Dr.Babasaheb Ambedkar Open University

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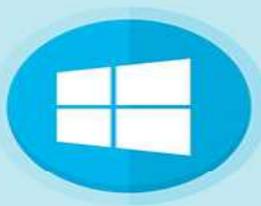
PGDMAD-101
Mobile Operating Systems

Post Graduate Diploma in Mobile Application Development

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Mobile Operating Systems

Dr. Babasaheb Ambedkar Open University

Mobile Operating System

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PGDMAD-101

Mobile Operating Systems

Block-3: Android Operating System and iOS

Block-4: Other Mobile Operating System

Block–1
Introduction to Generalize Operating System & Mobile Computing

Unit 1: Generalize Operating System

1

Unit Structure

1.1 LEARNING OBJECTIVE

After studying this unit, a student should be able to understand:

- Definition of generalize operating system (OS)
- Need of operating system
- Objectives of operating system
- Functions and views of operating system
- Multi-Tasking operating system
- Network operating system
- Distributed operating system
- Real Time operating system
- Embedded operating system
- Differences of operating systems

1.2 INTRODUCTION

In the last two decade the power of computing has changed. Now a day, computers are becoming more powerful. The storage capacity and computing speed are extremely fast. Today's computer applications are becoming user friendly with fast processing capability. In this information age, everyone is concerned with the computer and its performance. Now a day computer with good speed is a basic necessity of people. People do majority of their work with the help of computer. They use computer for the online shopping, booking a railway/air ticket, account management, storing files and many more. Have you ever thought how all these works are done? How does the computer manage all the work given by the user without any errors? How does the computer manage all the attached devices or hardware with the help of user?

In the beginning of computer era, the tasks to be performed by user where directly given to hardware. This made the user of computers difficult as user had to know the architecture of computer system. Later on various software were designed to assist the users. The software minimized the interaction of user with hardware, thus allowing users to perform all functionalities easily. This software that operates the computer system is known as Operating System (OS). An Operating System

which runs on computer is called Generalize Operating System. Now on wards in this block we will use the terms "Operating System" or "OS" for the "Generalize Operating System".

An Operating System is the first program that is loaded into computer by a boot program; it manages all the applications runs on the computer. An Operating System acts as a layer between the user or application and the hardware. It works in background, without letting us know who is managing all the hardware and application on computer.
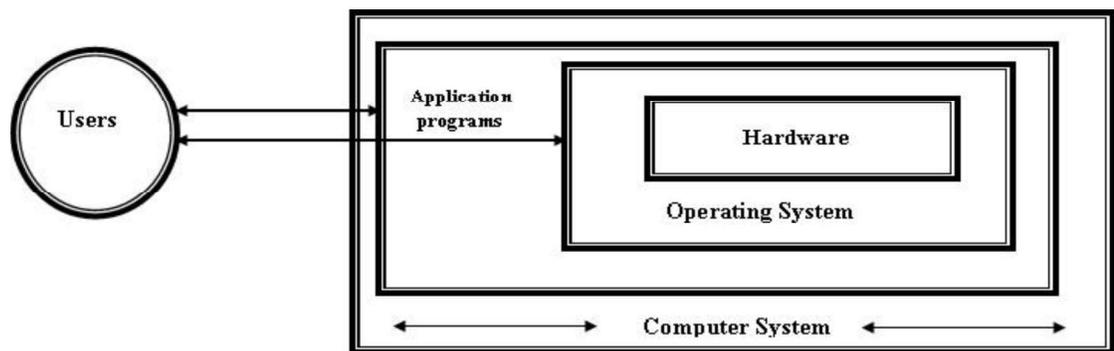
Figure-1 Layers of Operating System

As shown in the Figure-1, An Operating System plays a role of inter mediator between applications and hardware. Here, User gives input to the application/s, based on that OS perform processing and get result with the help of hardware and transmit it back to application for delivering the same to user.

An Operating System can also be defined in the following ways:

➢ "It is an integrated set of specialized programs used to manage overall resources and operations of the computer."

➢ "A software that acts as an interface between the users and hardware of the computer system"

➢ "A software that provides working environment to the user's applications"

➢ "A resource manager that manages the resources needed for all the applications in the background"

➢ "It is specialized software that controls and monitors the execution of all other applications that reside in the computer."

1.2.1 NEED OF GENERALIZE OPERATING SYSTEM

To understand the need of operating system, we need to answer the questions raised here. Often while working with computer system we might take faced questions like:

- While storing the data on file, who is allocating memory to the file?
- Who is mapping logical path of file to the physical location of file on hard disk?
- Today's computer can open and manage multiple windows at a time, who is managing all windows?
- Who protect user's data to unauthorized access by another users?
- While print command is given, who is transferring the data from file to printer?
- When any request is sent for the data from the network, who transfers data within network?
- Who provides the mechanism to transfer data between two applications?
- Who manages CPU and make sure that it is not sitting idle or busy forever?
- Who schedules the processes for the CPU execution?
- Who manages the memory (RAM) and how it is allocated as and when it is demanded by the processes?

Well, the answer of all the questions raised here is "Operating System". An Operating System has a responsibility to manage all the resources and applications in the computer system and provides friendly environment to the users.

1.2.2 OBJECTIVE OF GENERALIZE OPERATING SYSTEM

In the journey of Operating System development, the central theme is to keep in mind the convenience of the user.

The objectives of the Operating System are:

➢ **Convenience**

Main goal of the Operating System is to provide convenience to its user. Operating System hides the complex mechanism of hardware handling from the user and provides a user friendly GUI (Graphical User Interface) to its users.

➢ **Efficiency**

Operating System makes the computer system convenient to its user in an efficient manner. Operating System effectively manages all the resources such as printer, hard disk, RAM, CPU. Operating System makes arrangement that each running application can get resources as and when it is demanded. OS uses scheduling algorithm, so each application utilizes computer system resources at its optimal level. OS keeps track of who is using which resource, granting resource requests, and mediating conflicting requests from different programs and users.

➢ **Ability to Evolve**

An operating system should be constructed in such a way as to permit the effective development, testing, and introduction of new system functions without interfering with existing service

1.2.3 FUNCTIONS OF GENERALIZE OPERATING SYSTEM

We have understood the need of Operating System. Now it is time to discuss various functions of Operating System. The function can be divided into two parts namely user view functions and system view functions.

1.2.3.1 User View Functions

The user view is a top – down view function. It allows execution the of user's task on the computer system without knowing the complex hardware details of the computer system. It provides a simple interface between application and the hardware.

The user view functions are as follow:

➢ **Error Detection**

A variety of errors can occur while a computer system is running. These include internal and external hardware errors, such as a memory error, or a device failure or malfunction; and various software errors, such as division by zero and inability of the OS to grant the request of an application. Operating System traces the errors and prompts the error messages to the user. It also provides methods for debug and error-detection.

➢ **Coordination Between Applications and Users**

The OS acts as coordinator between various kinds of applications and its users. It coordinates assignment of compilers, interpreters, assemblers, and other software to various users of the computer systems.

➢ **Software Development and Execution**

The OS provides a variety of services for the new software, such as various kinds of editors and debuggers that help user to develop software efficiently and speedily. All software work on specific set of instructions, OS helps in fetching and execution of there instructions.

➢ **Access to I/O devices**

The input output (I/O) device has own set of instructions and control signals for operation. The OS converts the I/O device specific set of instructions and signals to uniform interface so that users can access such I/O devices in simple way.

➢ **File Access Mechanism**

The OS provides a file access matrix. Each file has specific rights of Read, Write for its users. The OS maintains the file access rights by various mechanisms to provide access to its users. In the case of a system with multiple users, the OS may provide protection mechanisms to control access to the files.

- ➢ **System access**

    The OS provides a protection method to its resources and data from unauthorized users and solves conflicts for resource dispute. The OS has control access as a whole and specific resource also.

1.2.3.2 System View Functions

The OS performs the most of functionalities in background which is called system view function. Managing the hardware, allocations of CPU, memory management are done in background without the users knowledge. Therefore, from the computer system's point of view, the OS is specialized program that controls the allocation and retentions of all the resources in the computer system. The system view functions are as follow:

- ➢ **Memory Management**

    Each running software on computer system demands memory dynamically. The OS provides functionality for the memory management. The OS keeps track of the primary memory like what part of it is in use by whom, what part is not in use, etc. and allocates the memory when software requests it.

- ➢ **Processor Management**

    Each running software acts as a process at machine level. At a time many processes stand in queue to execute set of instructions. The OS provides scheduling mechanisms to allocate the processor (CPU) to process and retain the processor when it is no longer required.

- ➢ **Device Management**

    The OS keeps track of all the devices attached with the computer system. Through the virtual machine manager (Drives), OS provide instructions to the device and receives output for the device.

- ➢ **File Management**

   The Files require physical memory (Secondary Memory) in the computer system. The OS allocates and retains the physical memory as file needs to be saved on hard disk. It also provides the method to retrieve the data from the physical location when needed.

- ➢ **System Performance**

   The OS keeps eye on the performance of various attached devices. It records the delay between the request for a service and response from the system.

1.3 TYPES OF GENERALIZE OPERATING SYSTSEM

We have seen the basic function and architecture of generalize operating system. Today, a variety of Operating Systems exist. For the day to day uses we have Window, Linux, and Ubuntu Operating System. Network OS is used to handle several computers on network. Embedded OS is used to manage mobile devices. Real time Operating System (RTOS) like RTLinux is used to handle real time tasks without time delays. Thus, depending on the requirement and project types, an appropriate Operating System is used.

1.3.1 MULTI -TASKING OPERATING SYSTEM

Today's most modern Operating Systems are multitasking. As name itself suggests, multiple tasks (here task may be process / thread / programs) are stored in main memory and executed at a time. If we can play MP3 music, write a text on text editor, search data on internet simultaneously then the OS is called Multi-Tasking OS (MOS). All the modern generalize operating systems are Multi-Tasking OS, functions of MOS is the same as functions of generalize OS.

Multi –Tasking OS is useful when the user wants to open and works on the multiple applications simultaneously on computer system. Microsoft Window, Linux, Ubuntu are the modern multi-tasking OS.
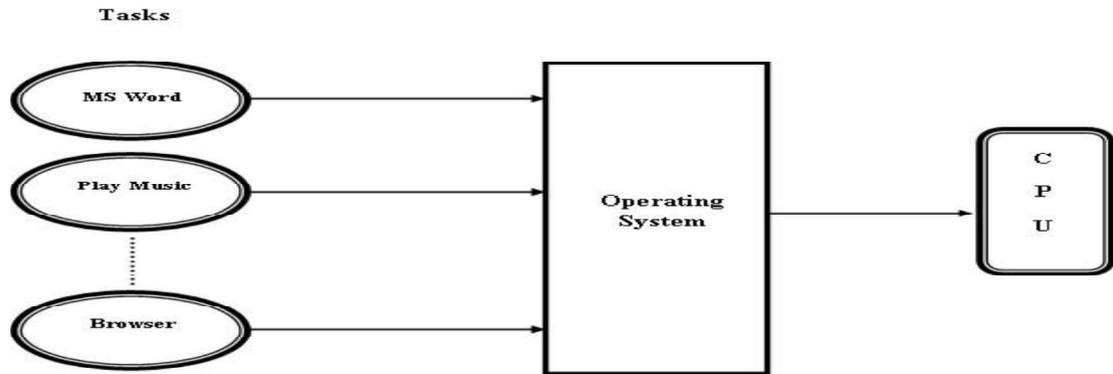
Figure-2 Multi-Tasking OS

Multi-Tasking OS works on time sharing and context switching concept. Here in a time sharing system, each process is assigned some specific quantum of time for which a process is meant to be executed. For example there are three processes P1, P2, P3 ready to execute. So each of them are assigned some time quantum for which they will execute e.g time quantum of 10 nanoseconds (10 ns). As one process begins execution (say P1), it executes for that quantum of time (10 ns). After 10 ns the CPU starts the execution of the other process (say P2) for the specified quantum of time, after 10 ns, the CPU starts the execution of the other process (Say P3) for the next 10ns. At the end of the time quantum OS removes one process (say P1) from the CPU and send second process (say P2) in the CPU for execution, is called context switching. Here time quantum is too small and context switching happens very fast, a user cannot feel the interrupts in the process execution. This way, the user is given the illusion that multiple-tasking are being executed simultaneously, But actually only one task is executing at a particular instance of time.

1.3.1.1 Advantages of Multi-Tasking Operating System

➢ The Multi-Tasking OS works on fixed time quantum, is able to provide quick response on request.

➢ The multi-tasking OS makes optimal CPU utilization at maximum, resulting in less CPU idle time.

➢ As it allocates fixed time quantum to each process, hence each process gets an equal opportunity of execution.

➢ All tasks run smoothly without a glitch in performance.

- User can run a single task or multiple tasks, with ease on computer system.
- Computer resources like RAM, Processor, I/O devices and hard drive are superlatively managed by OS.

