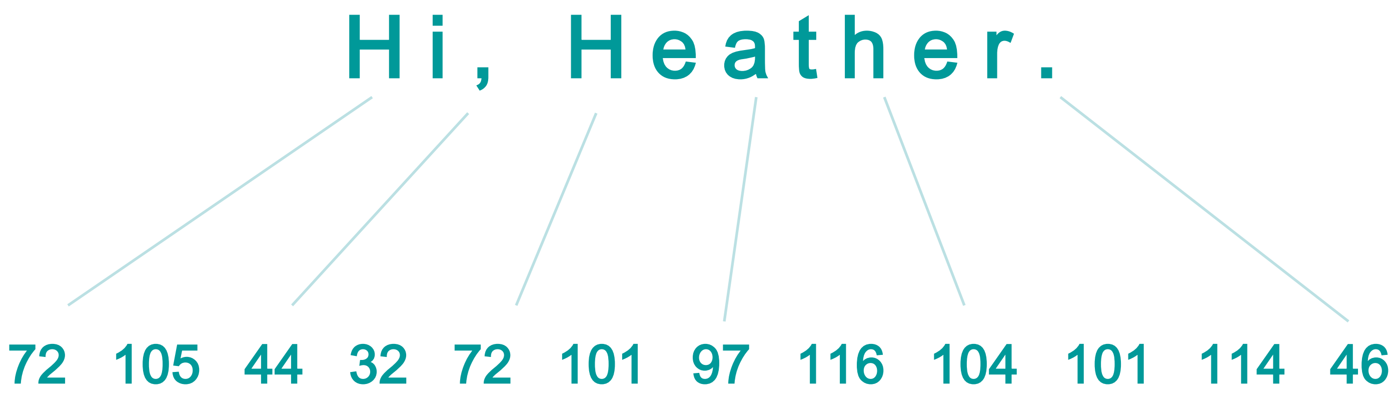


Digital Information

- **Computers store all information digitally:**
  - **numbers**
  - **text**
  - **graphics and images**
  - **video**
  - **audio**
  - **program instructions**
- **In some way, all information is *digitized* - broken down into pieces and represented as numbers**

Representing Text Digitally

- For example, every character is stored as a number, including spaces, digits, and punctuation
- Corresponding upper and lower case letters are separate characters



Binary Numbers

- **Once information is digitized, it is represented and stored in memory using the *binary number system***
- **A single binary digit (0 or 1) is called a *bit***
- **Devices that store and move information are cheaper and more reliable if they have to represent only two states**
- **A single bit can represent two possible states, like a light bulb that is either on (1) or off (0)**
- **Permutations of bits are used to store values**

Bit Permutations

1 bit	2 bits	3 bits	4 bits	
0	00	000	0000	1000
1	01	001	0001	1001
	10	010	0010	1010
	11	011	0011	1011
		100	0100	1100
		101	0101	1101
		110	0110	1110
		111	0111	1111

