CIS-350 INFRASTRUCTURE TECHNOLOGIES

COMPUTERS AND SYSTEMS – CHAPTER 1

Read thoroughly the Preface on pp. xix-xxiii, Part One on p. 2, An Overview of Computer Systems on p. 3, and Chapter 1 (sections 1.0-1.6) on pp. 5-35 (Englander).

Computer systems architecture is the subject of this course and the textbook.

Definition of the word architecture in the Webster's dictionary:

1. the art and science of designing and erecting buildings
2. architectural structures as a whole
3. a style and method of design and construction

Computer architecture (CA) is concerned with
1. the structure and operation of digital computers
2. the operational methods of the hardware
3. the services provided by operating systems software
4. the acquisition, processing, storage, and output of data
5. the interaction between computers

CA - relationship between hardware, software, data, and communication - these four elements make up a computer system.

The technology changes very rapidly. The question may arise: "Is it worth to study the architecture of computer systems?" May be, by the time you finish this course a new OS such as Windows 10 (evolved from Windows 7) will appear or new CA and communication protocols will be developed.

The computers are becoming faster and faster and have more computing power (Moore's Laws). Today, a PC or laptop is much more powerful than the first mainframe computers developed in 1960s. However, the basic concepts of the CA, OS, Networks, and Data Communications that really matter have changed little over the past several years. The new technologies are based on foundations of architectural concepts that were developed many years ago.

Ex.

- CA - 1940s (Von Neumann concept: binary system and stored program and stored data concept)
- OS - 1960s (multiprogramming, multitasking)
- GUI (Graphical User Interface) - 1970s, Xerox
- Communications techniques - 1970s
- Internet - 1970, uses protocols about 30 years old, FTP, TCP/IP
- Windows 7 is based on Windows Vista and Windows XP. The latter two, however, are conceptually based on the earlier versions of Windows; and Windows in turn is based on VAX/VMS (developed in 1970s by Cutler)
- The basic architecture of the IBM 360 - 1960 is very similar to the z10 EC IBM mainframe (Figure 1.10, p. 19)

Reasons to study CA and OS

1. Understanding of CA, OS, Networks, and Data Communications makes it possible to "ride the wave" of technological change and deal with new developments.
2. to understand the insides of the computer
3. to understand the jargon used (Figure 1.1, p.6)

   - Is the computer fast enough to run necessary programs?
   - Is the computer cost-effective?
   - Will it be obsolete in 6 months?

4. to make intelligent choices/decisions as a user, programmer, systems architect or system analyst, system administrator or manager, web services designer, or consultant

Programmers will be able to write programs that operate more efficiently. This will make their work more fruitful and rewarding. See p. 7 (textbook) for details.

System administrators may be asked to tune or modify the computer system to maximize its performance. Specifically, they may configure operating systems OS parameters, reconfigure networks, provide system security, and manage the entire system.

System architects will be responsible for the design and implementation of systems that meet an organization’s IT needs, recognizing that the differences in the cost and capabilities of the components that you select may have significant impact on the organization.

Web Services Designers will be able to optimize customer accessibility to Web services and optimize web system configurations. They will also know how to select appropriate data formats, page designs and scripting languages and design efficient Web pages.

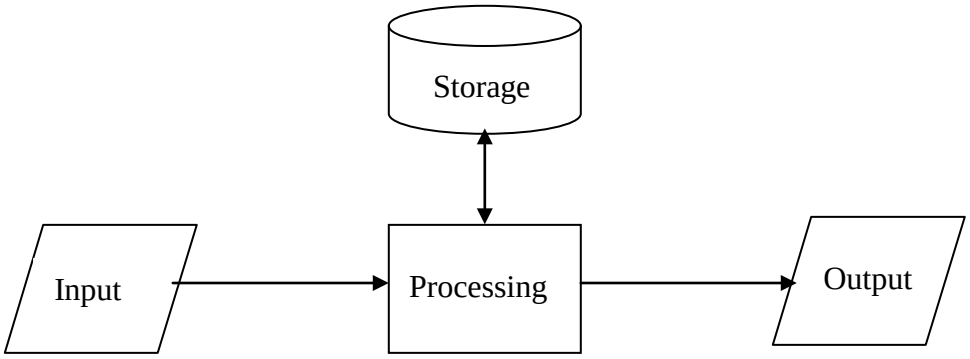
Users will understand better the capabilities, strengths, and limitations of the computer system.

