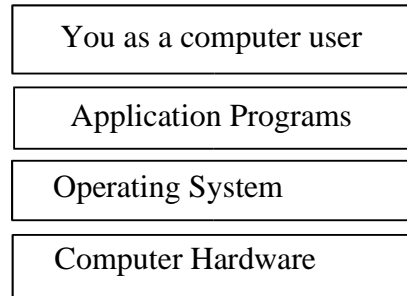


# 1. Computer and You

When you sit in front of a computer and working on it, following sub systems are involved:



**Figure 1. Layers in computing system**

At the top you are present as a computer user. You may be running (also called executing) an application program. Following are some sample application programs you could be running on the computer:

- Running a Video game application
- Running a media player application to play audio or video files
- Running a browser application to browse the Internet
- Running a Paintbrush program to draw a nice picture
- Running a Notepad or Wordpad or MS-Word to write or read some document
- Running Turbo-C compiler to write and build a program

All the above are examples of various application programs we run on a computer. All these application programs are running with the help of operating system. This operating system itself is another large program. But the purpose of operating system is to provide a convenient environment for all other application programs to run. All these application programs and operating system put together we call as software.

All the software runs on hardware. More precisely, the microprocessor (also called Central Processing Unit (CPU)) present in the hardware will execute the instructions present in the software. Following are the various components present in the computer hardware

- Microprocessor or CPU
- Memory, which includes following two types of memory
  - Volatile Memory typically called RAM (Random Access Memory)
  - Non-volatile memory typically called ROM or EPROM or Flash memory
- IO Devices, which includes the following:
  - Display Monitor
  - Keyboard
  - Mouse
  - Hard disk
  - CD-Drive with CD-ROM in it
  - Speakers
  - And Others

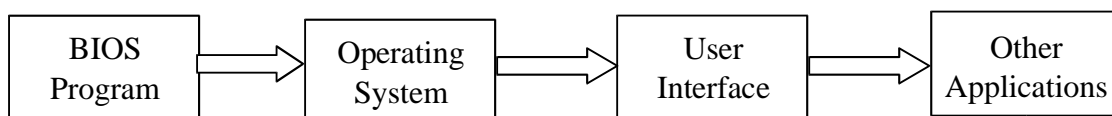
- IO Interfaces
  - Serial Interface
  - Parallel Interface
  - USB Interface
  - Network Interface

Interfaces present in the hardware will allow connecting various IO devices supporting the corresponding interface. For example printer may support USB interface or Parallel interface, so printer can be connected to one of these interfaces present in the computer.

## 2. What computer will do when you power-on?

Before switching on the computer, the software (i.e. applications and operating system) lies on the storage device present in the hardware. Common storage devices are hard disk and CD-ROM. So DEPIK supplied CD-ROM is holding the Linux operating system and application programs.

When you power-on a computer, the CPU executes the software (instructions). It is important to note that, CPU can execute software, which is present only in memory (i.e. either RAM or ROM). CPU cannot execute the software, which is present on the storage devices such as hard disk or CD-ROM. Because of this reason a small program called BIOS is always present in the non-volatile memory (ROM) of computer hardware. So when CPU is powered on, it executes the BIOS program. This BIOS program loads the operating system present either in hard disk or CD-ROM into the RAM. Then onwards CPU executes the operating system loaded in the RAM. The operating system loads the user interface program into RAM and runs that program. This user interface program allows the users to run any of their favorite applications. The sequence of these operations is called booting. Following figure shows this sequence of operations.



**Figure 2. Computer booting sequence**

## 3. More about BIOS Program

BIOS is a program that is present in the non-volatile memory (ROM/Flash) of a computer. When a computer is switched on this program runs first and initializes the various IO devices and executes some diagnostics programs. The diagnostic program will verify the health of the computer and reports to user if it finds any problem. If no problem is found, the BIOS program will read the operating system present in the hard disk or CD-ROM and loads into memory and runs it.

When you switch on a computer, in a few seconds the BIOS will run and BIOS will load and run the OS. However it is possible to interrupt the BIOS program from loading the OS, and then one can interact with the BIOS program to modify various BIOS settings. One such setting is the 'First Boot device'. BIOS always try to load the operating system from the first boot device. By default this 'First boot device' is set as Hard disk. However, one need to set

the 'First boot device' as CD to load the operating system from CD. To boot the DSL Linux one need to do the same thing.