1.3.1.2 Disadvantages of Multi – Tasking Operating System

- The Multi-Tasking OS shares the computer resources among the multi tasks that raise reliability issues for the MOS.
- In the Multi-Tasking OS, multiple tasks exist in main memory at a time, at times it may cause shortage of memory.
- If the processor in the computer system is slow then it may take long time to process programs.
- Sharing computer resources at a time raise a question of security and data integrity of user tasks.

1.3.2 NETWORK OPERATING SYSTEM

Network Operating System (NOS) is a specialized operating system that has special function to connect and manage autonomous computers in the local area networks. The main purpose of NOS is to allow users to share resources across the computer network. They can share data files or network devices such as printer, DVD drive or other electronic devices. The most widely used network operating systems are Microsoft Window Server, Microsoft NT, Novell Open Enterprise Server.

All modern NOS have following functions additional to generalize operating system:

- Managing the computer and peripheral devices attached in network.
- Creating and managing the network user account.
- Controlling access to network resources.
- Providing efficient communication service in the network.
- Monitoring and troubleshooting of the network.
- Providing network routing features.
- Providing interface to users for remote access of data files and devices across network.

The NOS is deployed on network server to administrate network resources such as storage device, network prints, computer nodes and communication services. The Network Operating System has two types:

➢ **Peer-to-peer NOS**

The Peer-to-Peer (P2P) NOS allow user to share their resources and files located on their computer and also can access resources located on other network computer. In P2P NOS all users have the same level of right to access the resources. The data in P2P NOS is stored on different computers within network. The P2P NOS basically used for small and medium local area network. Figure-3 shows the layout of peer to peer network OS.
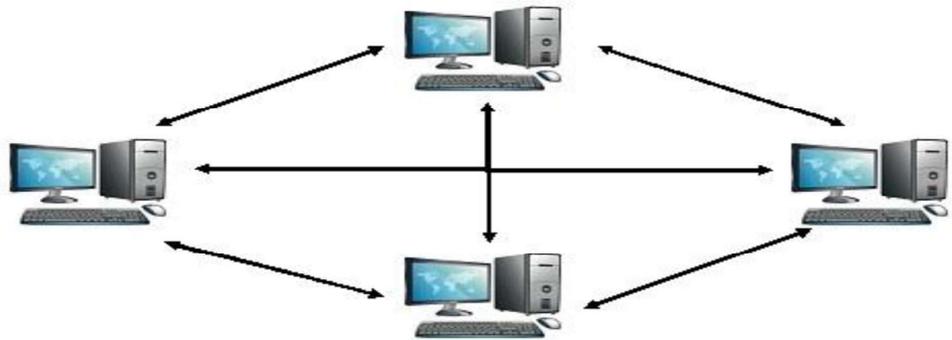
Figure-3 P2PNetwork OS

➢ **Client / Server NOS**

The Client / Server network operating system allows network to store data at central location called server. The computer node in the network called client, accesses this data through the network. Here Sever acts as a heart of the entire network system. Server manages users, network resources, access rights and security. To access the data client, need to connect with server. Figure-4 shows the client server network OS.
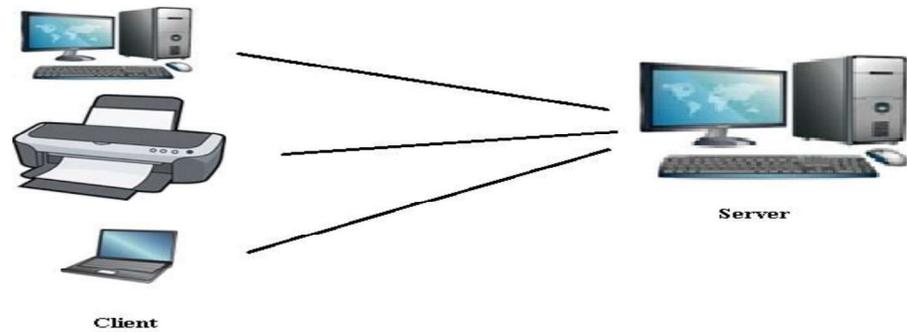
Figure-4 Client Server Network OS

1.3.2.1 Advantages of Network Operating System

➢ NOS has centralized server that is highly stable.

➢ Security issues are handled easily at server.

➢ Due to network connectivity, remote access is possible.

➢ New technology and hardware can easily be upgraded and integrated to the network.

➢ Less requirement of hardware as it is sharable.

➢ Data can be stored at central location, it becomes easy to access it from network.

1.3.2.2 Disadvantages of Network Operating System

➢ NOS's Servers are costly.

➢ Network systems are highly dependent on Server.

➢ Users are mostly dependent on server for their data.

➢ Maintenance and updatation is required regularly

➢ It has less security compared to stand alone computer system.

1.3.3 DISTRIBUTED OPERATING SYSTEM

Distributed operating system is multi-processors system to serve multiple applications and users in distributed manner. Here each node in network works as complete computer system. Using this multiple node data processing is done in distributed manner. It works on wide area network (WAN).

Resources sharing and fast processing is the main purpose of distributed OS. It is not possible to take advantage of thousands of processors on single board, but

the multiple processor are realized as single powerful machine in a network system, this machine is called distributed system. UNIX based IRIX operating system, DYNIX, AIX based on IBM RS/6000 are some of the distributed operating system. Figure-5 show the working layer of distributed operating system.
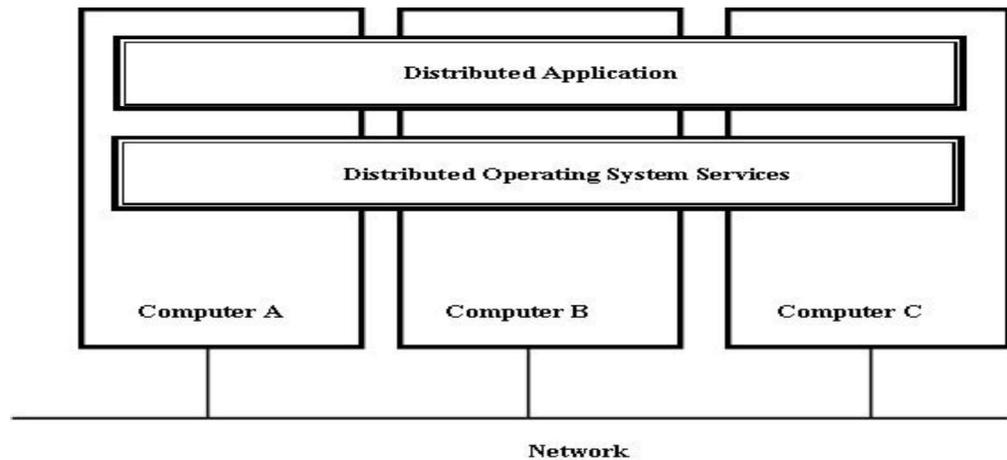
Figure-5 Distributed OS

By the distributed OS, it makes possible to make partitioning a computation into some sub computations which are distributed and run concurrently on various node of network, resulting process execution becomes fast.

All modern distributed OS has following functions additional to generalize operating system:

> ➤ It provides mechanism to run regular program in distributed fashion.
> ➤ It provides easier mechanism to user for accessing network resources.
> ➤ Processes may execute on any network node, Distributed OS needs to manage processes by efficient way as compared to generalize OS's process management.
> ➤ Multiple processes run on different network node, synchronization and inter process communication methods are provided by the distributed OS.
> ➤ Distributed OS provide one interface to all resources in the network, the user feel as if work is done on single OS.

1.3.3.1 Advantages of Distributed Operating System

➤ Distributed OS provides resource sharing in a way that user at one location can be use resources located on the other location.

➤ Distributed OS provides a distributed computing for speedy execution of process.

➤ If one of the computer system in a network fails still computing will be done with the use of remaining node in network.

➤ Using Distribute OS, fast, better and effective service can be provided to user.

➤ Less load on the host computers.

➤ Data exchange can be fast in network.

➤ Resource can be added and utilized easily in network.

1.3.3.2 Disadvantages of Distributed Operating System

➤ Failure of network will stop entire communication.

➤ Distributed OS is very expensive.

➤ Security issues may rise due to resource sharing in network.

➤ Message / Data Packet can be lost in network that effects on distributed computing.

➤ High bandwidth is required in network for large data transmission.

➤ To provide and maintain common interface for network resource is big challenge.

1.3.4 REAL TIME OPERATING SYSTEM

As we have discussed earlier in this unit that all the generalized Operating Systems work on time sharing. Time sharing systems have some drawback, if there is more load on the OS then response time is more and may increase if load increases. In some computation processes this kind of delay cannot be allowed. Such delay can cause system failure or disaster. For example any OS which needs to control the temperature of nuclear reactor 24*7, 365 days, if the OS fails to control the same for a minute, it may result in blast at nuclear plant. So in 1980 new kind of Operating system was developed that works on small response time. The time taken

by the system to respond to an input and display of required updated information is termed as the response time.

A Real-Time Operating System (RTOS) is a system in which the time required to process and respond to input is so small that it controls the environment. Here response time is too small as compared to other generalize operating system. RTOS responses immediately to user / application's request or within a fixed time frame, is known as Real –Time Processing. RTOS are used when there are very strict time requirements on the operation of a processor. Scientific applications, weapon control systems, nuclear control systems, Air Traffic Control Systems, image processing applications, voice / video calling applications and industrial control systems use Real-Time OS. Real-Time systems are two types:

> **Hard Real Time System**

In Hard Real Time System, processes should be executed in given time quantum. Processes cannot cross the time limit. Hard real time system gives guarantee that critical tasks are completed on time. All the weapons control systems are example of hard real time.

> **Soft Real Time System**

In Soft Real Time System, processes may not be executed in given time quantum. It may cross the time limit without harming the system. A critical real-time task gets priority over other tasks and retains the priority until it is completed. A voice / video calling applications, image processing applications are the example of soft real time. Figure-6 shows view of RTOS.
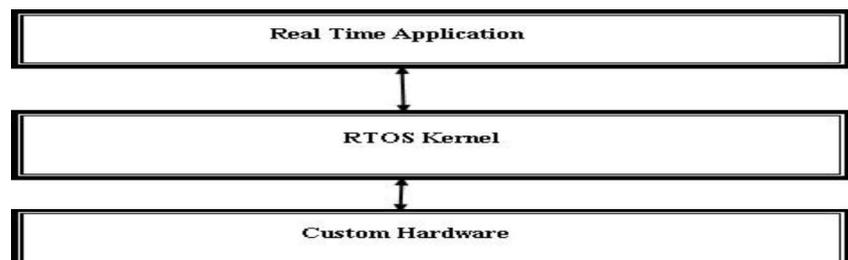
Figure-6 Real Time OS

All Real-Time OS has following functions additional to generalize operating system:

- ➢ RTOS works based on event driven switching, higher priority tasks are allocated CPU services first as compared to lower priority tasks.
- ➢ RTOS needs to work on fixed time sharing (quantum) manner.
- ➢ To manage the processor and other resources in such a way that it meets the requirement of real time applications.
- ➢ To synchronize with the system events.
- ➢ To respond quickly to any request that needs to manage RAM in efficient manner.
- ➢ To provide exclusive access to the computer resource.

1.3.4.1 Advantages of Real Time Operating System

- ➢ RTOS is developed to handle critical applications, thus the performance of applications is very high.
- ➢ RTOS uses its resources at maximum, thus more output from the resources.
- ➢ RTOS has efficient fault toleration technique, so we can say it is error free operating system.
- ➢ Memory management is best compared to generalize operating system.
- ➢ RTOS can be best used for any applications which run 24 hours and 7 days because it does less task shifting and gives maximum output.

1.3.4.2 Disadvantages of Real Time Operating System

- ➢ RTOS handles limited tasks. Very few tasks can run at the same time.
- ➢ RTOS uses very heavy system resources thus it is expensive operating system.
- ➢ Algorithm runs on RTOS is complex and difficult. It is very difficult to write that algorithm for a designer.
- ➢ It needs specific device drivers and interrupts signals to respond earliest to the interrupts.

➢ RTOS is low multi-tasking. RTOS runs few tasks so multi-tasking is done few times.

1.3.5 EMBEDDED OPERATING SYSTEM

Embedded operating system is the system which is made for specific tasks. An embedded system is a combination of computer hardware and software, it define for specific functions within a system. Embedded system has an operating systems but it is not generalized operating system. Embedded OS performs all the basic functions of OS like initialization, task management, memory management, process scheduling etc. but with little or no user interface. Embedded OS has limited tasks related to specific environment. ATM Machines, High-end cars, Mobile devices, digital television have embedded operating system.