Each additional bit doubles the number of possible permutations

Bit Permutations

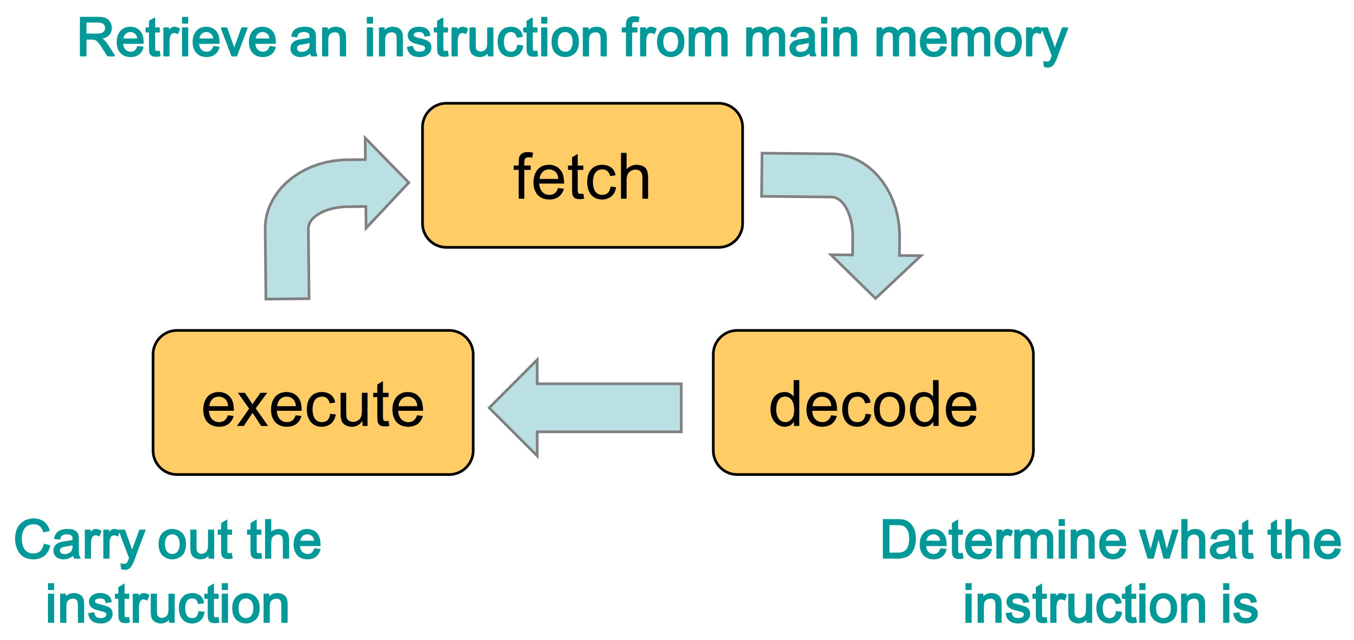
- Each permutation can represent a particular item
- There are 2^N permutations of N bits
- Therefore, N bits are needed to represent 2^N unique items

How many items can be represented by

1 bit ?	$2^1 = 2$ items
2 bits ?	$2^2 = 4$ items
3 bits ?	$2^3 = 8$ items
4 bits ?	$2^4 = 16$ items
5 bits ?	$2^5 = 32$ items

The Central Processing Unit

- A CPU is on a chip called a *microprocessor*
- It continuously follows the *fetch-decode-execute cycle:*

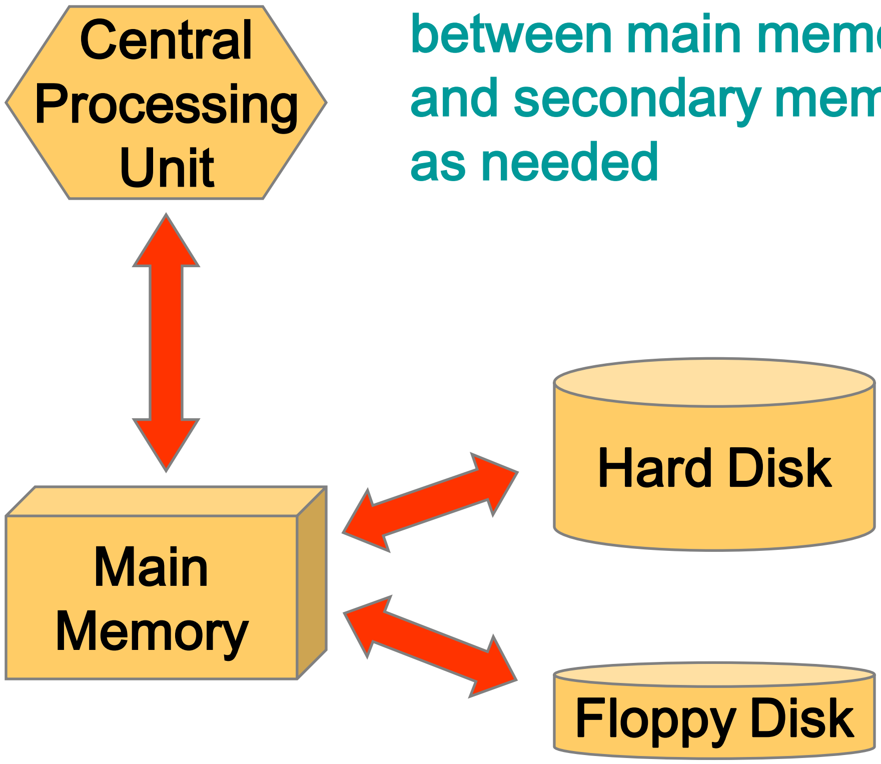

Retrieve an instruction from main memory
fetch
decode
execute
Carry out the instruction
Determine what the instruction is