## 4. Running Application Programs through User Interface

During booting of a computer, the operating system and user interface program will get loaded from hard disk into memory (RAM) and then get executed. All the application programs are still in the hard disk. The user sitting in front of the computer must start any application. Only when user starts the application, that application will get loaded from hard disk into memory and get executed. The main purpose of 'user interface' program is to allow the user to start an application. There are two types of user interface programs. These are:

- Command Line user Interface (CLI)
- Graphical User Interface (GUI)

The CLI program displays the command prompt and waits for a command from the user. The user has to type the command name and parameters by using a keyboard. The command name is nothing but the file name of that application program. The CLI takes the command name (i.e. application program name) and loads that application program into memory and executes it. Where as GUI program provides a graphical user interface to run an application. In this method user can directly double click the icon (Icon is a small image representing the application program) of the applications with a mouse. Another method is to open a menu by clicking the right mouse button and selecting the application from the menu. However note that even when GUI is present, still CLI is available through terminal or shell window. We always use this CLI, even while Linux is supporting GUI.

## 5. GUI and CLI Application Programs

We can also classify the applications into GUI applications and CLI applications. Typically GUI applications are started with GUI methods. Where as CLI applications are started using CLI method. However this is not a mandatory.

When we start a GUI application, it starts a new window. This window consists of menus and tool bars. User can interact with this application by clicking the menu items or tool buttons using mouse.

The CLI applications run in a terminal window, in which the program name is typed. They will never create a new window. User will interact with these CLI programs only through the keyboard.

There exists third type of programs called daemon programs or server programs. These programs do not have any user interface. They will run in the background by hiding themselves. Users cannot interact with them directly. Some other application programs will interact with these server programs. These application programs are called client applications. User will run these client applications and these client applications will interact with the server programs. For example when you are running a browser such as Internet Explorer, it is a client application program, but it is talking to some web server on the Internet, which is a server program. However note that, these client applications may using either GUI or CLI.

## 6. Standalone and Network Application Programs

We can also classify the application programs running on a computer into standalone application programs and network application programs. Standalone programs are independent programs. Whereas every network application program is talking to another network application program running on a different computer. So in order to run any network application program, the computer must be connected to a LAN or Internet.

Again network application we can classify into two types; these are client applications and server applications. Server applications are typically started automatically during booting time of computer. These server applications run in the background mode and not visible to the users. Client applications are typically started by the users and closed by the users. These client application programs will talk to the server application programs.

The best example for client application program is browser. It is started by the user, this browser program will talk to the web server (user may specify the web server address like google.co.in) and get the web pages from web server and displays them. If you go to any bank the application programs the bank employees using are client programs. These client programs will talk to the database server programs running on server computers.

## 7. Operating Systems

Operating system (OS) is the most important component of a computer. Operating system provides an environment for other applications to run. The most popular OS is “Microsoft Windows”. This Windows OS came with various new releases over a time like Windows 95, Windows 98, Windows 2000, Windows XP and latest one being Windows Vista.

But Windows OS costs money. It costs anywhere between Rs.3,000 to 6,000 or around that range. Most of the people may be using illegal or pirated copies of Windows software. Also note that you need to buy a separate windows copy for every computer. Buying one copy and loading into multiple machines is again illegal. When you get a computer hardware for 10K to 12K paying 3K to 5K for OS is expensive; specifically for developing countries like India.

Linux is another most popular OS. Linux OS has got a lot of following across the world, specifically in all universities. Linux OS is not only a free OS, but it is open source OS. So you can go through the source code of the Linux OS and can learn how an OS works internally. You can also modify the OS code and rebuild the OS to your new requirements. This makes every one to feel Linux as their own OS. Similarly a lot of open source application programs are available on Linux. So you can learn how those applications are developed, again you can modify them to your requirement.

Open source OS and open source application programs are invaluable aid for the students learning computer programming. Students can build a lot of software with the help of this open source software.

Linux is also a very powerful operating system. It is capable of running from small-embedded systems to high-end super computer kind of systems. Linux supports maximum number of file systems and networking protocols. Linux network stack is very powerful and

Linux network server applications are very famous. A lot of companies will look at the Linux source code, to learn the implementation of new network protocols. A lot of people with open source enthusiasm are continuously developing latest protocols for Linux.

Studying, understanding and using Linux is going to benefit a lot for all the computer and electronics students.

## 8. DEPIK's Damn Small Linux (DSL)

A lot of companies are taking the open source Linux OS and many open source application programs and putting them in one or more CDs. These companies are adding their own installation programs and configuration programs, which makes installation and configuration of Linux easy. These companies are called Linux distribution companies. There are many such distribution companies; important ones are RedHat, Debian, Suse (now part of Novell) and many others. Using these CDs you need to install the Linux on hard disk. After installation Linux will boot from the hard disk.