Embedded operating system has three main components: Hardware, Software and RTOS. Here RTOS supervises applications software and provides mechanism to handle the process. It sets the rules during the execution of applications. Here we should note that small scale embedded system may not have RTOS. So we can define an embedded system as a Microcontroller based, software driven, reliable and real-time control system. Figure-7 shows a view of Embedded OS.
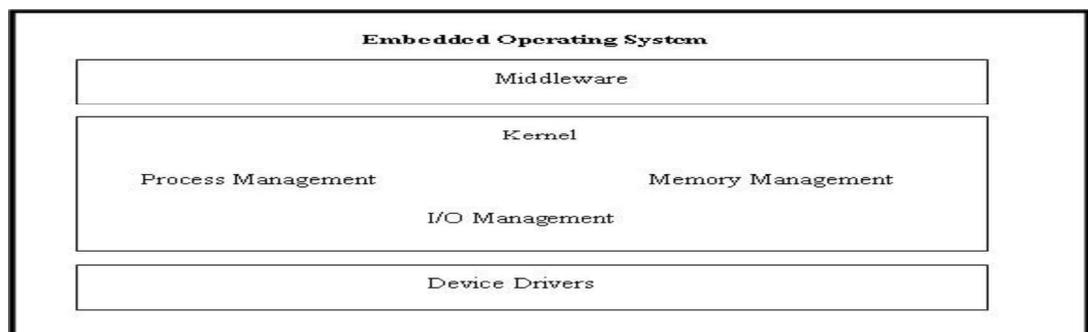
Figure-7 Embedded OS

Mobile OS is a part of Embedded Operating System. Now a day various kinds of Mobile Operating Systems are available in market. An android, iOS and window phone are the most popular Mobile Operating System, on the other hand black berry, symbain, bada, palm, webOs and meeGo are also Mobile Operating Systems.

As the book scope is restricted to Mobile Operating System, here we will learn Embedded Operating system in the concern with Mobile Operating System.

All Embedded OS has following functions in addition to generalize operating system:

> An embedded OS works on small scale devices. Power management is primary function of embedded work.

> An embedded OS has technique to manage tasks with limited memory.

> An embedded OS must work on a microcontroller or microprocessor.

> An Embedded system is inbuilt with hardware and software where the hardware is used for security and performance and Software is used for more flexibility and features.

1.3.5.1 Advantages of Embedded Operating System

> Embedded OS is combination of hardware and software thus it is easy to customize.

> Generally Embedded OS is small in size so can be loaded fast.

> Requires low cost to develop.

> Can work on low power.

> Can execute task with limited processing power.

> Works for the predefine task, thus performance is good.

1.3.5.2 Disadvantages of Embedded Operating System

> Embedded OS cannot be powerful multi-tasking.

> Troubleshooting is difficult.

> Difficult to transfer data from one system to other.

> It is difficult to update embedded OS.

1.3.6 COMPARATIVE STUDY OF TYPES OF OSs

We have seen the types of operating systems with their functions, advantages and disadvantage in the previous section. The Table-1 here shows that the applicability of OS to applications.

Type of Operating System	Applicable to which type of application
Multi Tasking OS	When a user wants to open and work simultaneously on many windows on the single system.
Network OS	When user want to remote login to a system, transfer a file or share resource on the network.
Distributed OS	When computational speed and resource sharing is required.
Real Time OS	Applicable to systems which require time bounded responses.
Embedded OS	Specialized systems with memory, power and processing restrictions. Used in consumer electronic items, mobile phone etc.

Table-1 Applicability of OS to applications

1.4 LET US SUM UP

In this unit we learnt about the working methodology of generalized operating systems. Let's quickly review the main points of the unit.

- ➢ An operating system is software that acts as an interface between the user and hardware of the computer systems.
- ➢ An operating system is a resource manager that in background manages the resources needed for all the applications run on it.
- ➢ We learnt main functions of generalized operating system. It is divided in two views: User view functions and System view functions.
- ➢ Multi - Tasking operating system work on time sharing concept. The switching between the processes is too fast so it seems like a Multi-Tasking.
- ➢ Network operating system used to manage network resources like computer nodes, printer and other devices.
- ➢ Distributed operating is used to serve multiple applications and users through multiprocessor.

> To handle the on time situation and give immediate response, we used Real Time operating system.

> Embedded operating system is system which is made to handle specific tasks.

1.5 CHECK YOUR PROGRESS

Give the answer of the following MCQ.

1. When a user wants to open and work simultaneously on many windows on his system, _____ OS is chosen.
   A. Real time   B. Batch
   C. Multi user   D. Multi tasking

2. When computational speed and resource sharing is required and implemented through combining multiple computer system in a network, _____OS should be chosen.
   A. Real time   B. Distributed
   C. Networking   D. Embedded

3. Symbian OS is used in _____ types of applications.
   A. Real time   B. Batch
   C. Networking   D. Embedded

4. _____ OS should be chosen on systems that require time bound response.
   A. Real time   B. Batch
   C. Networking   D. Embedded

5. _____ OS should be chosen in consumer electrics items, mobile phone, smart cards, etc.
   A. Real time   B. Batch
   C. Networking   D. Embedded

6. User Interface is a function of _____.
   A. User View   B. System View
   C. Both   D. None

7. Two types of Real time system are_____ and _____.
   A. Hard and Soft   B. Soft and Tight
   C. Hard and Tight   D. None of These

8. A software that acts as an interface between the users and hardware of the system is called _____.

A. Operating system   B. Multi tasking system

C. Multi programmed system   D. Time sharing system

9. The software that operates computer is known as _____

A. MS office   B. Complier

C. Operating System   D. None of these

10. RTOS stands for _____

A. Random Transfer Open Stack   B. Real Transform Open Schedule

C. Random Transform Office Schedule   D. Real Time Operating System

11. _____ is an example of Embedded Operating System

A. MS Windows   B. DOS

C. ANDROID   D. UNIX

12 When a user wants to remotely log on a network system to trasfer a file, _____ OS is chosen.

A. Real time   B. Batch

C. Networked   D. Embedded

1.6 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1.	D	2.	B	3.	D
4.	A	5.	D	6.	A
7.	A	8.	A	9.	C
10.	D	11.	C	12.	C

1.7 FURTHER READING

- Naresh Chauhan (2014), Principals of Operating System, Oxford.
- "Introduction to OS", https://nptel.ac.in/courses/106106144/2.
- "Embedded System", https://nptel.ac.in/courses/108102045/20.

1.8 ASSIGNMENTS

Write answers of the following Questions

1. What is the need of an operating system?

2. What are the functions of operating system from user's view point?

3. What are the functions of operating system from system's view point?

4. Explain the work of Multi-Tasking OS with advantages and disadvantages of it.

5. What are the functions of Network operating systems?

6. Explain the Distributed operating system.

7. What is Hard Real Time and Soft Real Time.

8. Explain the work of Embedded system along with advantages and disadvantages.

Unit 2: Functionalities Of Generalize Operating System

2

Unit Structure

2.1 LEARNING OBJECTIVE

After studying this chapter, students should be able to understand:

- Process management by the operating system
- Process scheduling and process life cycle
- Process Control Block (PCB)
- Concept of Threading
- Concept of Multitasking
- Memory Management
- Security objective and problems
- User management
- File management

2.2 INTRODUCTION

In the previous chapter we have discussed about the basics of operating system. The main functions of operating system are process management, memory management, security mechanism, user management, file management and device management.

In this chapter we will learn about all the functions performed by OS in detailed. We start with process management. Process refers to any activity done by an OS. As modern operating system provides multi-tasking environment, operating system need to manage number of processes that exist at the same time. OS needs to manage inter process communication, creation of process and status of process from creation to destruction. Operating system implements the multitasking concept by implementing the threading mechanism. The multi-tasking operating system needs to handle memory management. The multiple processes exist in the memory, each process demands memory dynamically. So operating system needs to make partition the memory to be allocated and to be reallocated. This memory partition needs to manage by the operating system.

The user of operating system stores the data in to the secondary device, generally in hard disk. This data is in the form of files and stored in hard disk. Without any proper mechanism it is too difficult to retrieve it from secondary device.

File system is the convenient mechanism to store data file in proper format. Computer system is accessed by the user. Each user has specific privilege to access set of resources and files. Operating system needs to manage its user to provide privilege for the resources. At the end we will discuss about the security issues of the computer system. We will also discuss the protection mechanism against the security threats.

2.3 PROCESSES MANAGEMENT

2.3.1 WHAT IS PROCESS

Process is the instance of the program that needs to execute. The program is the passive / static entity whereas process is the active / dynamic entity. When program is loaded in to main memory along with data it becomes, process. Before moving into the detail of process management we need to clear some terminologies like program, job, task and process.

2.3.2 TERMINOLOGY

Basically CPU needs set of instructions to be executed. This set of instructions is sometimes called program or job or task or process. When looked for operating system perspective each of these terms has specific meaning. The program, job, task and process are not the same for the operating system. Let's see the meaning of each of these terms and then see how a program is converted into process.

➢ **Program :**
A program is a set of instruction in the form of modules. The tem "Program" is used from the time of batch processing system. A code written in any programming (for e.g. C language) is called program. It contains only a set of instructions.

➢ **Job :**
In the batch processing system, the magnetic tapes need to be loaded and unloaded to do specific set of activities such as compiling, linking

and loading. The term "job" is used to perform the said activities required to execut the programs.

➢ **Task :**

The term "task" is used when a single processor executes concurrent program. It means a single user works on multiple programs simultaneously. For example while using a window operating system, the user opens media player, works on excels and check mails on browser simultaneously. It is also called multi-tasking. Figure-8 shows three tasks being performed on an OS.
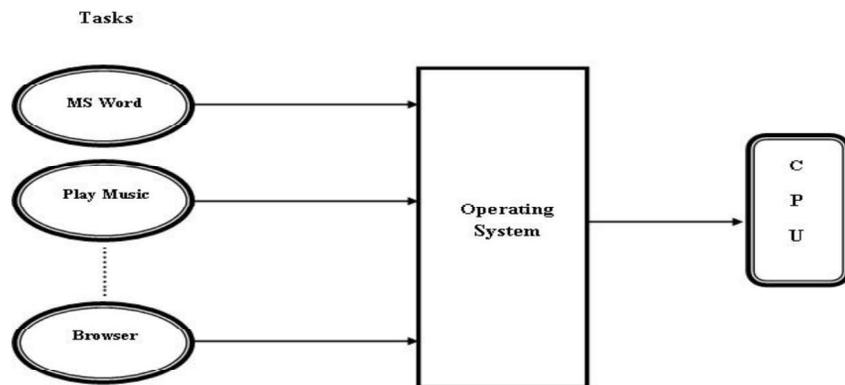

Figure-8 Multi-Tasking

➢ **Process :**

The Process is different from "Program" and "Job". When a program that is ready to execute, is loaded in to memory, it is called process. A program, ready to execute, is able to compete for the resources. The resources such as CPU time, memory, I/O devices and so on.

When a process gets CPU time, it requires several other things to complete the activity, this all things make process environment. The process environment has Program counter (PC), code section, data section, CPU registers and stacks. Figure-9 shows a glimpse of process environment.
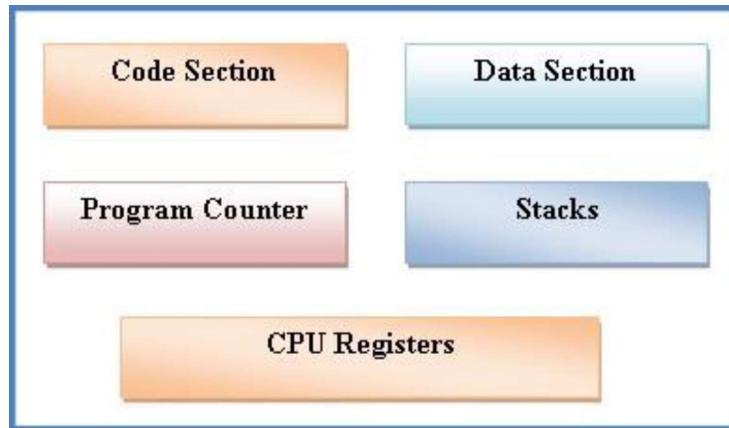
Figure-9 Process Environment

The Program counter is used for moving to next instruction when performing sequential execution. Data section stores the value of global and local variable of program. Code section stores the instruction of program along with program counter. CPU register and stacks are used to store data.

The Table-2 below shows the difference between program and process.

PROGRAM	PROCESS
It is a collection of instructions(Code Section) only	It is a collection of instruction (code section), data section, stacks, CPU register and Program Counter (PC).
It is Passive or Static entity	It is Active or Dynamic entity
It never compete of resources	It compete for resource.

Table-2 Program v/s Process

2.3.3 PROCESS SCHEDULING

After understanding the basic difference between program and process, now it's time to know how program gets converted in to process.