5. curiosity

Input-Process-Output (IPO) Model (Figure 1.3, p. 10)

Computer processing always boils down to these three IPO operations no matter of the type of work to be performed by a computer. Ex. Adding two numbers or accessing a Web page on the Internet.

Input → Process → Output



Input - data and programs are input from the keyboard

Process - performing arithmetic and logical operations, sorting, searching

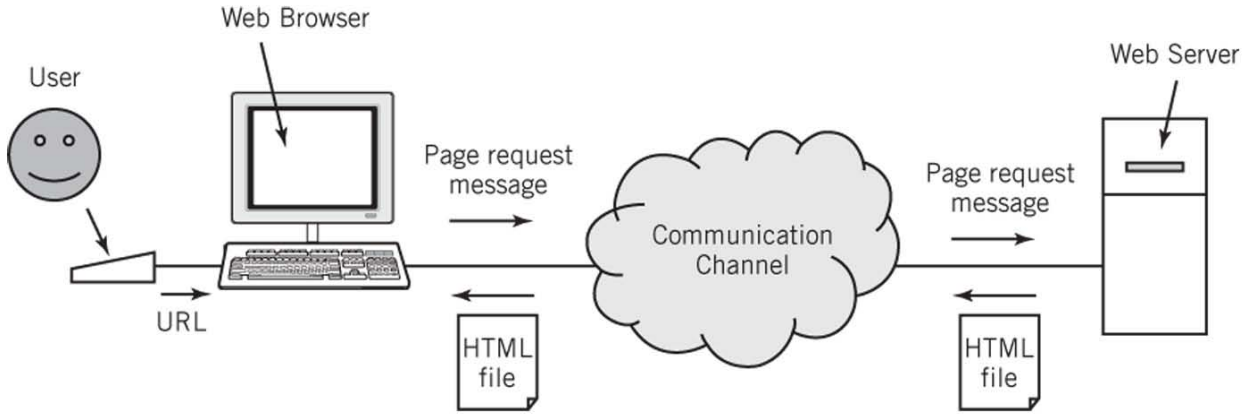
Output - the results of processing appear on the output device (screen, printer).

Storage - stores data and programs; could be interpreted as input and/or output
short-term storage – RAM: temporary
long-term storage – disk, tape, DVD-ROM, or thumb drive: permanent