Secondary Memory Devices

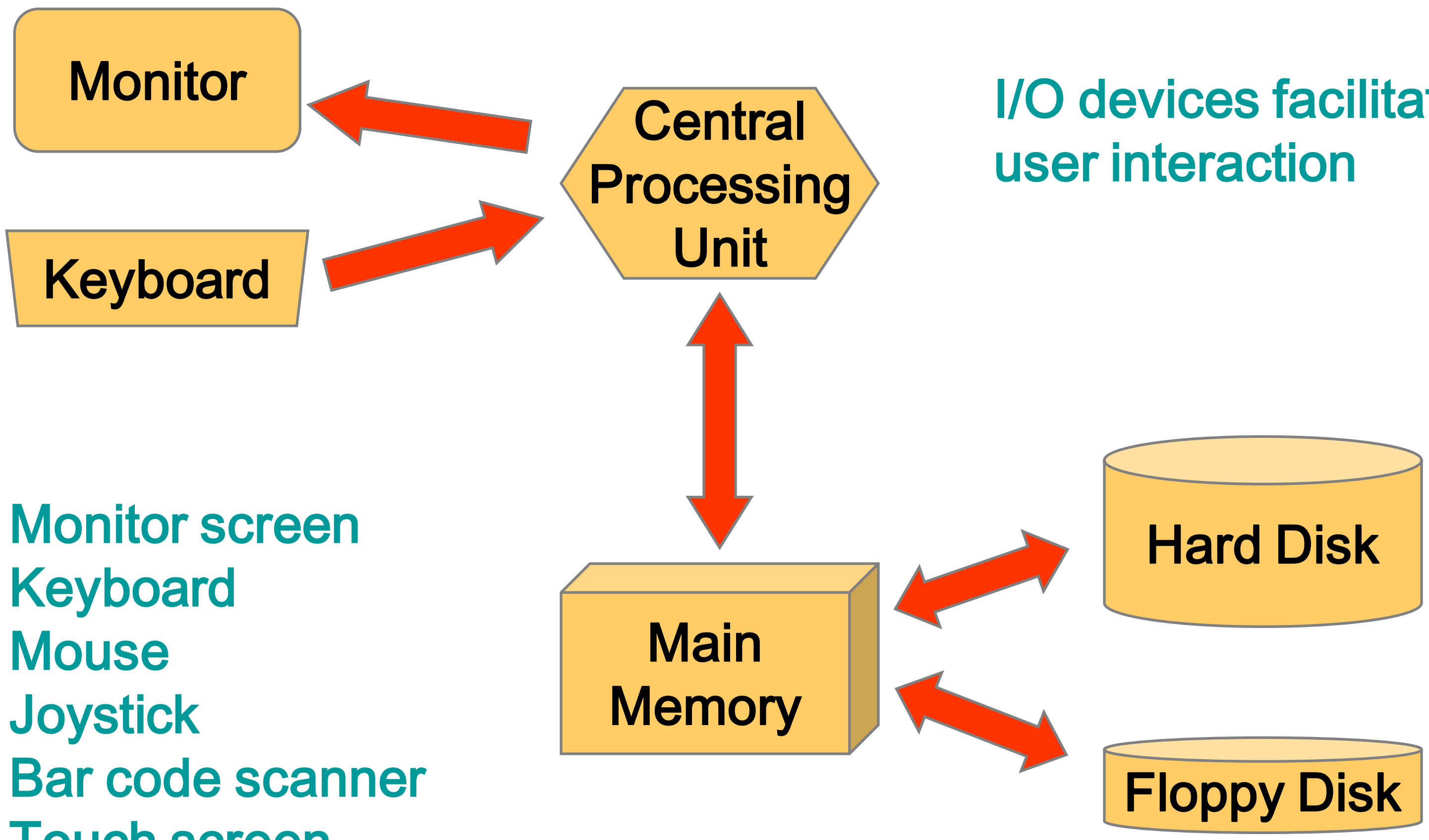
Secondary memory devices provide long-term storage

