Chapter 1: Computer Systems

Presentation slides for

Java Software Solutions

Foundations of Program Design
Third Edition

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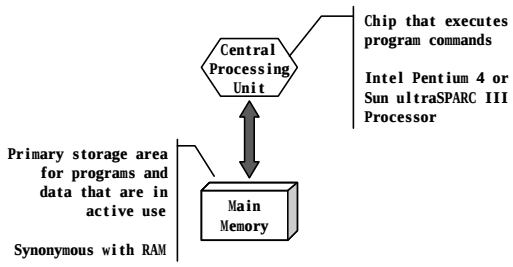
Computer Systems

- We first need to explore the fundamentals of computer processing
- Chapter 1 focuses on:
  - components of a computer
  - how those components interact
  - how computers store and manipulate information
  - computer networks
  - the Internet and the World Wide Web
  - programming and programming languages

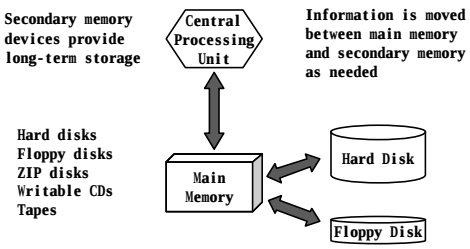
Hardware and Software

- 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

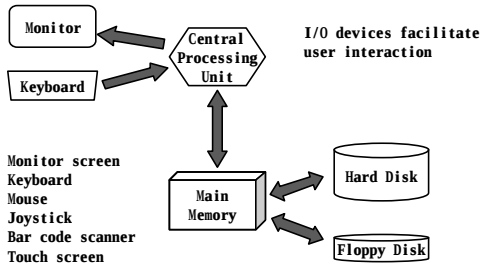
CPU and Main Memory



Secondary Memory Devices



Input / Output Devices



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, Windows 2000, 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)**

Analog vs. Digital

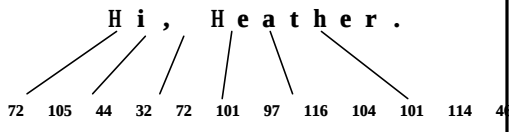
- **There are two basic ways to store and manage data:**
- ***Analog***
  - continuous, in direct proportion to the data represented
  - music on a record album - a needle rides on ridges in the grooves that are directly proportional to the voltages sent to the speaker
- ***Digital***
  - the information is broken down into pieces, and each piece is represented separately
  - music on a compact disc - the disc stores numbers representing specific voltage levels sampled at specific times

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 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

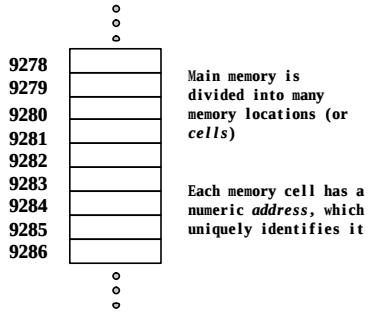
How many items can be represented by

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

A Computer Specification

- Consider the following specification for a personal computer:
  - 950 MHz Pentium 4 Processor
  - 512 MB RAM
  - 30 GB Hard Disk
  - CD-RW 24x / 10x / 40x
  - 17" Video Display with 1280 x 1024 resolution
  - 56 Kb/s Modem
- What does it all mean?

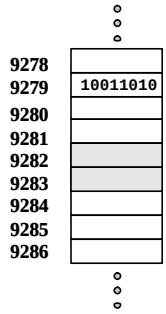
Memory



Main memory is divided into many memory locations (or *cells*)

Each memory cell has a numeric *address*, which uniquely identifies it

Storing Information



Each memory cell stores a set number of bits (usually 8 bits, or one *byte*)

Large values are stored in consecutive memory locations

Storage Capacity

- Every memory device has a *storage capacity*, indicating the number of bytes it can hold
- Capacities are expressed in various units:

Unit	Symbol	Number of Bytes
kilobyte	KB	2^{10} = 1024
megabyte	MB	2^{20} (over 1 million)
gigabyte	GB	2^{30} (over 1 billion)
terabyte	TB	2^{40} (over 1 trillion)

Memory

- Main memory is *volatile* - stored information is lost if the electric power is removed
- Secondary memory devices are *nonvolatile*
- Main memory and disks are *direct access* devices - information can be reached directly
- The terms *direct access* and *random access* often are used interchangeably
- A magnetic tape is a *sequential access* device since its data is arranged in a linear order - you must get by the intervening data in order to access other information