A program ready to execute is called job. When the job is ready to execute it is appended in the queue, call job queue. The job queue is placed in the hard disk. Then particular job is selected from the job queue and loaded in to the main memory through job scheduling. As soon as job is loaded in to the main memory it becomes a process and is stored in process queue. All the process placed in queue is called

ready queue and they all are in waiting for their turn for CPU allocation. All the processes in ready queue are competing for CPU and other system resources. The process from ready queue is selected for the CPU execution and process is transferred from the main memory to CPU. The activity of selecting next process for execution is called process scheduling. It also called CPU scheduling. The scheduling functions are performed by scheduler. Figure-10 shows how the process scheduling is done.
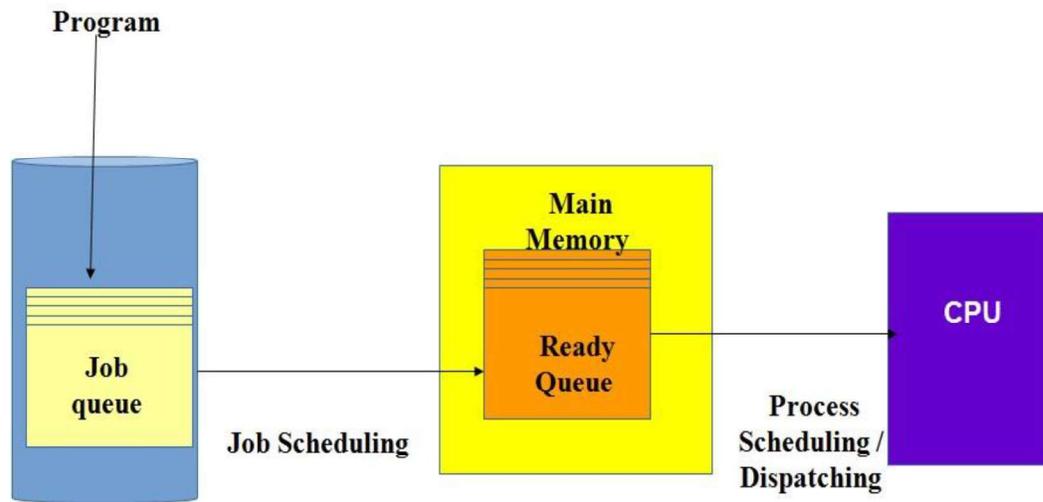

Figure-10 Process Scheduling

The scheduler use scheduling algorithm to select process from the ready queue and transfers it in to CPU. Various kind of scheduling algorithms are used by modern operating system depending upon their process management scheme. Although most widely used scheduling algorithms for the generalize operating systems are as follow:

➢ First Come First Served (FCFS)
➢ Priority Scheduling
➢ Shortest Process Next (SPN)
➢ Shortest Remaining Time Next (SRT)
➢ Round Robin

2.3.4 PROCESS LIFE CYCLE

As we know that the process is active / dynamic entity, it changes its status periodically. It passes through various states from its creation to destruction.

The process life cycle is divided into five states that are as follow:

➢ **New:**

Whenever new job is appended into job queue, the process at that instance is in "new" state. At this time process is still on secondary memory (Hard disk).

➢ **Ready:**

When job is selected from the job queue and transferred into main memory in ready queue, the process is in its "ready" state. At this point the process is ready to be executed.

➢ **Running:**

Scheduler selects particular process from the ready queue and dispatches it to CPU for execution, at this time process is in its running state. The process in running state competes for the system resources. In this state CPU executes instruction of the process. The process may not remain in the CPU till it executes all instructions. Whenever time quantum gets completed, CPU takes away the running process and chooses next ready process for execution.

➢ **Blocked:**

During the execution of the process, it may encounter an instruction where it needs to wait for I/O devices or some other event. In this case CPU will take away the process and CPU is given to other ready state process. Therefore a process that is waiting for the I/O device and taken away from the CPU is in its blocked state.

➢ **Terminated:**

Once the process has executed all its instruction and is about to complete it in a "terminated" state.
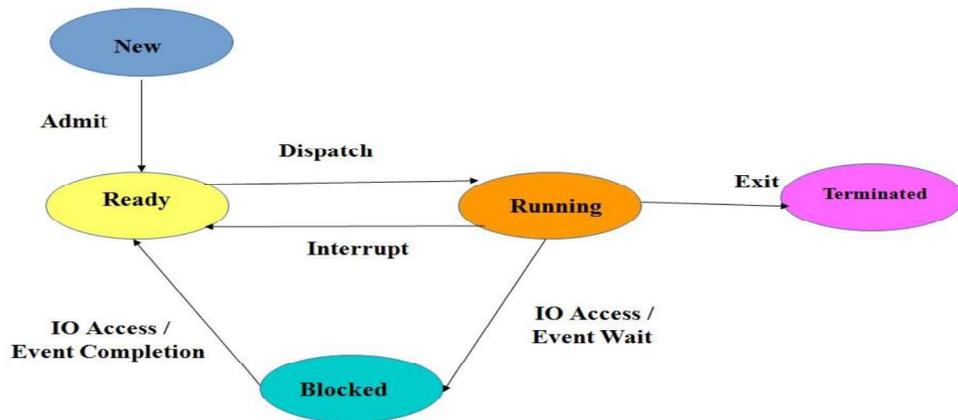
Figure-11 Process Life Cycle

Figure-11 shows the states and event execution during the process life cycle. The process changes its state whenever an event occurs. The event causes state transition. There are four events, which help in state transition of the process. The events are:

➢ **Admit (New State To Ready State)**

The event takes place when process transfers from secondary memory to main memory.

➢ **Dispatch (Ready State To Running State)**

This event transfers the process to the CPU for execution.

➢ **Interrupt (Running State To Ready State)**

The running process may be pre-empted from the execution by some other process. It may happen due to several reasons. In such a case running process needs to transfer from running state to ready sate.

➢ **IO or Event Wait (Running State To Blocked State)**

The running process reaches an instruction that needs requires it to wait for the I/O devices or event. At this time, the wait event transfers the process from the running state to blocked state.

➢ **IO or Event Wait Completion (Blocked State To Ready State)**

When the blocked process's wait is over, It is assumed to have accessed the I/O device or served by event which it was waiting has been over. At

this time wait completion event transfers process from the blocked state to ready state.

> **Exit (Running State To Terminated State)**
>
> When running process completes execution of all instructions, the exit event changes its state from running to terminated.

2.3.5 PROCESS COTROL BLOCK (PCB)

As already discussed the process environment consists of code section, data section, CPU registers and program counter. But these are not sufficient to manage the process. The operating system requires some additional attributes to control and manage processes. All these attributes stored in a stack, known as Process Control Block (PCB). It also called Process Descriptor.

Each process has its own PCB. That means when new process is created its PCB is created and when process is terminated the PCB is terminated. The PCB is responsible to manage and control its process during the process life cycle. It stores all the relevant data which is needed by the process during the life time. Figure-12 shows the stack of Process Control Block.
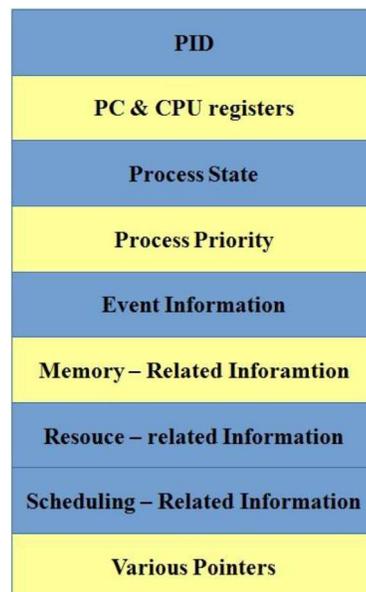

Figure-12 Process Control Block

The PCB stores the following details related to its process:

➤ **Process ID:** Process ID (PID) is the unique number to identify the process.

➤ **Program Counter:** It shows the address value at which next instruction of the process will be executed by the processor.

➤ **Registers:** It is used to store the data during the execution of process. Various kinds of registers are there like data registers, address registers, and control / status registers. They are used to store data during process execution.

➤ **State:** It indicates the current state of the process, and is used in process scheduling.

➤ **Priority**

Each process has its priority number, based on it scheduler gives preference to a process. High priority process will execute first.

➤ **Event Information**

Process life cycle passes from one state to other state using event. The event related information is stored here.

➤ **Memory Related Information**

Memory uses various kinds of registers and tables during life cycle. The information related to memory which is used by process is mentioned here.

➤ **Resources Related Information**

The process may need to access the system resources. These resources related information is listed here.

➤ **Scheduling Related Information**

The process executes based on scheduling algorithm. All the scheduling related information like waiting time of process, execution time of process etc. is stored here.

➢ **Pointers**

The parent process pointer, child process pointer, pointer to process's instructions and pointer to process's data are stored here.

Till this point we must have understood process creation and management, life cycle of process and process control block. These are the fundamental concepts of process management. Now we need to go in details of working of operating system.

2.4 THREADING

While learning the basic concept of process management, we should know that the CPU executes one process at a time. It means CPU is single tasking but the switching between the processes is so fast that we feel that it's multitasking. While switching between the processes the os requires storing the last values of attributes in PCB of the existing process and restoring the values of the attributes from PCB for an entering process. This entire sequence is called context switching. In the process management the context switching time is proportional to the frequency of processes arrived in scheduling. High context switching time incurs in terms of the system's performance.

In the evolution of the operating system, the need of operating systems which can respond very fast and has higher efficiency has increased. Both the requirement is fulfilled by the concept called threading. It is also called multi-threading concept.

2.4.1 WHAT IS THREAD

The thread is the path of execution within the process. A process can contain multiple threads. Thread has same properties as the process has. The idea of parallel computing is achieved by multi-threading concept. The process is divided into multiple threads. For example multiple tabs in browsers can be different threads. Thread is called light weight process.

The threads of same process can share some information of process like code section, data section and status of system resources used. As result, the time required for the context switching is less and performance of operating system

increases becomes fast. The main advantage of thread is that it minimizes the context switching time.

To manage the thread it requires the same attributes as process requires. All the required attributes are stored in the thread related structures, called Thread Control Block (TCB). The names of attributes are TID, PC, Registers, State, Priority, Event Information, Scheduling Information and TCB pointers. Figure-13 shows three threads within the process.
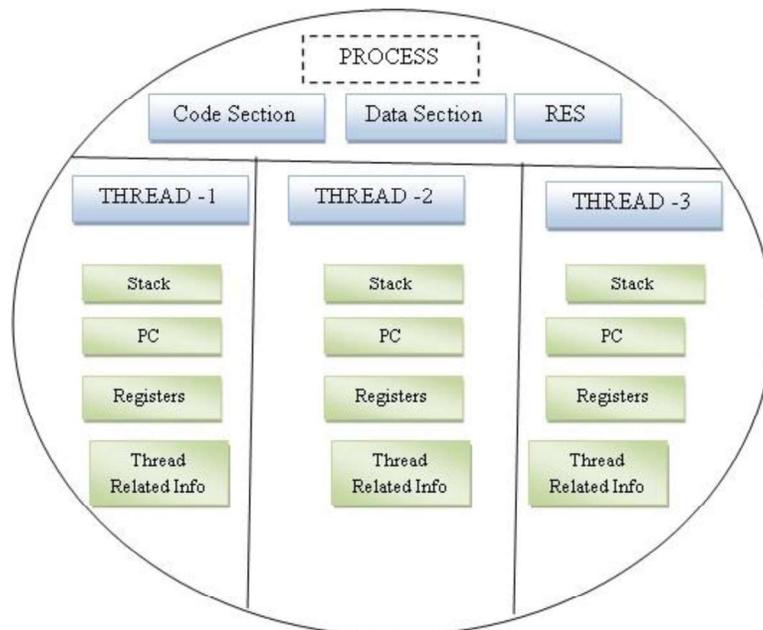
Figure-13 Process Having Three Threads

Threads are implemented in two ways:

➢ **User Thread**

The user thread is managed by the application in the user space of operating system. It is created and managed by thread library which is provided by the operating system. The thread library contains code for creating and destroying threads, for passing messages and data between threads, for scheduling thread execution and for saving and restoring thread contexts.

➢ **Kernel Thread**

The kernel thread is managed by the kernel of the operating system in the kernel space. Kernel threads are supported directly by the operating

system. The Kernel performs thread creation, scheduling and management in Kernel space.

2.4.2 PROCESS VS THREAD

The Table-3 shows the difference between Process and Thread.

Process	Thread
Process requires more resources than thread.	Thread requires fewer resources than process.
Process switching needs interaction with operating system.	Thread switching does not need to interact with operating system.
Multiple processes cannot share data and code section.	Threads can share data and code section.
In multiple processes each process operates independently from the others.	One thread can read, write or change another thread's data.
If process is in block state, it will not execute until the process is unblocked.	If one thread is blocked, a second thread of the same process can run.

Table-3 Process v/s Thread

2.5 MULTITASKING

The multitasking concept is somewhat different from multi-threading. We have already discussed about the multi-tasking operating system in previous unit. The multi-tasking is implemented at the process level whereas multi-threading is implemented at the thread level. Modern operating system achieves multitasking by using multithreading.

2.6 MEMORY MANAGEMENT

Multi-tasking operating system raises the issue known as memory management. Process management to work properly needs support from memory management. Each executing process needs memory. So it is essential for the operating system to keep track of memory to be allocated to process and a memory

which is free. Memory management needs to decide which process will get memory at what time and which memory will be freed by the processes.

2.6.1 STATIC AND DYNAMIC MEMORY ALLOCATION

Memory is the resource of the computer system, which needs to be divided and allocated to ready process. This allocation needs to perform in such a manager that memory and CPU can be utilized efficiently.