Information is moved between main memory and secondary memory as needed

Hard disks
Floppy disks
ZIP disks
Writable CDs
Writable DVDs
Tapes



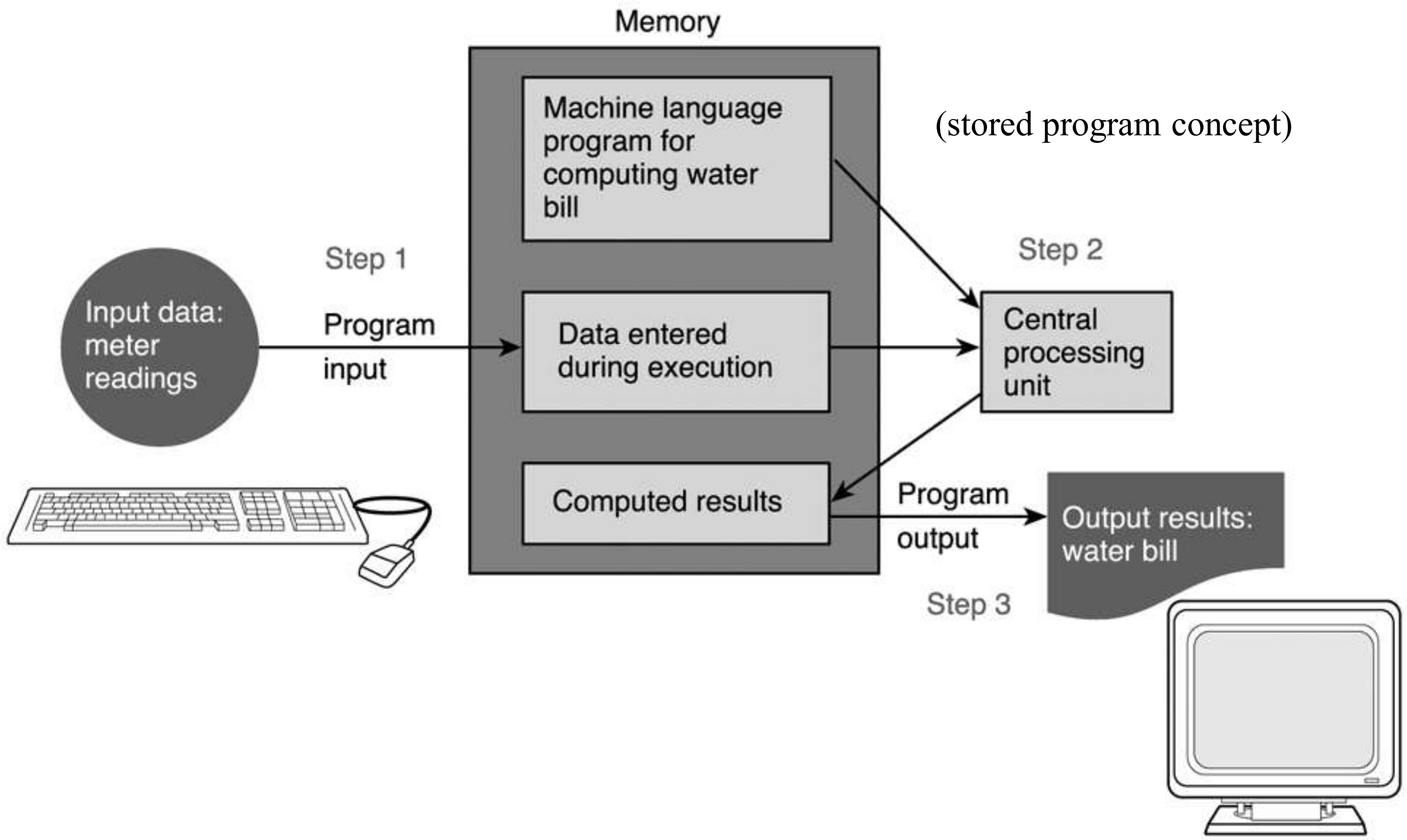
Input / Output Devices



I/O devices facilitate user interaction

Monitor screen
Keyboard
Mouse
Joystick
Bar code scanner
Touch screen