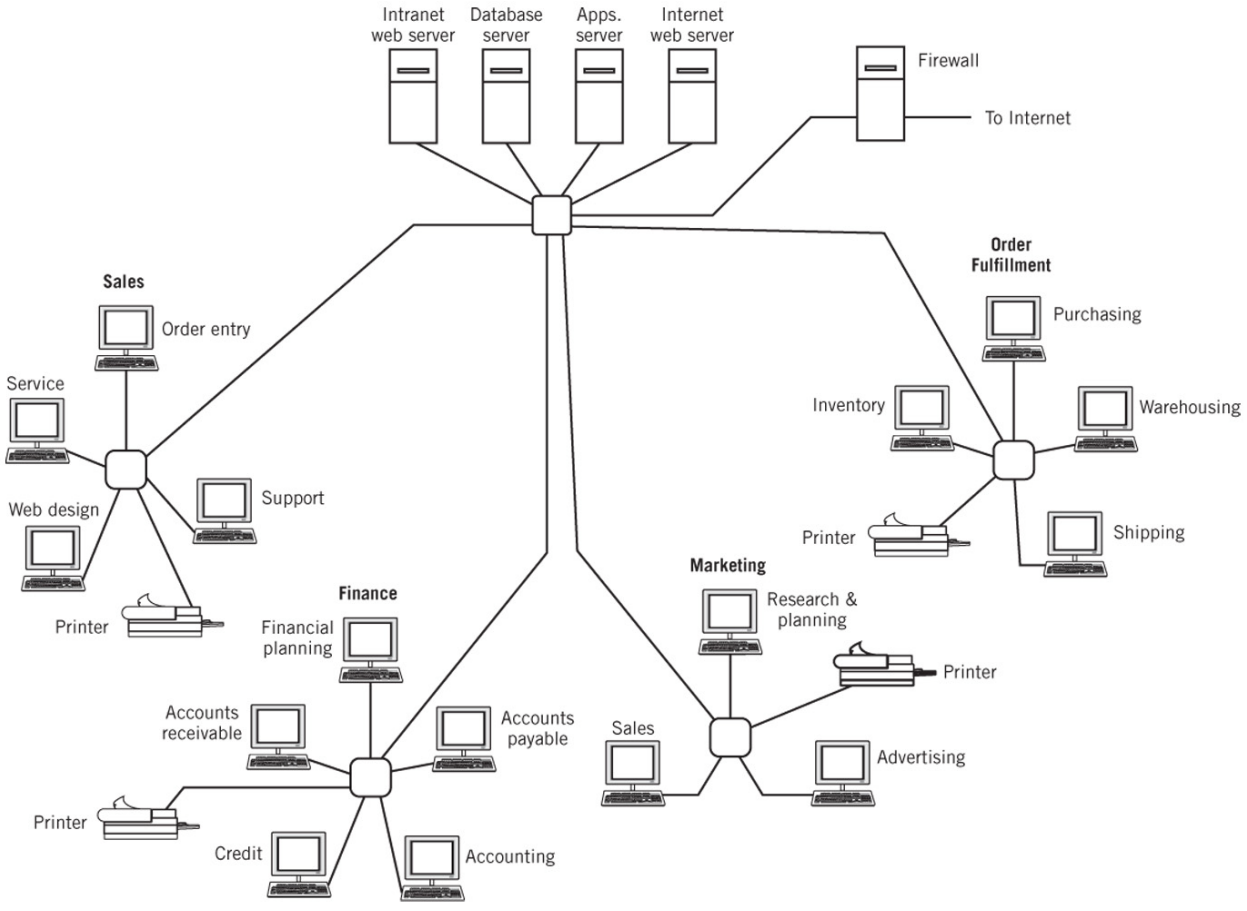
Ex. Program segment for adding two numbers in pseudocode

```
int a, b, c;        //declaration statement (C#)
read a, b;          //input
c=a+b;              //processing (C#)
write c;            //output
```

Ex. Accessing a Web page on the Internet (Fig. 1.3, p. 10)



A simple illustration of computer systems embedded in a larger IT system (Fig, 10.4, p.11).



Basic data processing operations and high-level language constructs used to implement these 3 basic operations (input, process, and output) are shown in Fig. 1.5 and Fig 1.6 (pp. 12-13), respectively.

Components of the computer system (hardware, software, data, and the communication component)

1. Hardware - physical components and devices, tangible part. Allow to input programs and data, process them, store, and output the results.

2. Software - both application software and system software (operating system). The computer software tells the hardware what tasks are to be performed and in what order. Tasks involve instructions to execute and data to manipulate.

3. Data - in a numeric, character, graphic, sound form or other form

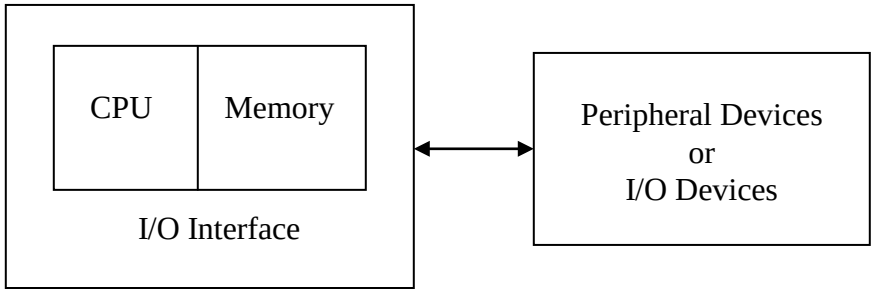
4. The communication component - consists of hardware and software that transport programs and data between interconnected computer systems

Hardware and OS make up the architecture of the computer system. The communication component connects individual computer systems together. The data and application software are supplied by the user.