RAM vs. ROM

- *RAM* - Random Access Memory (direct access)
- *ROM* - Read-Only Memory
- The terms RAM and main memory are basically interchangeable
- ROM could be a set of memory chips, or a separate device, such as a CD ROM
- Both RAM and ROM are random (direct) access devices!
- RAM probably should be called Read-Write Memory

Compact Discs

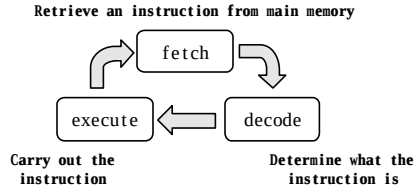
- A CD-ROM is portable read-only memory
- A microscopic pit on a CD represents a binary 1 and a smooth area represents a binary 0
- A low-intensity laser reflects strongly from a smooth area and weakly from a pit
- A CD-Recordable (CD-R) drive can be used to write information to a CD once
- A CD-Rewritable (CD-RW) can be erased and reused
- The speed of a CD drive describes how fast it can write information to a CD-R (24x), a CD-RW (10x), and how fast it can read (40x)

DVDs

- A DVD is the same size as a CD, but can store much more information
- The format of a DVD stores more bits per square inch
- A CD can store 650 MB, while a standard DVD can store 4.7 GB
  - A double sided DVD can store 9.4 GB
  - Other advanced techniques can bring the capacity up to 17.0 GB
- There are various recordable DVD technologies – the market will determine which will dominate

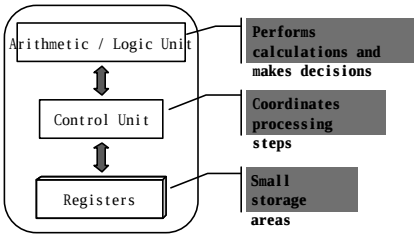
The Central Processing Unit

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



The Central Processing Unit

- The CPU contains:



The Central Processing Unit

- The speed of a CPU is controlled by the *system clock*
- The system clock generates an electronic pulse at regular intervals
- The pulses coordinate the activities of the CPU
- The speed is measured in *megahertz* (MHz)

Monitor

- The size of a monitor (17") is measured diagonally, like a television screen
- Most monitors these days have *multimedia* capabilities: text, graphics, video, etc.
- A monitor has a certain maximum *resolution* , indicating the number of picture elements, called *pixels*, that it can display (such as 1280 by 1024)
- High resolution (more pixels) produces sharper pictures

Modem

- *Data transfer devices* allow information to be sent and received between computers
- Many computers include a modulator-demodulator or *modem*, which allows information to be moved across a telephone line
- A data transfer device has a maximum *data transfer rate*
- A modem, for instance, may have a data transfer rate of 56,000 *bits per second* (bps)

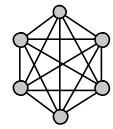
Networks

- A *network* is two or more computers that are connected so that data and resources can be shared
- Most computers are connected to some kind of network
- Each computer has its own *network address*, which uniquely identifies it among the others
- A *file server* is a network computer dedicated to storing programs and data that are shared among network users

Network Connections

- Each computer in a network could be directly connected to every other computer in the network
- These are called *point-to-point* connections

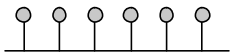
Adding a computer requires a new communication line for each computer already in the network



This technique is not practical for more than a few close machines

Network Connections

- Most networks share a single communication line
- Adding a new computer to the network is relatively easy

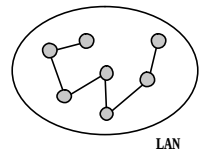


Network traffic must take turns using the line, which introduces delays

Often information is broken down in parts, called *packets*, which are sent to the receiving machine and then reassembled

Local-Area Networks

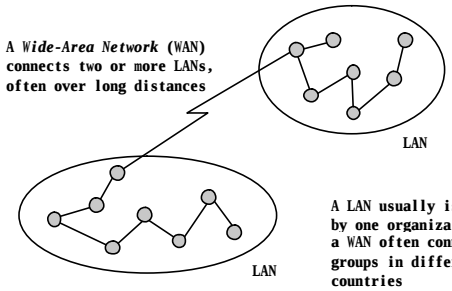
A *Local-Area Network* (LAN) covers a small distance and a small number of computers