Memory allocation is performed by two methods:

➢ **Static Allocation**

The allocation is done before the execution of a process is called static allocation. It happens when the location of the process in the memory is known at compile time, the compiler generates an absolute code for the process.

➢ **Dynamic Allocation**

If the memory allocation is done during the process execution it is called dynamic allocation.

2.6.2 LOGICAL AND PHYSICAL ADDRESSES

All the modern operating system works based on dynamic memory allocation. Let us learn how dynamic memory is allocated by the operating system to running process. In the dynamic allocation, the place where memory for the process will be allocated is not known at the compile time and load time. The CPU at compile time generates some addresses, known as logical addresses. These logical addresses need to be converted into absolute addresses at the time of execution of the process. The absolute addresses are known as physical addresses. The dynamic memory management of the operating system performs the conversion of logical addresses into physical addresses. Through the dynamic memory allocation technique, operating system allocates memory to process as and when it is required at run time. It is the best way to manage memory dynamically.

2.6.3 SWAPPING

In modern operating system, due to multitasking at times no memory is available for execution of new processes. In this case the best solution is to take out

a process from the memory, and allocate the available memory to new process. This process is called swapping.

Here new issues are raised as to which process should be taken out from memory and where it will be placed? Well we can take out a process which has low priority or is blocked or stands last in queue. The process will be placed it in secondary memory (Hard disk).

The action of taking out a process from memory is called swap-out, and the process is known as a swapped – out process. The action of bringing back the swapped-out process into memory is called swap-in. the entire action is called swapping. A separate space in the hard disk, known as swap space is allocated by Os to perform the swapping activity. Swapping is the technique which is used by operating system to manage memory efficiently.

2.7 SECURITY

Security is the most important parameter for the modern operating system. In this section we will discuss about the objective of security and protection mechanism adopted by the operating system.

2.7.1 SECURITY OBJECTIVES

The basic security concepts that need to be taken care by the operating system are as mentioned:

➢ **Confidentiality**
  It refers to protection against disclosure of information to any unauthorized entity.

➢ **Authentication**
  It refers to validity of a message, it means the information received by the receiver has originated from a specific known sources.

➢ **Integrity**
  It refers to protection against the altered message in transmission.

- **Authorization**

  It refers to the process, through which a requester is allowed to perform operation.

- **Availability**

  It refers to the information and communication services that are available for user to 24*7.

2.7.2 SECURITY PROBLEMS

The lack of security could be extensive and can cause loss of information, corruption of data, privacy violations and so on. The main security problems are categories in three parts as under:

- **Unauthorized Disclosure**

  It is a threat to confidentiality of a system. In communication, an unauthorized node receives the sensitive data that are supposed to have been transferred between two authorized parties. This activity is known as interception.

  An unauthorized entity may infer the information, by observing the traffic in a network, or from a database, and disclose the same. It is known as inference.

- **Deception**

  It is a threat to the integrity. An unauthorized entity may pose to be an authorized one and attempts to gain access of the system. This attack is known as interception. A file or database may be altered or some data may be replaced with false data. This attack is known as falsification. A user may deny that he has sent or received data. This attack is known as repudiation.

- **Disruption**

  It is a threat to the objective of availability. For instance, a system receives so much data that the communication system is not able to handle them, thereby, interrupting the operation on the system. This attack is known as denial – of – service (DoS)

2.7.3 PROTECTION MECHANISMS

There are various kinds of resources available in the computer system. Operating system need to implement effective protection mechanisms to protect the resources. The protection mechanisms are based on two principles:

➤ **Need to Know Principle**

It state that unless a user has a specific reason to access a piece of information, the permission to access is denied.

➤ **Principle of Least Privilege**

It states that a process or user must be able to access information or resources that are necessary for its legitimate purpose.

Various kinds of protection models are used to implement the protection mechanisms. The techniques are Access Control Model, Access Matrix Model, Access Control Lists (ACL), Capability List (C-lists) and so on.

2.8 USER MANAGEMENT

The operating system needs to determine the identity of the user at the time of logging. This process is called authentication. An authentication has two steps:

➤ **Identification**

It refers to a unique identifier allocated to the user for authentication.

➤ **Verification**

Here, the verification of user is performed, that is, conformation which binds the user and the identifier.

Operating system authenticates the user when they login which is based on either password, PIN, biometrics identity, token, smartcard, OTP, key or patterns.

2.9 FILE MANAGEMENT

Operating system uses File System to manage the files in the computer system. File system is the convenient way to store and retrieve the data. Files are used to

store related information and are mapped to the hard disks or other storage media by the operating system.

The information stored in a file is in bits, bytes, lines or records. File system has two views: Logical View and System View. The user only sees the logical view of the file. The work of system views is to map the logical file to the secondary storage.

The following are the primary elements of a file system:

➢ **File Management:** It manages how the files are stored, referenced, shared and secured.
➢ **File Allocation:** It provides the methods to allocate files on the disk space.
➢ **File Access Methods:** It provides the methods to access stored files.

The Files can be accessed by the any of the following technique:

➢ **Sequential File Access:** By this technique file is accessed in the sequential manner, it means it can access in the same order as it is stored.
➢ **Indexed Sequential File Access:** It is a combination of sequential and random access mechanism. The key field is maintained in sequential manner, based on key filed the pointer of main file moves to read write operations.
➢ **Indexed File Access:** In this type of access it is not necessary to store data in a file sequentially and to search the record by the key field. Here multiple indexes are there for each attribute, by which the user can, search a record in the main file.
➢ **Direct File Access:** Direct access is meant for a random structure of secondary storage.

2.10 LET US SUM UP

In this unit we learnt about the concepts of process management, Threads, Multitasking, Memory Management, Security, User Management and File management.

Let's quickly review the main points of the unit.

> ➤ Process is the instance of the program that is different from program.
> ➤ Process is dynamic entity and program is static entity.
> ➤ Process has environment that consist of PC, Code Section, Data Section, and CPU Registers.
> ➤ Process scheduler selects process for the next execution.
> ➤ Process life cycle shows the states of process and events that passes through.
> ➤ Process related data is stored in Process Control Block (PCB)
> ➤ Thread is the path of execution within the process. A process can contain multiple threads.
> ➤ Thread related data is stored in Thread Control Block (TCB)
> ➤ Memory can be allocated in two ways: static allocation and dynamic allocation.
> ➤ Each modern operating system need to focus on security objectives and its problems.
> ➤ The modern operating systems are also responsible to manage users and files.

2.11 CHECK YOUR PROGRESS

Give the answer of the following MCQ.

1. Process is _____ of the program.
2. A _____ is a set of instructions in the form of modules.
3. Compiling, linking and loading activities are done by _____.
4. PC stand for _____.
5. Program is _____ entity.
6. Process is _____ entity.
7. When job is loaded into the main memory, it becomes _____.
8. A process selected for next execution is called _____.
9. FCFS stands for _____.
10. SPN stand for _____.
11. A process is transferred from New state to Ready state by _____ event.

12. A process is transferred from Running state to Ready state by _____ event.

13. PCB stands for _____.

14. TCB stands for_____.

15. The memory allocation done before the execution of a process is called _____ allocation.

16. _____ refer to protection against disclosure of information to any unauthorized entity.

17. The ACL stands for _____.

18. _____ refers to protection against the altered message in transmission.

2.12 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1. Instance	2. Program	3. Job
4. Program Counter	5. Static	6. Dynamic
7. Process	8. Process Scheduling	9. First Come First Server
10. Shortest Process Next	11. Admit	12. Interrupt
13 Process Control Block	14. Thread Control Block	15. Static
16. Confidentiality	17. Access Control List	18. Integrity

2.13 FURTHER READING

- Naresh Chauhan (2014), Principals of Operating System, Oxford.
- "Introduction to OS", https://nptel.ac.in/courses/106106144/2.
- "Process and Thread Management", https://www.youtube.com/watch?v=OrM7nZcxXZU.
- "memory management in operating system", https://www.youtube.com/watch?v=W0068fRJTGQ.

2.14 ASSIGNMENTS

Write answers of the following Questions.

1. What is process? How is process created?
2. Explain Process life cycle with diagram.
3. Write a short note on Process control block.
4. What is Threading? Explain how it is different from process.
5. How memory management is done the operating system.
6. List the security objectives need to be taken care by operating system.

Unit 3: Operating System Structures

3

Unit Structure

3.1 LEARNING OBJECTIVE

After studying this chapter, students should be able to understand:

- General terms of operating system
- Booting sequence of operating system
- Concept of system call
- Monolithic architecture of operating system
- Microkernel architecture of operating system
- Exokernel architecture of operating system
- Hybrid architecture of operating system

3.2 INTRODUCTION

In above unit-1 we discussed about the basic functions of OS along with types of operating system. Now it's time to learn: How does operating system start? How does it initialize hardware? Which kinds of architectures are followed by generalize operating systems?

Booting is the first process of the operating system through which entire environment is setup. After completion of booting process, OS system starts its initial processes and handsover the control to user by providing user interface. Operating System needs to work with hardware on behalf of user and provide back results which generated by hardware. To work with hardware, operating system uses various kind of system calls. At end of this unit we will discuss about the various architectures which have been developed over time. Before delving into booting process of operating system, there are some basic concept that needs to be understood.

3.3 GENERAL TERMS OF OPERATING SYSTEM

➢ **BIOS**

Basic Input-Output System (BIOS) is responsible for performing basic input – output operations. These operations are low level routines that are used by OS to interact with I/O devices such as keyboard, mouse, monitor etc. Later on we will see that BIOS is responsible to initialize the loading

process of OS to main memory (RAM) from secondary memory (Hard disk).

> **Bootstrapping**

The OS is stored on hard disk. We need to load OS from hard disk to the main memory (RAM). To do the same we need to execute a set of instructions that load the OS onto memory. The entire execution process of loading OS from secondary memory to main memory called Bootstrapping or Booting process.

> **Boot Loader / Bootstrap Loader**

The set of instructions that load OS from hard disk to memory is known as Boot Loader / Bootstrap Loader. Sometime it is also called Boot Software.

> **Boot Device**

The Operating System is permanently stored in secondary memory. The secondary memory can be hard disk, CD, Pen Drive or any external device. The device that stores the OS is called Boot Device.

> **Boot Sector**

BIOS contains a program that loads the first sector of the boot device which is called Boot Sector. It is called boot sector because of its location. It is located in the first sector on hard disk (Sector 1, Cylinder 0, and Head 0). It is also called Master Book Record (MBR). Generally boot sector is the part of hard disk with size of 512 bytes. In the MBR the first 446 bytes are the primary boot loader, which is also referred as PBL. The next sixty-four bytes are the partition table, which has the record for each of the hard disk's partitions. The MBR ends with two bytes that should be 0xAA55. These numbers act as validation of this sector indicating that it is the boot sector or Master Boot Record.

- **Privileged Instructions**

  OS's user is not allowed to access attached devices directly. If a user wants to access device and get some result, He / she need to pass the instruction to the operating system. On the behalf of the user, operating system interacts with the device and gives the result to the user. Thus this kind of instructions which are not directly executed by the user but needs to pass by the OS, are called Privileged Instructions.

- **System Call**

  All the Privileged Instructions that need to interact with hardware and other resource are known as system calls. For example when a user wants to display some text on monitor, he/she need to write some output instructions in proper format. This instruction program is called system call.

3.4 GENERAL BOOTING SEQUENCE

Generally booting process is dependent on operating system. It varies with types of operating systems. Here we are going to discuss the general booting sequence. Following steps shows how the operating system can be loaded and start operating.

Step – 1:

Turn on the CPU button. Whenever the computer is switched on, all CPU pins and registers are reset to specific values and the control is transferred to the BIOS in the ROM or flash-RAM.

Step – 2:

The first job of the BIOS is to initialize and identify system devices such as the keyboard, mouse, monitor, video card, hard disk etc. This initialization process is called Power on self-test (POST). Power on Self-Test is the foremost routine which checks and tests the basic hardware. If it fails, it will display error.

Step – 3:

After the execution of POST, the BIOS determines the Boot Sector (or Master Boot Record) and reads it. This boot sector contains a program called MBR. It copies MBR to RAM. The MBR first examines the partition table and determines which partition is active.

Step – 4:

In the particular partition, there is a boot loader / bootstrap loader, which loads in to memory. The boot loader now loads operating system from secondary memory to RAM (bootstrapping).

Step – 5:

Once the operating system has loaded into RAM, the boot process relinquishes control to the operating system. After that operating system first queries the BIOS for the configuration informations. The operating system checks drivers for the attached devices and load into the kernel space.

Step – 6:

At the end system will display user login screen. The user programs are loaded into the memory as the user log in to system.

It might be noted that this sequence may slightly change in different OS.

3.5 SYSTEM CALL

We know that Privileged Instructions are called system calls. The role of system calls is important for understanding the operations of operating system. Before going into details of system calls, we need to understand the working mode of operating system.