The Hardware Component

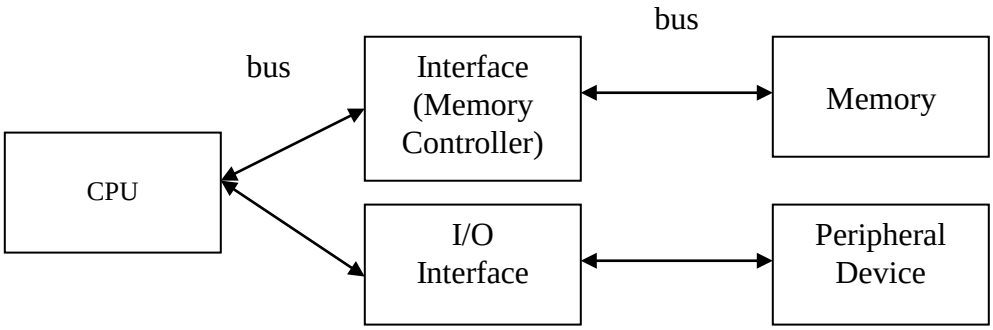
1. CPU (Central Processing Unit)
2. Memory (holds programs and data)
3. I/O devices (peripheral devices) allow one to input data and programs, store them, and output the results (Fig. 1.8, p. 15).

A typical hardware block diagram of a typical PC system is presented in Fig. 1.7 on p. 14.



The CPU - conceptually it is often viewed as a composition of three primary subunits
1. Arithmetic and Logic Unit (ALU) - performs arithmetic operations and logic comparisons
2. Control Unit (CU) - fetches instructions from memory, controls the processing of instructions and movement of data within the CPU. (ALU+CU housed in a single chip.)
3. The Interface Unit (IU) - moves data and instructions between the CPU and other hardware components such as peripheral devices and memory. It also interconnects the CPU with memory and peripheral devices through buses or special separate processors called channels

PC Systems

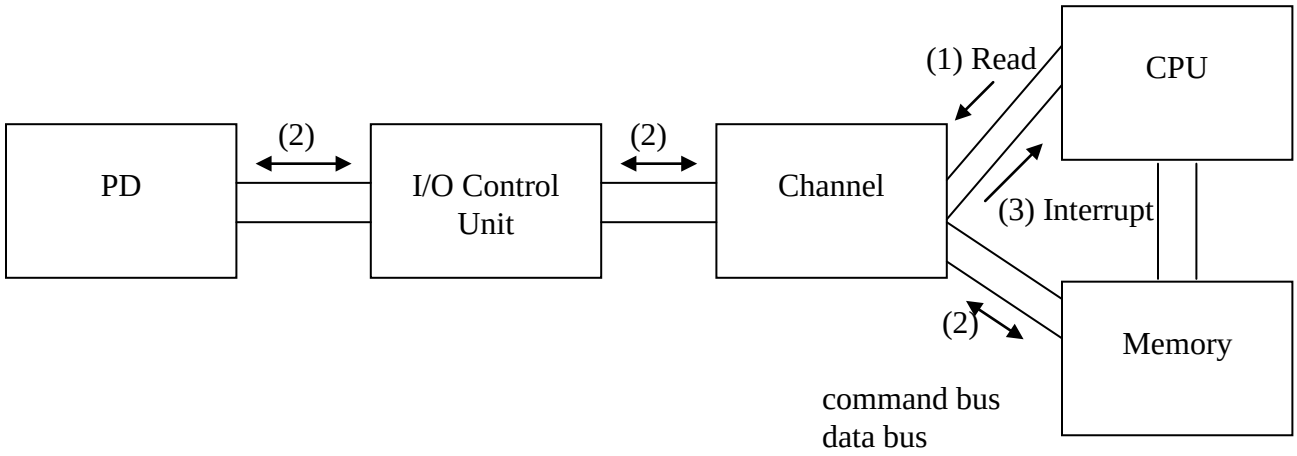


Other systems (mainframe systems)

The CPU is connected with peripheral devices via channels.

A channel (front-end processor or back-end processor)
- is equipped with its own processor
- releases the CPU to do other tasks
- is responsible for I/O operations

The channel and the I/O Control Unit (IOCU) translate data and control I/O devices.