But now a days, some other companies are started offering Linux Live CD distributions. One can use this live CD to boot Linux operating system directly from CD drive, without installing it on the hard disk. Using these live CDs one can practice and learn Linux without really installing it on the hard disk. This gives a lot of comfort for newcomers to Linux. The KNOPIX is the first such live CD distribution.

Damn Small Linux (DSL) is yet another such live CD distribution based on KNOPPIX. The specialty of DSL is its size. This DSL occupies just 50 MB of space on CD. The total capacity of CD is around 650 MB. Within 50 MB, DSL people are able to pack lot of useful applications along with the Linux OS. We at DEPIK found DSL is ideal distribution for students learn the complete working of operating system and its applications. Another advantage of DSL is that, it runs very quickly even on oldest computers. At DEPIK we are able to use our old computers again with good graphical user interface.

Original DSL does not include all the software development tools like compilers, linkers and debuggers. We at DEPIK, included these software development tools (from open source) and distributing them to the students like you.

## 9. Computer Users

We talked enough about operating systems and DEPIK's DSL. Now it is time to talk about users of computers, in our figure 1, we placed users in the top layer. We can classify the computer users into the following groups:

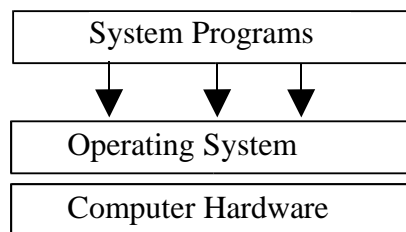
- Application users
- Administrators
- Application Programmers
- System Programmers
- Software Testers
- Kernel Programmers

Application users will use the applications available on the computer. Sample applications are listed in the section 1 of this document. Application users could be home users or office users. Office users are the ones who are using computer applications as part of their work at office, like bank and supermarket billing employees.

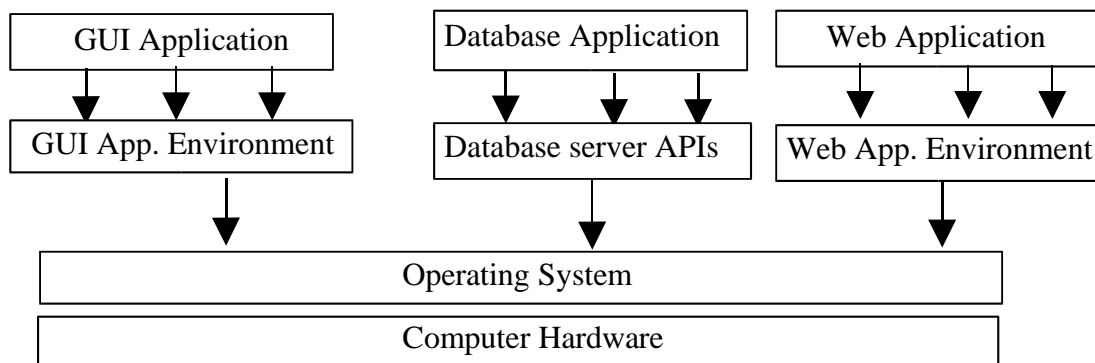
Administrators are responsible for maintaining the computers. We can also classify the administrators into various groups based on the things they are maintaining. For example system administrators will maintain computer hardware and operating system. Networking administrators will take care of networking related things. Application administrators will take care of applications such databases and web servers. As applications will become huge and complex, then for each such application a separate administrator may be required.

Application programmers are responsible for developing the application software. Application programmers will use the application specific APIs (Application Programming Interface) in their programs. So they need to learn the API functions and its environment. For example graphical user interface (GUI) programmers will learn the GUI APIs. Database programmers will learn the database APIs provided by the Database server. A game programmer will use the APIs available on game programming environment. Web application programmers will use the Web server APIs.

System programmers also will develop the applications. But these applications will use the APIs provided by the Operating System itself. So system programmers will study the OS provided APIs typically called 'System calls'. Most of the server applications will come under this class of programs. Typical system programs are multi-processing and multi-threading application with Inter Process Communication (IPC) between them. The following figures illustrate the differences between application software and system software.



**Figure 3. System Programs**



**Figure 4. Application Programs**

As shown in the above figures, System programs directly uses the APIs provided by OS. Where as each type of application program uses the APIs provided by application environment. Application programs will not call OS APIs directly. This makes application programs independent of the OS. For example someone develops web application by using Apache web server. This application runs on any OS, where apache is running.

Also as shown in the figure, developing application environment, such as database server or web server is the domain of system programmers.

Both application and system software developers will use the following programming languages.

- C
- C++
- Java
- C#

Following scripting languages are also used for the development of application programs. System programmers will not use scripting languages.

