CC-112 Programming Fundamentals

Introduction to Computers

Nazar Khan
Department of Computer Science
University of the Punjab

Introduction

- Computers are hardware – physical objects that run on electricity.
  - keyboard
  - screen
  - mouse
  - hard disks
  - memory
  - CD/DVD drives
  - processing units
- They are controlled by software.
- We will learn how to command computers to perform actions and make decisions.

Hardware

- Computers perform calculations and make logical decisions phenomenally faster than human beings.
- Billions of calculations/second – more than a human can perform in a lifetime.
- Supercomputers perform thousands of trillions instructions/second.
- Computing hardware keeps getting faster and cheaper.
- Moore's law: In about every two years, computers become twice as better – inexpensively.

Computer Organization

- Any computer can be divided into 6 logical units.
  1. Input unit
  2. Output unit
  3. Memory unit
  4. Arithmetic and logic unit (ALU)
  5. Central processing unit (CPU)
  6. Secondary storage unit

Input unit

- Keyboards, touch screens and mouse devices.
- Voice commands, scanning images, barcodes and QRcodes.
- Reading from storage devices such as hard drives, DVD drives, and USB flash drives.
- Video from a webcam or YouTube.
- An e-book or PDF from the Internet.
- Position data from GPS device, and motion and orientation information from an accelerometer.

Output unit

- Screens (including touch screens).
- Printers.
- Audio/video on PC or giant screens.
- Internet messages.
- Control of other devices, such as robots and “intelligent” appliances.
- Secondary storage devices – hard drives, DVD drives and USB flash drives.
- Smart-phone and game controller vibration.
- Virtual reality devices like Oculus Rift.

Memory unit

- Stores information that is immediately available for processing.
- Also stores processed information until it can be placed on output device.
- Volatile information – typically lost when the computer's power is turned off.
- Often called memory, primary memory or RAM (Random Access Memory).
- Most commonly 2 to 16 GB. GB stands for gigabytes – a gigabyte is approximately one billion bytes. A byte is eight bits. A bit is either a 0 or a 1.

Arithmetic and logic unit (ALU)

- Performs calculations, such as addition, subtraction, multiplication and division.
- Also makes decisions such as less than, greater than, etc.

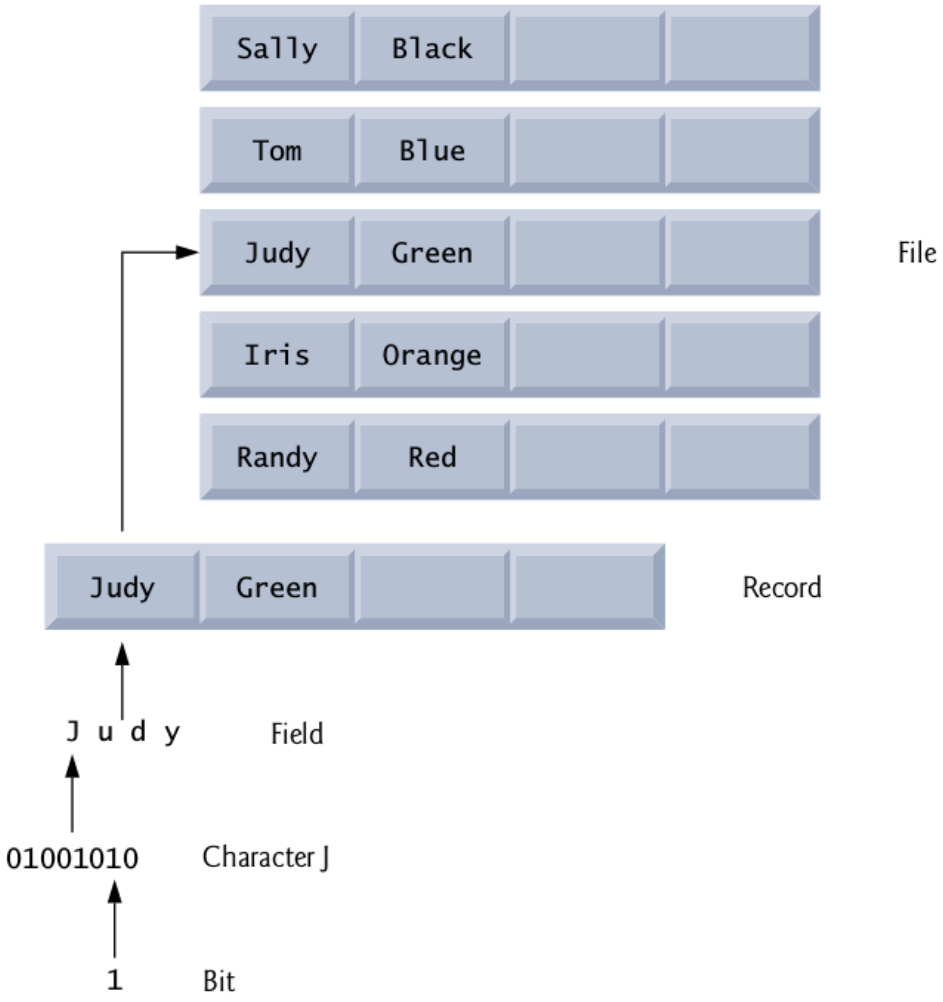
Central processing unit (CPU)

- Coordinates and supervises the operation of the other units.
- Tells the input unit when information should be read into the memory unit.
- Tells the ALU when information from the memory unit should be used in calculations.
- Tells the output unit when to send information from the memory unit to certain output devices.
- Many computers have multiple CPUs and, hence, can perform many operations simultaneously.
- A multi-core processor implements multiple processors on a single integrated-circuit chip
  - a dual-core processor has two CPUs and a quad-core processor has four CPUs.
- Today's desktop computers have processors that can execute billions of instructions per second.