Modern operating system have two modes – Kernel Mode and User Mode. All the user processes are executed in user mode and all privileged operations are executed in kernel mode. Many times user processes need to access system devices that need to execute privileged operations. The privileged operations are not allowed to execute in user mode, they are only allowed to be execute in kernel mode. Since operating system prevent direct access of kernel mode, problem is how user mode processes execute privileged operations.

User mode process uses the kernel mode function by a special interface. This interface permits interaction between user mode and kernel mode. This interface is called system call. In other word system call is an instruction which requests operating system to perform the specific operation that need hardware access. Generally system calls are made by the user program in the following situations:

- To create, delete or open a file in the file system.
- To create and manage new processes.
- To create network connection.
- To send and receive data packets from network
- To access hardware
- To manage main memory
- To protect the data.

3.5.1 TYPES OF SYSTEM CALLS

System calls are used to access the system resources. The type of system calls depends on the use of these resources. Basically there are five broad categories of system calls, which are as follow:

- **Device Management System Calls:**

  The user needs to access devices such as keyboard, mouse, and monitor. However, he/she cannot access them directly. These system calls are responsible for device manipulation such as reading data from keyboard, displaying data on monitoring etc. The general command related to this category are request of the devices, release of the device, read / write operation etc.

- **File Management System Calls:**

  The user store his/her data in various kind of files. User needs to create, update, open, close, read, write or delete a file in the computer system. The user thus needs to access this resource through file management system calls. These system calls are responsible for file manipulation such as creating a file, reading a file, writing into a file etc.

➢ **Communications System Calls:**

In computer system, processes need to communicate internally. All the communication operations are performed by the communications system calls. These system calls are useful for inter process communication. They also deal with creating and deleting a communication connection.

➢ **Process Control System Calls:**

The process is the basic entity in the operating system. The process needs to be created, deleted or aborted. All the process management are performed by the process control system call. These system calls deal with processes such as process creation, process termination and other activities.

➢ **Information Maintenance System Calls:**

Information Maintenance system calls are for accounting and providing information to the user. Such information can be about a process, memory, hard disk space, operating system, computer system etc. These system calls handle information and its transfer between the operating system and the user program.

3.6 ARCHITECTURE OF OPERATING SYSTEM

To get efficient performance from the operating system, it should be partitioned into subsystems. This sub systems are separated based on its tasks, inputs, outputs, and performances. These sub systems can then be arranged in to architectural configurations. An Operating system works on any one architecture from the four type mentioned below:

➢ Monolithic Architecture
➢ Microkernel Architecture
➢ Exokernel Architecture
➢ Hybrid Architecture

3.6.1 MONOLITHIC ARCHITECTURE

Now we know that in the modern operating system, operating system has user mode and kernel mode. Kernel mode is use to access the hardware. The kernel has unrestricted access to all resources and hardware of the system.

The earlier operating systems were developed in the same way as a programming. The OSs has one file with all functionalities and calling each other without any restrictions. Due to limited functionalities provided by OSs, all are placed in kernel mode. This kind of structure is called Monolithic architecture.

In the early monolithic architecture, every component of the operating system was contained within the kernel. It means that all the functions were executed in single space called kernel space. The advantage of this kind of structure is that functions can communicate efficiently to each other. Monolithic architecture has drawback also, as all functionalities placed in single layer (kernel mode), it is difficult to isolate errors or difficult to modifications in a functions or modules.
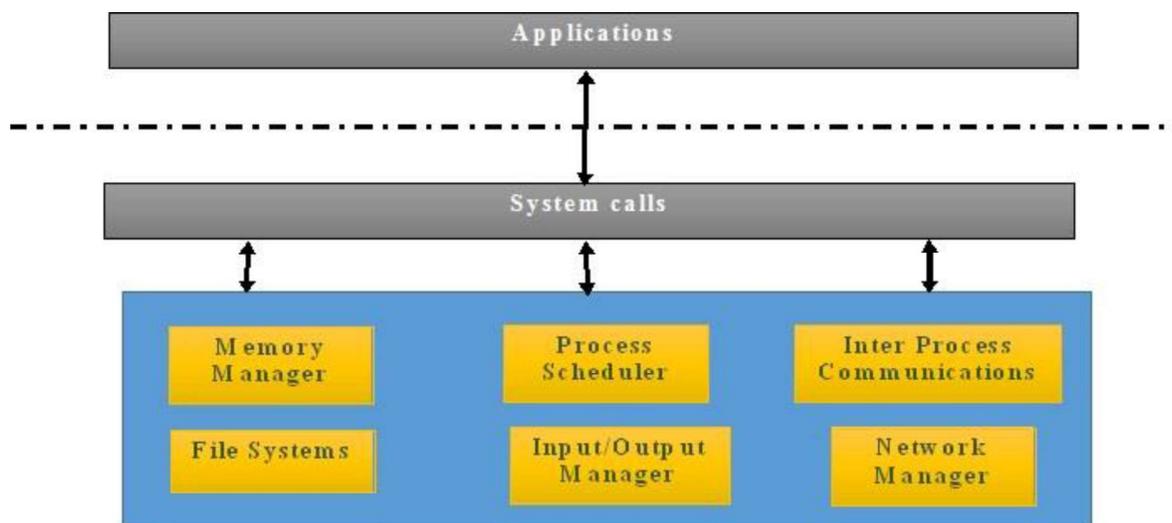

Figure-14 Monolithic Architecture

Figure-14 shows the monolithic architecture. Microsoft Window 95, Microsoft Window 98, BSDs, Solaris, DOS, initial version of UNIX and Linux are the operating system, which are built on monolithic architecture.

3.6.2 MICROKERNEL ARCHITECTURE

As operating system became larger and more complex, the size and work of kernel has also increased. Large sized kernels are difficult to maintain. OS developer also faced problem of extensibility, efficiency and reliability of kernel.

So developers tried to invent a new OS architecture that had less load in kernel mode. As a result, Microkernel architecture was developed. In micro kernel architecture very small number of essential functionalities are handled by the kernel. The kernel which manages only essential functionalities is called microkernel and architecture is called microkernel architecture. The essential functionalities may be process management, inter – process communication, memory management and so on. In this kind of architecture, other non-essential functionalities are moved up in the user mode. The non-essential functionalities may be file system management, network management, process scheduler, device manager and so on.

This kind of architecture divides the large sized kernel in to two parts: Kernel mode and User mode. Each mode has specific limited functionalities to handle. As a result, kernel (microkernel) is extensible, portable and scalable.

Microkernel architecture has been used in many operating system. Examples of operating systems that use a microkernel are - QNX, Integrity, PikeOS, Symbian, L4Linux, Singularity, K42, Mac OS X, HURD, Minix, and Coyotos. Figure-15 shows Microkernel Architecture.
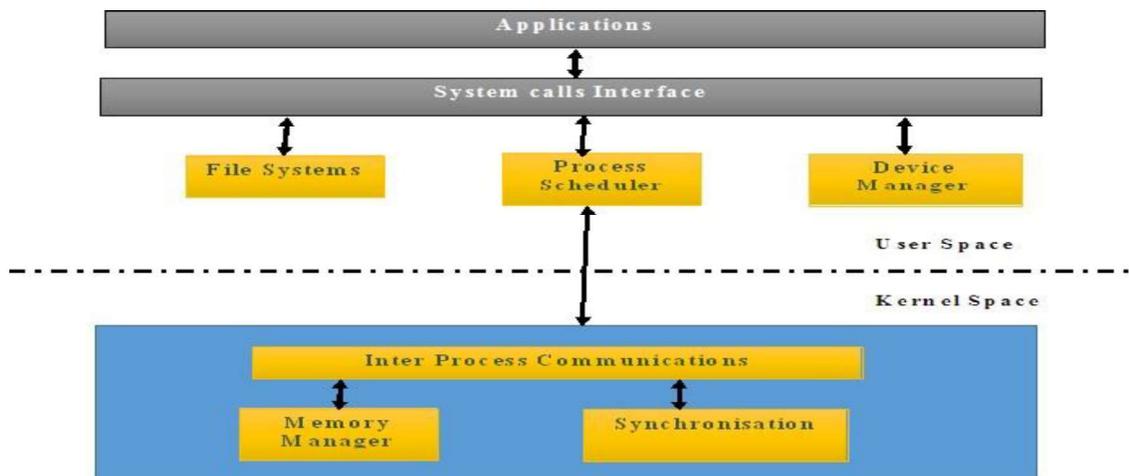

Figure-15 Microkernel Architecture

Table-4 shows the comparison between Monolithic Architecture and Microkernel Architecture.

Functionality	Monolithic Architecture	Microkernel Architecture
Work	All kind of functionalities are executed in single space called kernel space.	Essential functionalities are executed in kernel space and non-essential functionalities are executed in user space.
Size	Monolithic kernel is large in size.	Microkernel is small in size
Execution	Fast execution	Slow execution
Extensible	It is hard to extend	It is easy to extend
Security	If any service crashes, the entire system crashes.	If any service crashes, it does not effect on entire system.
Example	Linux, Free BDS, Microsoft Window 98, Microsoft Window 95, Solaris, Dos	Symbian, L4Linux, Mac OS, Minix

Table-4 Monolithic v/s Microkernel Architecture

3.6.3 EXOKERNEL ARCHITECTURE

Everyone knows that operating systems work as an interface between user's applications and hardware. User's applications need to send hardware instructions to OS, OS passes these instructions to the hardware on behalf of the user and sends back the result. This working methodology of kernel makes the lives of application programmers easier. Along with this they also realize that giving so much abstraction to the developer affects the performance of application. Applications that run on such architecture suffer with slower execution of functions resulting in performance issues.

To solve the performance issues, MIT provided new system with the concept of kernel with minimum functionality and provide access of resources to the application's developer as well. This architecture is designed to separate resource protection from management to facilitate application-specific customization. This

kernel is called exokernel. In order words exokernel work as an executive for application programs. It ensures the safe use of resources and allocates them to the applications.

Here, new concept "library OS" is introduced in exokernel architecture. The "library OS" request the exokernel to allocate resources like disk space, memory address, CPU etc. and use the resources in the way it suits the application. For an example, an application can manage its own disk-block cache. It can also share the pages with the other applications, but the exokernel allows cached pages to be shared securely across all applications. Thus, the exokernel protects pages and disk blocks, but applications manage them. Figure-16 shows exokernel architecture.
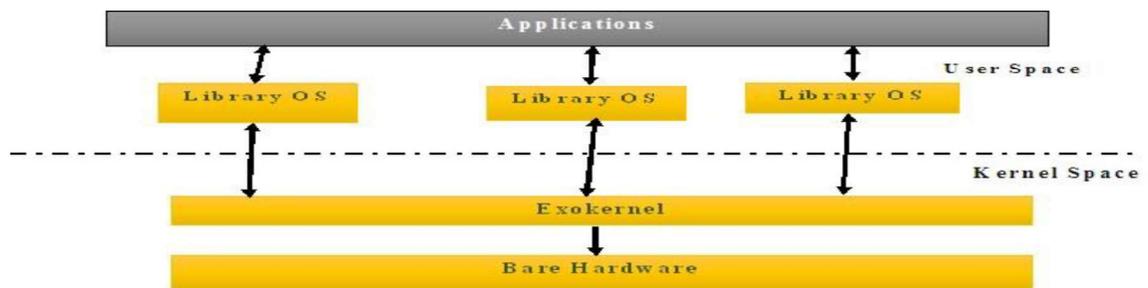

Figure-16 Exokernel Architecture

The performance of system will increase significantly by this kind of architecture. It has drawback also, its interface design is too complex and system consistency is very less. Exokernel was developed in 1994 by MIT. They developed two exokernels, namely Aegis and XOR, this concept has not been used in any commercial operating system and still research is going on.

3.6.4 HYBRID ARCHITECTURE

Many operating systems are not based on one architecutural model of the operating system. They may contain combination of architecture of multiple operating systems that have different approaches to performance, security, usability needs etc. This is known as a hybrid operating system.

A kernel having the mixed approach of various architecture is called hybrid kernel. The hybrid kernel attempts to combine the features and aspects of the microkernel and the monolithic kernel. This means that the kernel structure should

be similar to a microkernel but the structure should be implemented like a monolithic kernel.

A well-known example of the hybrid kernel is the Microsoft Windows NT kernel. It is called a hybrid kernel instead of a monolithic kernel as the emulation subsystems run on the user mode rather than the kernel mode, unlike in monolithic kernel. The NT kernel cannot be called a microkernel as well. This is because almost all the system components run on the same address space as the kernel, which is a feature of the monolithic kernel.

3.7 LET US SUM UP

In this unit we learnt about the booting sequence of operating system, concept of system call and various architecture of operating system. Let's quickly review the main points of the unit.

- ➤ BIOS is responsible for the basic input and output operations.
- ➤ At the time of switch on, the set of instructions that load operating system from hard disk to main memory is call bootstrapping.
- ➤ System call is responsible to interact with hardware and other resources.
- ➤ Device management system call, file management system call, communications system call, process control system call, information maintenances system call are the type of system calls used by operating system.
- ➤ In the monolithic architecture all kinds of functionalities are executed in kernel space.
- ➤ In the microkernel architecture only essential functionalities are executed in kernel space and non-essential functionalities are executes in user space.
- ➤ To increase the performance in the microkernel architecture, new architecture is invented called exokernel architecture.
- ➤ A kernel having the mixed approach of various architecture is called hybrid kernel.