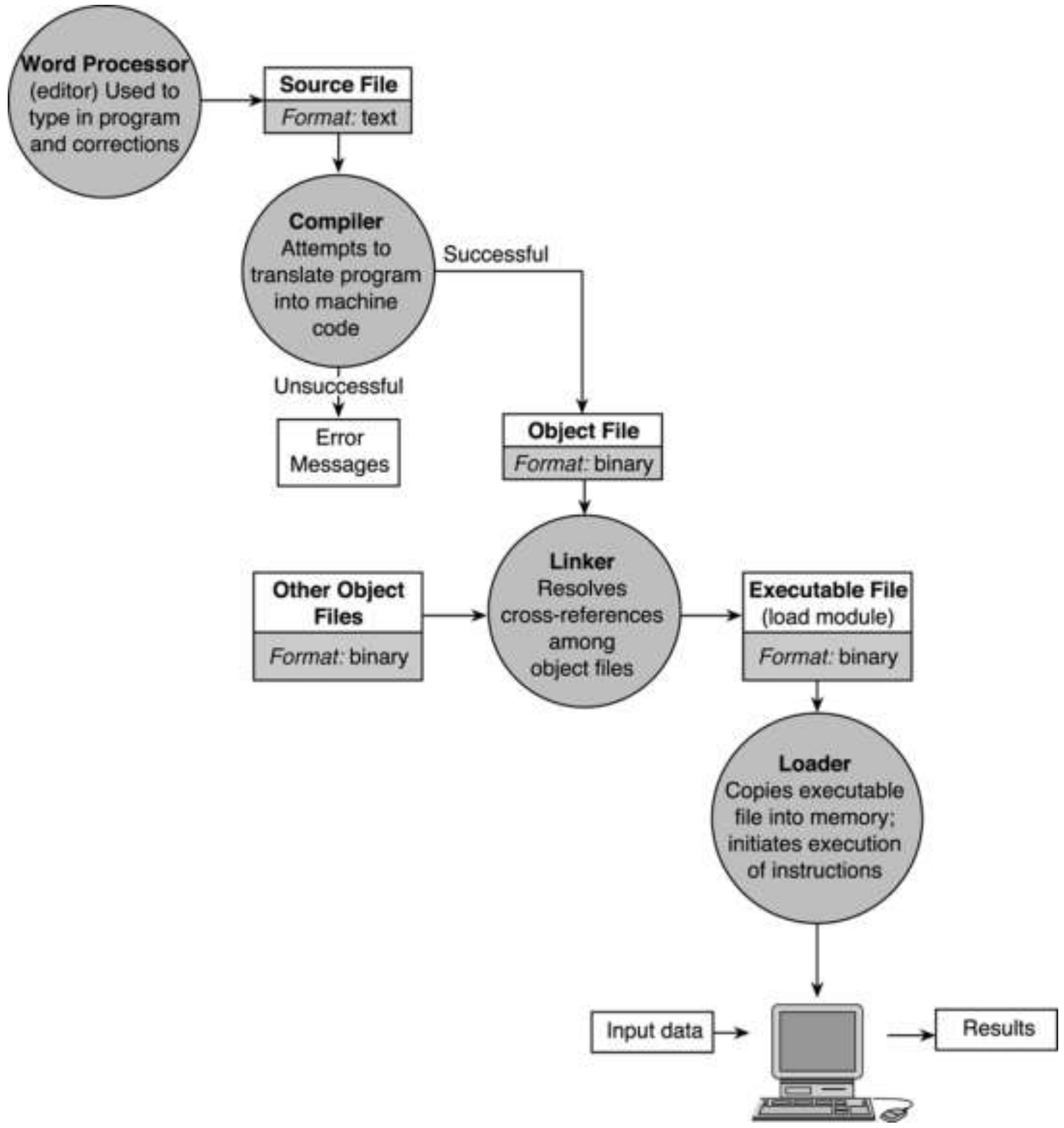
Flow of Information During Program Execution


Memory
Machine language program for computing water bill
(stored program concept)
Step 1
Program input
Input data: meter readings
Data entered during execution
Step 2
Central processing unit
Computed results
Program output
Output results: water bill
Step 3