LAN

A LAN often connects the machines in a single room or building

Wide-Area Networks



The Internet

- The *Internet* is a WAN which spans the entire planet
- The word Internet comes from the term *internetworking*, which implies communication among networks
- It started as a United States government project, sponsored by the Advanced Research Projects Agency (ARPA) - originally it was called the ARPANET
- The Internet grew quickly throughout the 1980s and 90s
- Less than 600 computers were connected to the Internet in 1983; by the year 2000 there were over 10 million

TCP/IP

- A protocol is a set of rules that determine how things communicate with each other
- The software which manages Internet communication follows a suite of protocols called *TCP/IP*
- The *Internet Protocol* (IP) determines the format of the information as it is transferred
- The *Transmission Control Protocol* (TCP) dictates how messages are reassembled and handles lost information

IP and Internet Addresses

- Each computer on the Internet has a unique *IP address*, such as:

  `139.179.21.213`

- Most computers also have a unique Internet name, which also is referred to as an *Internet address*:

  `gordion.cs.bilkent.edu.tr`

- The first part indicates a particular computer (`gordion`)
- The rest is the *domain name*, indicating the organization (`cs.bilkent.edu.tr`)

Domain Names

- The last part of each domain name, called a *top-level domain* (TLD) indicates the type of organization:

  edu - educational institution
  com - commercial entity
  org - non-profit organization
  net - network-based organization

Sometimes the suffix indicates the country:

tr - Turkey
uk - United Kingdom
au - Australia
ca - Canada

New TLDs have recently been added:

biz, info, tv, name

Domain Names

- A domain name can have several parts
- Unique domain names mean that multiple sites can have individual computers with the same local name
- When used, an Internet address is translated to an IP address by software called the *Domain Name System* (DNS)
- There is <u>no</u> one-to-one correspondence between the sections of an IP address and the sections of an Internet address

The World Wide Web

- The *World Wide Web* allows many different types of information to be accessed using a common interface
- A *browser* is a program which accesses and presents information
  - text, graphics, video, sound, audio, executable programs
- A Web document usually contains *links* to other Web documents, creating a *hypermedia* environment
- The term Web comes from the fact that information is not organized in a linear fashion

The World Wide Web

- Web documents are often defined using the *HyperText Markup Language* (HTML)
- Information on the Web is found using a *Uniform Resource Locator* (URL):

```
http://www.bilkent.edu.tr/information/student.html
http://www.google.com
ftp://java.sun.com/applets/animation.zip
```

- A URL indicates a protocol (http), a domain, and possibly specific documents

Problem Solving

- The purpose of writing a program is to solve a problem
- The general steps in problem solving are:
  - Understand the problem
  - Dissect the problem into manageable pieces
  - Design a solution
  - Consider alternatives to the solution and refine it
  - Implement the solution
  - Test the solution and fix any problems that exist

Problem Solving

- Many software projects fail because the developer didn't really understand the problem to be solved
- We must avoid assumptions and clarify ambiguities
- As problems and their solutions become larger, we must organize our development into manageable pieces
- This technique is fundamental to software development

Programming Languages

- 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*

Language Levels

- There are four programming language levels:
  - machine language
  - assembly language
  - high-level language
  - fourth-generation language
- Each type of CPU has its own specific *machine language*
- The other levels were created to make it easier for a human being to read and write programs

Basic High Level Languages

- Imperative Languages
  - Fortran, Algol, Cobol, Pascal, C, Ada
- Functional/ Logic Languages
  - Lisp, ML, Miranda, Schema
  - Prolog
- Object-oriented Languages
  - Smalltalk, C++, Java

Programming Languages

- A program must be translated into machine language before it can be executed on a particular type of CPU
- This can be accomplished in several ways
- 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

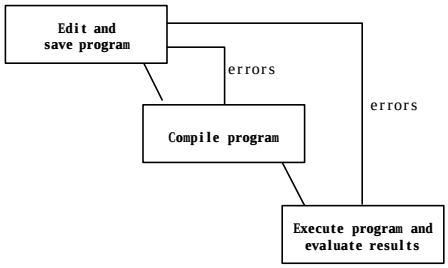
Syntax and Semantics

- 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 meant to tell it to do

Errors

- 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*)

Basic Program Development



Summary

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  - components of a computer
  - how those components interact
  - how computers store and manipulate information
  - computer networks
  - the Internet and the World Wide Web
  - programming and programming languages