1. Channel receives the I/O signal (Read) from the processor which is executing program A.
2. The channel assumes the responsibility for this operation and releases the processor to do other tasks (program B). The communication between the processor and the channel is broken temporarily. The channel establishes the link (communication) with the peripheral device and supervises the data flow between the peripheral device and memory. While the channel handles data for program A, the CPU executes program B.
3. After the Read operation is complete, the channel issues an interrupt signal to the CPU.

The channel is an asynchronous device that works independently from the processor.

Memory

1. Primary storage, main storage, RAM, temporary
2. holds programs and data in the binary form for access by the CPU
3. made up of numbered or addressed cells called bytes (8 bits)
4. each cell (byte) has a unique address
5. bytes can be combined to form
   - half-words (2 bytes or 16 bits)
   - words (4 bytes or 32 bits)
   - double words (8 bytes or 64 bits)
6. capacity
   - 16KB: year 1970
   - 64KB: year 1980
   - 256MB: year 2002
   - 2-4GB (PCs or laptops), several TB (z10 EC IBM system): year 2011

Modern computers address memory at least 4 or 8 bytes at a time to take advantage of larger instruction and data groupings. The amount of primary storage determines the maximum number of instructions and data words that can be loaded into memory from a peripheral device at one time.

Secondary storage (hard disk, tape, CD-ROM, DVD ROM)

1. holds programs and data in a permanent manner
2. capacity of hard disk - 500GB for PCs, Terabytes for mainframes – practically unlimited

The Software Component - computer programs that tell the computer what to do, intangible

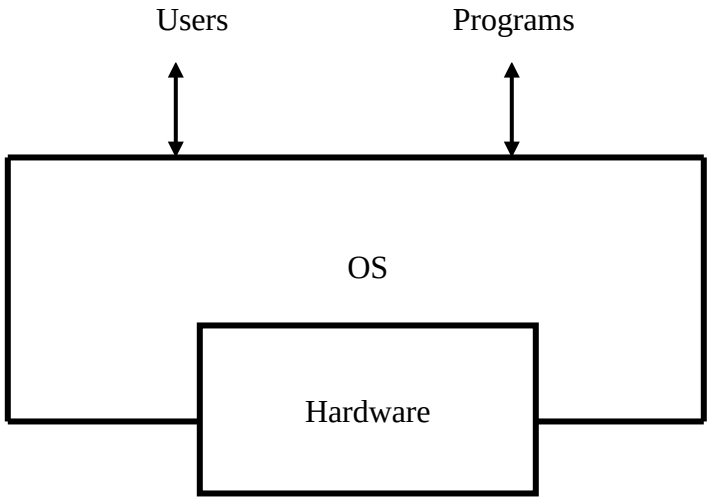
Two categories: Systems software and application software

System software (Operating System) - very essential part of every computer system.

Operating system (OS)

1. set of sophisticated software programs that control computer resources (hardware, software, and data)
2. acts as an intermediary between a programmer/user of a computer system and the computer hardware

Users and programs communicate with the computer hardware through the OS. The OS controls and coordinates the use of hardware among the various programs for the various users. Hardware includes basic computer resources: CPU, memory, I/O devices.