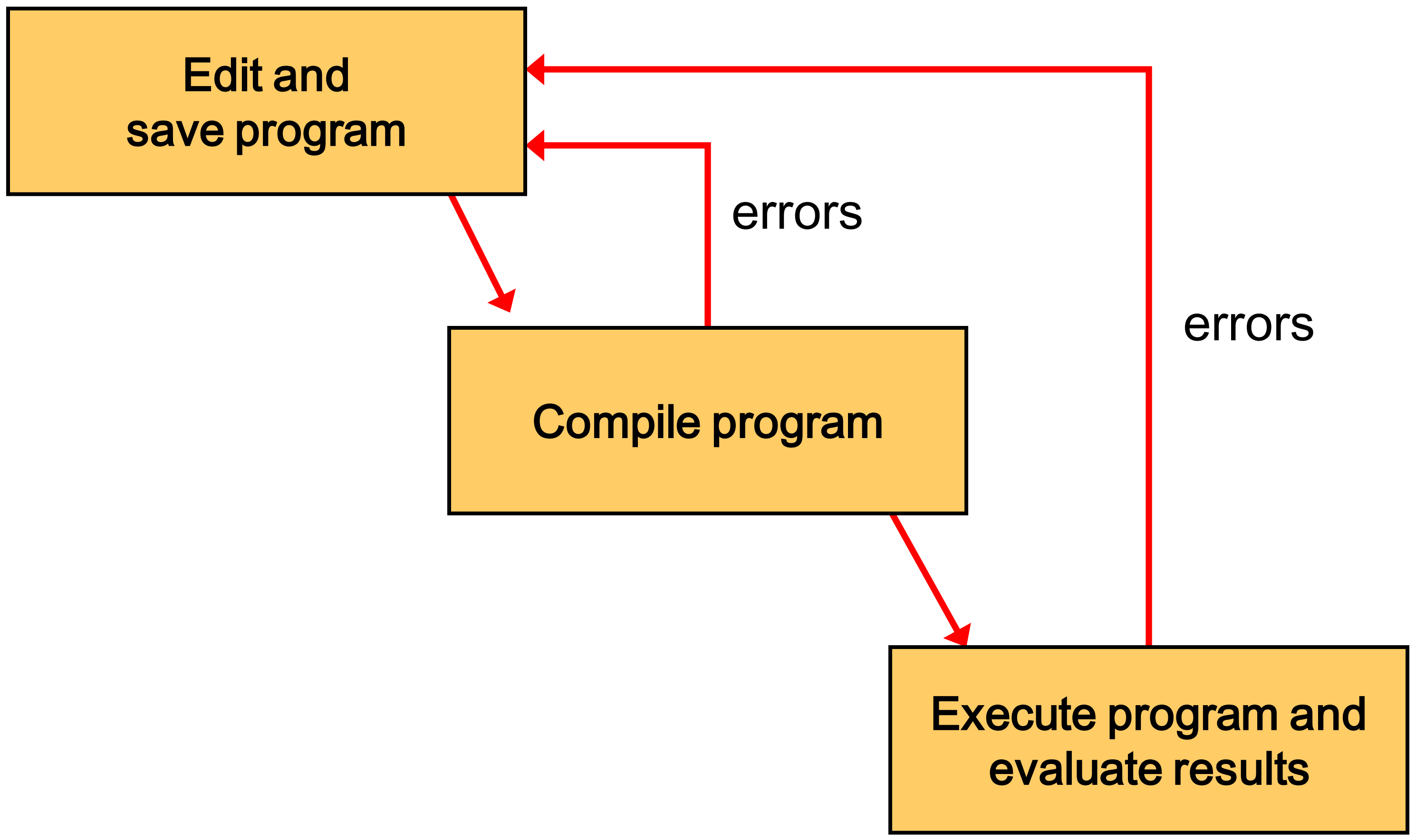
Program Development

- The mechanics of developing a program include several activities
  - writing the program in a specific programming language
  - translating the program into a form that the computer can execute
  - investigating and fixing various types of errors that can occur
- Software tools can be used to help with all parts of this process

Entering, Translating, and Running a High-Level Language Program


Word Processor (editor) Used to type in program and corrections
Source File
Format: text
Compiler Attempts to translate program into machine code
Successful
Unsuccessful
Error Messages
Object File
Format: binary
Other Object Files
Format: binary
Linker Resolves cross-references among object files
Executable File (load module)
Format: binary
Loader Copies executable file into memory; initiates execution of instructions
Input data
Results

Basic Program Development



Errors (a.k.a., bugs)

- **A program can have three types of errors**
- **The compiler will find syntax errors and other basic problems (*compile-time errors*)**
    - **If compile-time errors exist, an executable version of the program is not created**
- **A problem can occur during program execution, such as trying to divide by zero, which causes a program to terminate abnormally (*run-time errors*)**
- **A program may run, but produce incorrect results, perhaps using an incorrect formula (*logical errors*)**

Programming Languages

- **Each type of CPU executes only a particular *machine language***
- **A program must be translated into machine language before it can be executed**
- **A *compiler* is a software tool which translates *source code* into a specific target language**
- **Often, that target language is the machine language for a particular CPU type**

Syntax and Semantics

- **The *syntax rules* of a language define how we can put together symbols, reserved words, and identifiers to make a valid program**

- **The *semantics* of a program statement define what that statement means (its purpose or role in a program)**

- **A program that is syntactically correct is not necessarily logically (semantically) correct**

- **A program will always do what we tell it to do, not what we <u>meant</u> to tell it to do**