Secondary storage unit

- To store programs or data not actively being used by other units until they're again needed, possibly hours, days, months or even years later.
- Persistent information – preserved even when the computer's power is turned off.
- Takes much longer to access than information in primary memory, but its cost per unit is much less.
- Hard drives, DVD drives and USB flash drives, some of which can hold over 2 TB (TB stands for terabytes – a terabyte is approximately one trillion bytes).
- Typical hard drives on desktop and notebook computers hold up to 2 TB.

Data Hierarchy



Bits

- The smallest data item in a computer can assume the value 0 or the value 1.
- Called a bit (short for "binary digit" – a digit that can assume one of two values).
- Impressive functions performed by computers involve only the simplest manipulations of 0s and 1s – examining a bit's value, setting a bit's value and reversing a bit's value (from 1 to 0 or from 0 to 1).

Characters

- Tedious for people to work with data in the low-level form of bits.
- Easier to work with decimal digits (0–9), letters (A–Z and a–z), and special symbols (e.g., $, @, %, &, *, (,), –, +, ", :, ? and /).
- Digits, letters and special symbols are known as characters.
- A computer's character set is the set of all the characters used to write programs and represent data items.
- Computers process only 1s and 0s, so a computer's character set represents every character as a pattern of 1s and 0s.
- Unicode character set is composed of characters containing one, two or four bytes (8, 16 or 32 bits).
- Unicode contains characters for many of the world's languages.
- ASCII (American Standard Code for Information Interchange) character set is a popular subset of Unicode that represents uppercase and lowercase letters, digits and some common special characters.

Fields

- Just as characters are composed of bits, fields are composed of characters or bytes.
- A field is a group of characters or bytes that conveys meaning. For example,
  - a field consisting of uppercase and lowercase letters can be used to represent a person's name, and
  - a field consisting of decimal digits could represent a person's age.

Records

- Several related fields can be used to compose a record.
- Record for an employee might consist of the following fields
  - Employee identification number (a whole number)
  - Name (a string of characters)
  - Address (a string of characters)
  - Hourly pay rate (a number with a decimal point)
  - Year-to-date earnings (a number with a decimal point)
  - Amount of taxes withheld (a number with a decimal point)
- Thus, a record is a group of related fields.

Files

- A file is a group of related records.
- More generally, a file contains arbitrary data in arbitrary formats.
- In some operating systems, a file is viewed simply as a sequence of bytes – any organization of the bytes in a file, such as organizing the data into records, is a *view* created by the application programmer.
- It's not unusual for an organization to have many files, some containing billions, or even trillions, of characters of information.

Machine, Assembly and High-Level Languages

- Programmers write instructions in various programming languages.
- Some are directly understandable by computers and others require intermediate translation steps.
- Hundreds of such languages are in use today. These may be divided into three general types:
  1. Machine languages
  2. Assembly languages
  3. High-level languages

Machine Languages

- Any computer can directly understand only its own machine language, defined by its hardware design.
- Machine languages generally consist of strings of numbers (ultimately reduced to 1s and 0s) that instruct computers to perform their most elementary operations one at a time.
- Machine languages are machine dependent (a particular machine language can be used on only one type of computer).
- Such languages are hard to understand for humans.
- For example, an early machine-language payroll program that adds overtime pay to base pay and stores the result in total pay:
  +1300042774
  +1400593419
  +1200274027

Assembly Languages and Assemblers

- Programming in machine language was simply too slow and tedious for most programmers.
- Instead of using the strings of numbers that computers could directly understand, programmers began using English-like abbreviations to represent elementary operations.
- These abbreviations formed the basis of assembly languages.
- Translator programs called assemblers were developed to convert early assembly-language programs to machine language at computer speeds.
- Assembly-language program that adds overtime pay to base pay and stores the result in total pay:
  load basepay
  add overpay
  store totalpay
- Although clearer to humans, it's incomprehensible to computers until translated to machine language.

High-Level Languages and Compilers

- With the advent of assembly languages, computer usage increased rapidly, but programmers still had to use numerous instructions to accomplish even the simplest tasks.
- To speed the programming process, high-level languages were developed in which single statements could be written to accomplish substantial tasks.
- Translator programs called compilers convert high-level language programs into machine language.
- High-level languages allow you to write instructions that look almost like everyday English and contain commonly used mathematical notations.
- High-level language might contain a single statement such as totalPay = basePay + overTimePay
- From programmer's standpoint, high-level languages are preferable to machine and assembly languages.
- C is one of the most widely used high-level programming languages.

Interpreters

- Compiling a large high-level language program into machine language can take considerable computer time.
- Interpreter programs, developed to execute high-level language programs directly, avoid the delay of compilation.
- However, interpreted programs run slower than compiled programs.