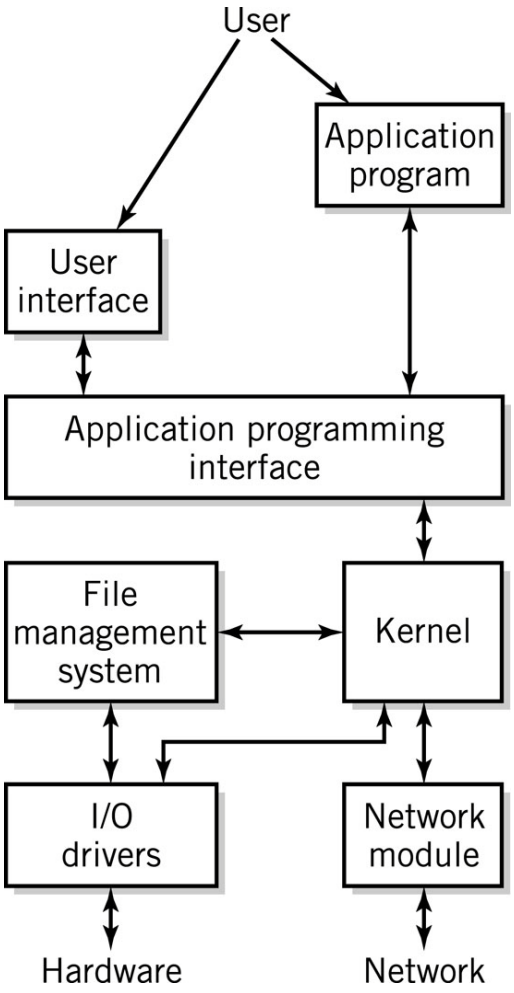


There is a strong relationship between the OS and CA. Changes in the design of hardware may cause changes in the OS and vice versus.

OS

1. controls the operation of the entire computer
2. manages and allocates computer resources
3. UNIX/Linux, MS-DOS, Windows (Windows NT, Windows 2000, Windows XP, Windows Vista, Windows 7), OS/2, IBM z/OS, Mac OS X.

A simplified OS block diagram is shown in Figure 1.9, p. 17.



1. Application programming interface (API) - acts as an interface for application programs and users to access the internal services provided by the OS.
2. Kernel - main module, manages memory, schedules time for each program to execute, manages and arranges services provided by other modules, provides security
3. File management system – manages and allocates secondary storage to files and translates logical read/write requests into specific I/O primitive commands (seek track 10, write to track 10, etc.)
4. I/O drivers – the modules that actually retrieve the files
5. Network module – controls interactions between the computer system and the network(s) to which it is attached.

OS software is stored on a hard disk. OS is loaded into memory by the bootstrap or Initial Program Load (IPL) program stored in read-only memory (ROM). IPL is part of OS.

Application software

1. programs that you purchase to get your work done - Microsoft Office 2007 (Word, Excel, Access, PowerPoint), Browsers (Internet Explorer 7, Mozilla Firefox 3.6.13)
2. programs that you write in Java, C#, C++ or C language

The Communication Component

Computers today rarely operate as standalone machines. The vast majority of computers are connected with each other via communication channels. A wired communication channel includes a wire cable, a fiber-optic cable, or a telephone line. A wireless communication channel includes radio waves (Wi-Fi or Bluetooth), microwaves, and satellites. In addition, networked computers must use additional software and hardware to communicate with each other. The hardware includes a modem or a network interface card (NIC). They also use special set of rules called protocols (TCP/IP, HTTP – Internet protocols, FTP) and standards (HTML, MPEG-4).

Standards and Protocols – very important

Standards are agreements among interested parties such as manufacturers, vendors, and engineers to ensure that various system components will work together interchangeably. Standards apply to every aspects of computing: hardware, software, data, and communications, i.e., the physical layout of pins on a connector, data formats, and programming languages to name a few.

Ex.

Standards for computer languages: Java, SQL, C#, C++.
Image data: GIF, JPEG
Video images: MPEG-2, MPEG-4
Processing Web pages: HTML, XML
Text format standard: ASCII, EBCDIC, Unicode
Sending high quality print images: Postscript, Portable Data Format (PDF) by Adobe Corporation

Standards are created to ensure that the protocols and data formats are universally compatible. A standard may be created by committee or may become a de facto standard through popular use.

Protocols are quite common in real life. For example, they include a wedding protocol, formal dinner protocol, or diplomatic protocol to name a few. In the computer field, protocols define the specific agreed-upon sets of ground rules that computers must follow to communicate with each other. Protocols also define communication between I/O devices and software programs. Protocols define communication features such as data representation, signaling characteristics, message formats, meanings of messages, and error detection.

Ex.

TCP/IP – a suite of protocols that define the data movement through the Internet
HTTP – defines communication between a Web browser and a Web server; and thousands of other protocols

The Computer Systems (z10 EC IBM System versus Laptop)

These two computers vary in magnitude and price. Although the IBM computer may be much faster and handle more users and programs concurrently than the laptop, their basic operation is based on the same concepts: RAM, hard disk storage, CPU, I/O devices, OS, buses, etc.