3.8 CHECK YOUR PROGRESS

Fill in the blanks.

1. BIOS stands for _____.
2. The set of instruction that load the operating system is called _____.
3. The set of instruction that are not directly executed by the user but need to pass by the user is called _____instruction.
4. POST stands for _____.
5. Privileged instructions is also called _____.
6. To manage the attached hardware _____ system calls is used.
7. To manage the files _____ system calls is used.
8. To manage the process _____ system calls is used.
9. To manage the user _____ system calls is used.
10. _____ architecture is large in size.
11. _____ architecture is slow in execution.
12. Linux is the example of _____ architecture.
13. Mac is the example of _____ architecture.
14. Exokernel was invented by _____.
15. A kernel having mixed approach of various architecture is called _____ kernel.

3.9 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1. Basic Input –Output System
2. Boot loader
3. Privileged
4. Power on self-test
5. System call
6. Device management
7. File management
8. Process control
9. Information maintenance
10. Monolithic
11. Microkernel
12. Monolithic
13 MicroKernel
14. MIT
15. Hybrid

3.10 FURTHER READING

- Naresh Chauhan (2014), Principals of Operating System, Oxford.

3.11 ASSIGNMENTS

Write answers of following Questions.

1. Define the terms : BIOS, Boot loader, Privileged Instructions

2. Writes the steps for booting sequence.

3. What is system call? Explain types of system calls in detail.

4. Explain Monolithic architecture with diagram

5. Explain Microkernel architecture with diagram.

6. State the difference between microkernel and monolithic architecture.

Unit 4: Mobile Computing 4

Unit Structure

4.1 LEARNING OBJECTIVES

After studying this chapter, students should be able to understand:

- Architecture of wireless communication technology
- Concept of computing on move
- Basic of wireless communication standards
- Characteristics of mobile computing
- Responsibilities of mobile operating system
- Constraints of mobile operating system
- Structure of mobile computing application

4.2 INTRODUCTION

In previous units, we have learnt about the basic work of generalize operating system. In this unit we will learn about the working methodology of mobile operating system. Mobile operating system needs to perform all the activities which are performed by the generalize operating system. In addition, mobile operating system needs to handle incoming and outgoing calls, receiving notification, send and receive SMS etc. Mobile operating system also needs to identify its device's geographical location and provide computing to the mobile applications that works on geographical location. A mobile operating system controls everything from handling the input, to controlling the memory and the overall functioning of the device. It also manages the communication and the interplay between the mobile device and other compatible hardware such as computers, televisions or printers. In short mobile operating system does computing based on mobility. Here in this unit we will learn about location based computing handled by the mobile operating system.

4.3 MOBILE COMPUTING

Mobile computing is an ability to compute remotely while on the move. We can also say that computing on mobility is called mobile computing. It is also called ubiquitous computing or nomadic computing. It is a kind of technology which allows transmission of any kind of data (voice, graphics, binary or else) using wireless device. Mobile computing consists of three components:

4.3.1 Wireless Communication Technology

The wireless communication technology refers to the infrastructure that provides a faultless and reliable communication facility. The technology consists of wireless protocols, services, bandwidth and other necessary components which are required by the wireless communication.

4.3.1.1 Architecture of wireless communication technology

To set up the communication infrastructure four main components are required. The Base Station, the core network, Radio Access Network and Mobile hardware. First of all the entire coverage area is divided into small part. The small part is called Cell so it is also called cellular mobile communication. The base station (BS) is established in the center of each cell. The BS receives data from the mobile device in the cell and forwards the data to the appropriate mobile device. If the destination mobile hardware is located in other cell then BS will use "hands-off" mechanism to the destination BS. The BS keeps track of the data of all mobile hardware in its cell. The BS and mobile hardware communicates with each other over the radio access network. It is the primarily component of the BS. Figure-17 shows the architecture of wireless communication technology.
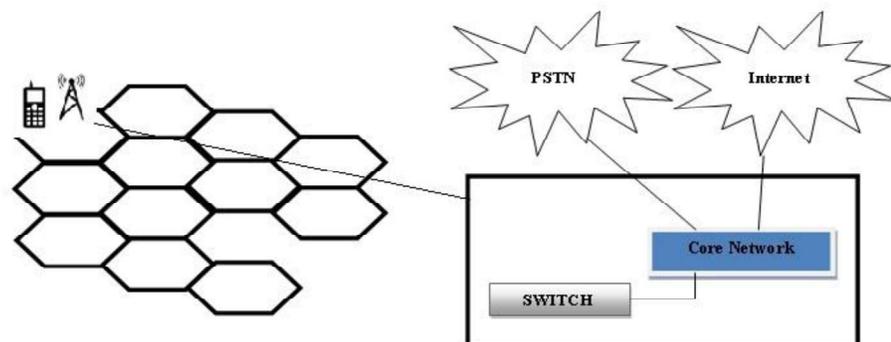

Figure-17 Architecture of Wireless Communication Technology

On the other hand, the core network interconnects with the base stations (BSs) and Mobile Switching Center (MSC). The core network also provides an interface to other networks such as traditional telephone line (PSTN) and the Internet.

4.3.1.2 Wireless Communication Standard

The wireless communication standard has developed to great extent in last five decades. The growth of standard is categorized in terms of generation. Each generation provide higher data transmission rate and additional capabilities. The Table-5 shows the summary of the wireless communication standard for each generation.

Generation	Feature	Standards	Speed
1st (1G)	Supports analog transmission Only voice communication	Nordic Mobile Telephone (NMT), Advanced Mobile Phone System (AMPS), Total Access Communication System (TACS)	600 to 1200 Bps
2nd (2G)	Digital transmission Single channel can be use by multiple user	Global System for Mobile (GSM)	9.6 Kbps
2nd (2.5G)	Supports web browsing Supports video stream	General Packet Radio Service (GPRS)	28Kbps
3rd (3G)	Supports enhanced Video stream	Universal Mobile Telephone System (UMTS),	384 Kbps
4th (4G)	IP telephony Gaming services High definition mobile TV	Long Term Evolution (LTE)	5.8 Mbps
5th (5G)	Low Battery Consumption Multiple data transfer rate	5G NR (5G New Radio)	1GBps (minimum)

Table-5 wireless communication standard for each generation

4.3.2 Mobile Hardware

Any device that can be easily carried and moved from one place to another is called a mobile device / mobile hardware. It may be laptop, PDA, Tablet, smart phone etc. These kinds of devices have a capability of sending and receiving signals. These devices can also transmit and receive signals at the same time.

4.3.3 Mobile Software

Mobile software is the program that runs on the mobile hardware. It is responsible to manage the hardware. It also deals with the requirement of mobile applications. It is an interface between mobile applications and mobile hardware. Generally, mobile software is called mobile operating system (MOS). Mobile operating system is the kernel of the mobile hardware. Android, iOS, Window Phone, BlackBerry are the example of mobile operating systems. The detailed working of mobile operating system will be learnt in the upcoming block.

4.4 CHARACTERISTICS OF MOBILE COMPUTING

Most important characteristics of mobile computing are computing on the move that is transmitting or receiving data by any or both sender and receiver even when they are in motion. The following are the some of the important characteristics of mobile computing.

➤ **Location alertness:**

A mobile device with the Global Positioning System (GPS) can provide the current location of the mobile user. Many mobile applications provide a location based services. For example cab service provides the current location of car. It also provides the traveler moving direction on real-time. The Map application provides the location based information such as fuel pump, restaurants, ATM point and many more.

➤ **Omni Presence:**

Omni presence is also called "present everywhere". Mobile computing needs to perform computing from anywhere and at anytime. A mobile user can receive the notification at anywhere at any time but within wireless coverage area.

➢ **Broadcasting:**

Mobile computing supports broadcasting characteristics. The mobile computing has capability of broadcasting messages simultaneously to thousands of mobile user. For example, all users at a specific location, such as a cab service operator may send advertising information to those who are near to the airport.

➢ **Ability to enhancement:**

Mobile computing has a capability to work in the changing environment. It adjusts to bandwidth fluctuation without inconvenience to the mobile user. In mobile computing, adjustment is crucial due to disconnections or fluctuations of bandwidth that can rise due to any reason.

➢ **Customization:**

Mobile environment can be easily personalized as per the user's profile. For example mobile user can block notification from the specific source, he/she can block message etc. This can be easily done through customization.

➢ **Library Support:**

Mobile operating systems should contain middleware libraries and frameworks with APIs which implement and abstract the functionality of the features of the mobile devices. The purpose is to provide functional consistency and to ease the software development. Middleware library and framework is a software layer that acts as a mediator between the application and the mobile operating system.

➢ **Robustness:**

A user expects a mobile operating system to be robust. This means it should be strong and unlikely to fail or crash. The device must not only be designed to avoid crash, but must also provide support functions and policies. These support functions and policies allows the device to handle application errors and out-of-memory situations, without hampering the functionalities of the Smartphone.

4.5 RESPONSIBILITIES OF MOBILE OPERATING SYSTEM

In comparison to the generalize operating system mobile operating systems have some additional responsibilities which are mandatory to be performed. The most important responsibility of mobile operating system is efficient utilization of device resources for the multiple tasks. The resources managed by the mobile operating system are processor, SD cards, files, cameras, speaker etc. Mobile OS is expected to run multiple mobile applications at the same time and each application may require one or more resources. For example mobile user can play music and at the same time he/she can take photo. Here playing music requires access to the speakers, music files with internet communication and music bits computing. At the same time user uses mobile camera to capture the photo.

The mobile operating system needs to provide highly interactive interface with the limited size of screen. Along with this, the interface needs to control the communication with the base station using the different type of communication protocols. The communication may be based on data, voice or video form. The mobile operating system offers a high resolution screen and a big / small screen size that helps user to carry out different functions easily. Some mobile device provides touch screen facility for better view and easy functioning of the device.

The mobile devices communicate with base station, computers and various types of peripheral devices. In such devices, mobile operating system requires enhanced communication support. The mobile operating system uses communication protocols depending on the generation of the communication technology like 1G, 2G, 3G etc. To communicate with the computer laptops and other devices, mobile OS needs to support TCP/IP and other wireless protocols. To communicate within small range it supports Bluetooth and multiple interfacing protocols and hardware interfaces.

The mobile operating system provides support to a various types of input mechanisms. The user can give input by the use of small touch on screen or using querty keyboard. The input comes from the attached device such as thumb scanner, cameras or any kind of attached sensors.

Various mobile applications run on the mobile operating system. Basic applications like address book, messaging, map, phone book etc need hardware access. All the installed mobile applications are managed by the mobile operating system.

The mobile operating system also manage incoming and outgoing calls The user can manage multiple calls (conference calls) and concurrent calls on the mobile device with the help of User Interface (UI). The mobile operating system allows you to record the calls in digital format and save them to your computer.

Latest mobile device identify its location using GPS. The GPS (Global Positioning System) feature present in the mobile device helps users to get driving directions, point of interest in the locality, or search businesses by using the gadget. By managing this facility actual implement of mobile computing is achieved by the mobile operating system.

Mobile device has a feature like inbuilt digital high resolution camera and voice / sound recorder. User of the mobile device can take video using such inbuilt device. The Mobile operating system need to provide a support to share the captured video as Multi Media Message (MMS) using email, Bluetooth or other communication technology / software. The mobile OS also manage the facility of sending and receiving the text messages.

Mobile operating system uses memory for the various tasks. This is an important responsibility of mobile operating system. The RAM (Random Access Memory) is the physical location in the chip where the mobile operating system and other applications run. The RAM size for a mobile device can be small, so mobile operating system manages it in efficient manner. Besides the Ram, users can add flash memory for storing their data like contact details, songs, video recording etc. Flash Memory in a mobile device is either inbuilt or can be installed as an add-on.

An important responsibility of mobile operating system is synchronizing data with a computer. Most of the mobile device comes with the facility to synchronize to a PC. This feature allows maintaining the latest contact information, mails stored on software.

4.6 SPECIAL CONSTRAINS FOR THE MOBILE OPERATING SYSTEM

The operating system for a mobile device needs to work in presence of many types of constraints which are not faced by the generalize operating systems. Some of the important constraints of the mobile operating system are as under:

➢ **Limited Battery Power**

Mobile device receives the power supply from the battery. The battery power is limited and drains fast if we make extensive use of mobile device, so mobile operating system needs to minimize power consumption.

➢ **Limited Processing Power**

Majority of the mobile device have ARM based processors. These processors are certainly energy efficient, powerful and cheaper compared to the desktop processors yet these are significantly slower.

➢ **Limited Memory**

Mobile device usually have small size of memory as compared to general computer system. To cope up with this condition mobile operating system itself is of small size and yet provides a rich set of functionalities to meet users demand.