- Perl
- PHP
- Python
- TCL

However C language is the mother of all other languages and scripts listed above. So good knowledge in C language is a must for proficiency in any of the languages or scripts given above.

The software testers are responsible for testing the applications developed by application programmers as well as application environments developed by the system programmers. Typically testing an application is a manual process, but there are tools available to automate the testing process. One needs to test the application after every modification and release. So testing every time manually is difficult and error prone. That's why automatic testing is a must. So test engineers will learn the testing tools and test strategies and methodologies.

Testing the application environments developed by system programmers is different. Here one needs to develop sample application programs to test the APIs provided by the environment. So these test engineers should be a good programmers test to develop the test programs.

The kernel programmers are responsible for developing the kernel sub systems such as file systems, network protocol stacks and device drivers. Good knowledge of kernel internals, hardware concepts such as I/O controller, Interrupts and DMA are required. C, C++ and a bit of Assembly language are commonly used for kernel programming.

## 10. Files and Directories

A very important concept developed and used by the Operating System is 'File' and 'Directory' concept. Directory is also called a 'Folder'. Operating system allows storing any

information in the form of file on a storage device. Every storage device provides a large number of blocks for reading and writing. Each block will have a fixed size, typically 512 or 1024 (1K) or 2048(2K) or 4096(4K) bytes. A storage device such as hard disk may have 80 million blocks with each block as 1024 bytes. This hard disk is called 80GB (Giga Bytes) hard disk. Other storage devices are Floppy disk, CD-ROM, DVD-ROM, USB flash disk and Compact Flash Disk. All these storage devices provide a set of blocks to read or write.

Operating system abstracts these blocks present on the storage devices as files and directories. So when any program wants to store some information, it creates a file by specifying the file name and writes data into that file. When we write to a file, OS will allocate set of block numbers (these blocks need not be contiguous) and writes data in those blocks. Any time, the program can open that file by specifying the file name and can read the data. OS will find out the blocks associated with that file name and reads data from those blocks.

A lot of application programs will use files. If you run an application to play a song, the application is reading the song from some MP3 file. If you run an application to see a photograph, the application is reading photograph from a JPEG or GIF file. If you prepare some document by using MS-Word application, it saves your document in a file. So file is a very important concept provided by the OS and used by the application programs.

Also note that every program we are executing is itself stored in a file. These files are called executable files. So every application program is one executable file. When we run that application program, the content of the executable file are loaded into memory (RAM) and then get executed. When we write a C program, we are creating a new file, and writing the program statements in that file. These files are called program source files. When we compile these source files, we will get executable file. Now we can run that executable file. All the application programs are developed in the similar manner.

Directory or Folder is another related concept introduced by OS. Directory is a placeholder to keep information about files and other directories. So a directory holds files and other directories. These directories are called sub directories. The root directory is the top most directory. In Linux operating system there will be only one root directory with name (or symbol forward slash) `"/`. In windows each storage device will have a separate root directory, like `'A:\'`, `'C:\'` and `'D:\'`.

In Linux OS, when there are multiple storage devices, one of the storage device is called a root device. The root directory `"/` represents the root directory of the root device. All other storage devices will be mapped on to the various directories present in the root device. For example, the root device will have a directories called `'/mnt/floppy'` and `'/mnt/cdrom'`. A floppy device's root directory will be mapped on to the `'/mnt/floppy'` directory of root device. So when we try to display the contents of `'/mnt/floppy'` directory, what you we see is the contents of root directory of floppy disk. Similarly the root directory of CD-ROM will be mapped on to the `'/mnt/cdrom'` directory. This mapping operation is called 'mount' operation. We use 'mount' command to do this mapping.

So in Linux files or directories present in all the storage devices can be accessed from a single root directory. Where as in Windows each storage device will have a separate Drive letter like `'A:'`, `'C:'`, and `'D:'`.

## 11. Home Directory

A directory is a placeholder to keep the files and sub-directories. In Linux OS, every user will have a separate directory called home directory. The name of this directory will be same as user's Login name. All users home directories are placed in another directory with name '/home'. So the home directory of user 'bharat' is going to be '/home/bharat'. Users can create files and sub directories inside their home directories. Again inside the sub-directory then can create files and sub-directories. This can go on for any depth.

When you boot DSL from CD, you will automatically logged in user 'dsl'. So your home directory is going to be '/home/dsl'.

## 12. Practice Linux

The information provided in this chapter is very practical and useful information. In the next chapter we are going to show you how to use Linux. After getting familiar with using Linux, come back and read this chapter again. Try to correlate the material given in this chapter with the practical experiences of using Linux.