1. IBM - Fig. 1.10, p. 19

- located far from the users
- users communicate with it using thin-terminals, PCs, laptops, etc.
- several hundred CPUs
- 2TB RAM
- Tens of billions of instructions per second – measures the speed and performance of a computer)
- Linux, IBM z/OS
- many I/O devices, 1000TB hard disk space (practically unlimited)
- executes thousands of programs concurrently (multi-programming)
- services thousands of users simultaneously (multi-user)
- weighs about 5000 pounds

2. Laptop PC - Fig. 1.11, p. 19

- much smaller
- stand-alone
- Multiple CPUs
- 2-4GB RAM
- 200 MIPS
- 500 GB hard drive
- Windows XP, Windows 7, Linux
- Weight < 5 pounds
- can be used to connect to the mainframe through a modem and communication software
- single-user
- multi-tasking

The fact that these two different computers operate in a similar way opens the door for so called open computing and distributed computing. This means that different computers can work together, share files, processors, programs, and transfer data between one another to increase the overall efficiency of the system.

There are two types of distributed systems: tightly-coupled systems and loosely-coupled systems. In a tightly-coupled system, the processors share memory, system bus, some or all I/O devices, and the clock. Also, distances between devices are short. In a loosely-coupled system (network), the computers have more autonomy, each having its own memory, buses, clock, and I/O devices.

The Concept of Virtualization

Virtual – something that does not exist, not in actual fact - the Webster's Dictionary

In the computer language, virtualization refers to the abstraction of computer resources. The virtualization of a computer allows a single computer to appear as a multiplicity of computers, each with its own operating system and hardware resources.

Virtual memory – a carefully orchestrated work of computer hardware and software that gives the user an impression of unlimited main memory or memory much larger than the real (physical memory)

Virtual machine – VM/CMS (Virtual Machine Conversational Monitor System developed by IBM in 1980s)

VMware Workstation for PCs - VMware Workstation provides the most dependable, high performing, and secure virtual machine platform. It offers the broadest host and guest operating system support, the richest user experience, and the most comprehensive feature set. With support for over 200 operating systems including Windows 7, Windows Server 2008 R2 and over 20 other versions of Windows, along with Redhat, Ubuntu, OpenSuse and 26 additional versions of Linux. VMware Workstation delivers the broadest guest platform support for running multiple operating systems at the same time on your PC. VMWare is available in the CIS lab.

Virtual networks

History of Hardware and Operating System Software

Hardware

1st digital computer – 1945; big, no keyboard, no printer, panel with switches to enter programs

The computer hardware obviously evolved
- faster
- more memory
- cache memory
- virtual memory
- new I/O devices (mouse, plotters, scanners, etc.)
- parallel processing
- vector processing
- cheaper
- smaller

However, the basic architecture of today's computers is similar to that developed in 1945 - John Von Neumann concept (stored program concept and binary processing) has not changed since then.

Operating Systems Software

- had to evolve too to support an ever-increasing power of computers (Unix), networking, open and distributed computing, client-server computing, Internet- and web-enabled computing

- early computers: no OS at all

- single-user batch processing or interactive systems
  - one user only could communicate with the computer or execute one program
  - command line interface (CLI), MS-DOS: C:\>command, 1980s

- multi-programming batch processing
  - many programs are served/executed concurrently - MVS/JCL, 1960s

- multi-user, multitasking on-line (interactive) systems (UNIX), 1970s

UNIX

- Ken Thompson (AT&T Labs) developed a personal operating system called UNIX using assembly language.
- Dennis Ritchie developed the programming language C which was used to rewrite much of UNIX in a high-level language.
- UNIX introduced
  - A hierarchical file system
  - The shell concept
  - Document production and formatting
  - Tools for networked and distributed processing
  - Piping and I/O redirection concepts inherited by DOS
  - Portability

DOS & WINDOWS

- 1982: Stand-alone, single user computer
- PC-DOS, MS-DOS (disk operating system)
- Later versions of DOS added
  - Hierarchical directory file storage
  - File redirection
  - Better memory management
- Windowing systems
  - Windows 2.0, Windows 3.1, Windows 95
  - Windows NT, Windows XP, Windows Vista
  - Windows 7

In the meantime,

- GUI - graphical user interface was introduced by Xerox Corporation in 1970s
  - Implemented in Apple Lisa and Apple Macintosh by Steve Jobs, UNIX - X Window System, later versions of Windows, and IBM z OS