➢ **Limited Screen Size**

The mobile screen size is small compared to laptop or desktop computer. Mobile operating system needs to support innovative user interface to overcome this to minimize user's inconveniences. The mobile operating system should take minimum input from the user interface.

➢ **Bandwidth fluctuation**

Mobile device communicate with other devices with the use of wireless medium. A wireless medium is directly susceptible to atmospheric noise and there by causes high bit error rate. In addition, bandwidth of wireless medium may have fluctuation randomly due to atmospheric noise, movement of objects.

- ➢ **Small size of keyboard**

    The mobile device provides very small sized keypad or display touch screen based keypad. In both the interface, typing in the documents is difficult. To overcome this limitation mobile operating system provides a facility of the word completion prompts.

4.7 STRUCTURE OF MOBILE COMPUTING APPLICATIONS

One of the most important responsibilities of mobile operating system is to run the mobile applications. The mobile operating system need to run mobile application onto hardware; manage the middleware components and user interface. Generally mobile application is structure is three tire, namely presentation tier, application tier and data tier.

Presentation tier focuses on user interface. A good user interface facilitates the users to issue requests and to present the results to them meaningfully. The application tier is responsible to make logical decisions and perform calculations. It also moves and processes data between the presentation and data layers. The application tier is the heart of the application. The data tier is responsible to provide the basic facilities of data storage and manipulation.

4.8 LET US SUM UP

In this unit, we have learnt about mobile computing. Let's quickly review the main points of the unit.
- ➢ Mobile computing is an ability to compute while on the move.
- ➢ The wireless communication technology is refers to the infrastructure based on reliable communication technology consisting of wireless protocols, services, bandwidth and other necessary components.
- ➢ To setup the communication infrastructure four main components are required: Base Station, the core network, Radio Access Network and Mobile hardware.
- ➢ Mobile communication standards start from 1G and latest implement is 5G.

- Mobile computing has some characteristics like location awareness, omni presence, broadcasting, ability to enhancement, customization, library support and robustness.
- Mobile operating system has some constrains like limited battery power, limited processing power, limited memory, limited screen size, bandwidth fluctuation and Small size of keyboard.

4.9 CHECK YOUR PROGRESS

Fill in the blanks.

1. Mobile computing is computing on _____.
2. Mobile computing is also called _____ or _____ computing.
3. The primary work of wireless communication technology is to transmit _____.
4. BS stands for _____.
5. The _____ receives data from the mobile device in the cell.
6. MSC stands for _____.
7. First generation wireless communication standard support speed between _____ to ____BPS.
8. GPRS stands for _____.
9. LTE stands for _____.
10. GPS stands for _____.

4.10 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1. Move
2. Ubiquitous, nomadic
3. data
4. Base Station
5. Base Station
6. Mobile Switching Center
7. 600, 1200
8. General Packet Radio Service
9. Long Term Evolution
10. Global Positioning System

4.11 FURTHER READING

- Prasant Kumar pattnaik, Rajib Mall, Fundamentals of Mobile Computing, PHI.

4.12 ASSIGNMENTS

Write the answer of the following Questions

1. Explain architecture of wireless communication technology.

2. List the wireless communication standards.

3. Write a short note on characteristics of mobile computing.

4. Explain responsibilities of mobile operating system.

5. What are the constrains for mobile operating system?

Block-2
Mobile Devices &
Mobile Operating System

Unit 1: Mobile Devices

<div style="text-align: right">**1**</div>

Unit Structure

1.1 LEARNING OBJECTIVE

To gain the knowledge regarding the mobile hardware architecture and hardware components of mobile such as processor, RAM, graphics, sensors etc.

1.2 INTRODUCTION

Mobile is a device which is made up by using different components like processor, RAM, graphic and different sensors. Mobile devices having the touch screen display which provides better user experience to provide the input. Now days mobile devices become the important part of human being in daily life to perform some task like phone calls, text SMS, reminders of important events and mathematical calculations etc. Mobile devices are capable to connect with internet and also capable to interconnect with each other by using the WIFI and Bluetooth.

1.3 MOBILE HARDWARE ARCHITECTURE

Mobile hardware architecture is the important part of mobile devices. Mobile device having the different hardware parts which are difficult to manage. We need to study the hardware architecture to understand the management of hardware by using the mobile operating system. Every latest smartphone used the System on Chip (SoC) Architecture. Following are the main components of the smartphone architecture.

- Application processor is used to execute the user's applications with the instructions from the middleware and the mobile operating system.
- A baseband processor with the own OS components performing radio transmission and reception of the audio, video and the data.
- Different peripherals for the user interface.
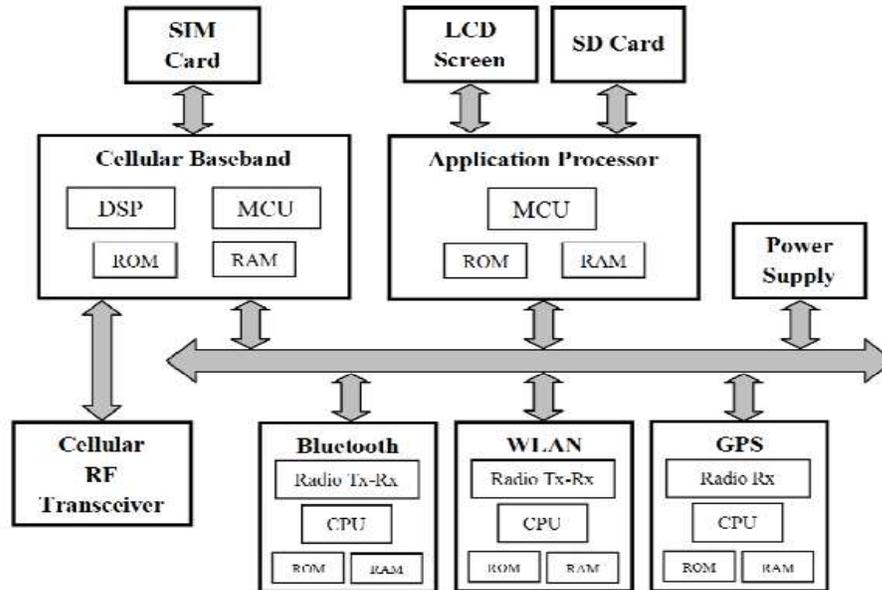
Figure-18 Mobile Hardware Architecture [1]

➢ **Receiver (RX)**

RX hardware component is the receiver of the incoming signals. After receiving the incoming signals, hand shaking is done with the physical layer. Later these signals are processed by the processor. The radio OS components hand shake with the peripheral to display the coming data to the user.

➢ **Transmission (TX)**

Device drivers support to write the data to the memory, from where they collected, for example audio from microphone, video from camera and location from the GPS sensor. After that data is processed by processor as per the transmission protocol. SIM (Subscriber Identifier module) plays an important role in data reception and transmission.

➢ **Application Execution**

The application processor executes mobile applications such as games, speech processing, internet browsing, image processing etc. latest smartphone have large volatile memory such as 1 GB, 2GB etc.

➢ **Typical ARM processor**

Processors which are used in mobile are quite different from those processors which are used in the laptop or in the computers. ARM processor

becomes the popular processor because of its capabilities like, optimization of battery life with good performance. Modem processor is separated by the ARM processor.
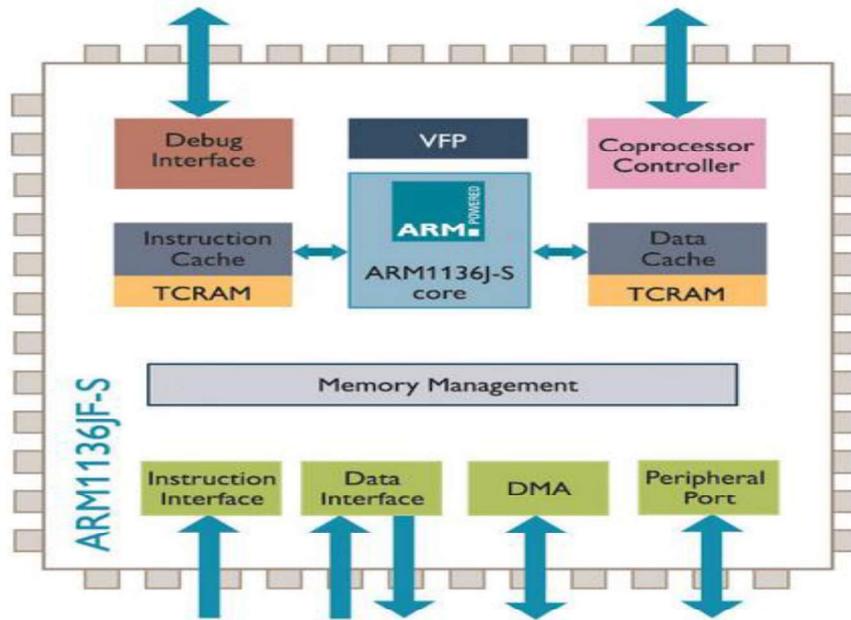
Figure-19 ARM Processor [1]

1.4 MOBILE HARDWARE DEVICES

Mobile is a smart device which is the combination of hardware and software. Mobile operating system is used to user interaction with mobile devices as well as used to manage the all hardware parts of the mobile devices such as processor, RAM, different sensors and different applications.

1.4.1 PROCESSOR

The processor is the central hub of any smartphone. Mobile processor is working like CPU (Central processing Unit) of the computer. Processor received command and it executes every command submitted by the user to perform different task with high accuracy and speed.

Processors which are used in mobile are quite different from those processors which are used in the laptop or in the computers. ARM processor becomes the popular processor because of its capabilities like, optimization of

battery life with good performance. Modem processor is separated by the ARM processor.

Latest smartphones are come with the multiple core processors like (2, 4 or even 8)

Figure-20 Available mobile Processors [2]

➤ **Qualcomm Snapdragon**

Qualcomm is the US Company which is developed the processor for smartphones. Qualcomm processor is used in all smartphones and tablets except Apple. Qualcomm is known of because Snapdragon its brand which is released the mobile processor as well as LTE modems.

➤ **Apple Mobile processor**

Apple does not make any processor instead they contract with processor manufacture company such as Samsung and TSMC for making custom processors for Apple phone.

➤ **Intel Atom**

Intel is American multinational company developed the processor for mobile as well as computers. Atom is the brand name identify for the low power consumption and low cost 32-bit and 64-bit processors for smartphone and tablets.

➢ **Nvidia Tegra**

Nvidia is the American company developed the processing units for the graphics, gaming units and mobile devices. Nvidia developed the chips for tablets and smartphone known as the Tegra brand.

➢ **MediaTek**

MediaTek is a Taiwanese semiconductor company providing chips for mobile devices, HDTVs and other electronic devices. MediaTek processor is working on the basis of 64 Bit ARM architecture. Clock speed of MediaTek processor is up to 3 GHz. They come in different cores such as Dual core, Quad core, Hexa core and Deca core.

➢ **HiSilicon**

HiSilicon is a Chinese company owned by the by Huawei. This company creates chip based processors working on the basis of ARM architecture. Processors are released by the HiSilicon such as K3V1, K3V2, K3V2E, Kirin 620, Kirin 650, Kirin 910 and Kirin 960.

➢ **Samsung Exynos**

Exynos is a brand of Samsung Electronics which makes processors based on ARM architecture. Samsung Exynos designed the series of processors such as Exynos 7 Dual, Exynos 7420, Exynos 7 Octa 7580, Exynos 7 Octa 7870.

1.4.2 GRAPHICS

The mobile GPU or graphics processing unit is used to accelerate the graphics applications such as 3D games, user interface and 3D contents on your mobile device. Photo realistic 3D games and live graphical user interface are examples to design the mobile GPU. GPU (Graphics processing Unit) is the central part of the hardware in the smartphones. GPU is handling the virtual elements of smartphone display while CPU handling the all heavy computations as well as the logical operations behind the screen. GPU and CPU are both the essential parts of the smartphone which directly deal with the device performance.

1.4.3 MEMORY AND STORAGES

Memory includes major components such as RAM and ROM.

> ➢ **RAM (Random Access Memory)**

      RAM is the most important and critical part of the smartphone along with the processor and graphics. Without RAM the computing performance of smartphone become very poor. RAM is the working as the middle man between the file systems which are stored on to the ROM. Large and critical files are needed by the processor to store on to the RAM, waiting to the access.

      RAM are used in the smartphone is technically D-RAM (Dynamic Random Access Memory). Contents of the D-RAM module is changed quickly and easily to store the different files. RAM is different from the ROM, if power is disconnected the data is lost from the RAM, it means RAM is the volatile (Temporary) storage. Speed of the smartphone is depends on the Ram. The clock speed is directly affects the input/output speed of the RAM.

Figure-21 of the iPhone 4S (Yellow Rectangle) [3]

Storage of smartphone is consisting by internal and external storage components.

➤ **Internal storage**

Like the RAM internal storage of the smartphone is the critical, without any place to store the OS and critical file smartphone is nothing to do. Depending on the operating system is loaded on to the device there are multiple storage chips in to the devices. File system is stored on to the chip is called as the ROM (Read only Memory).
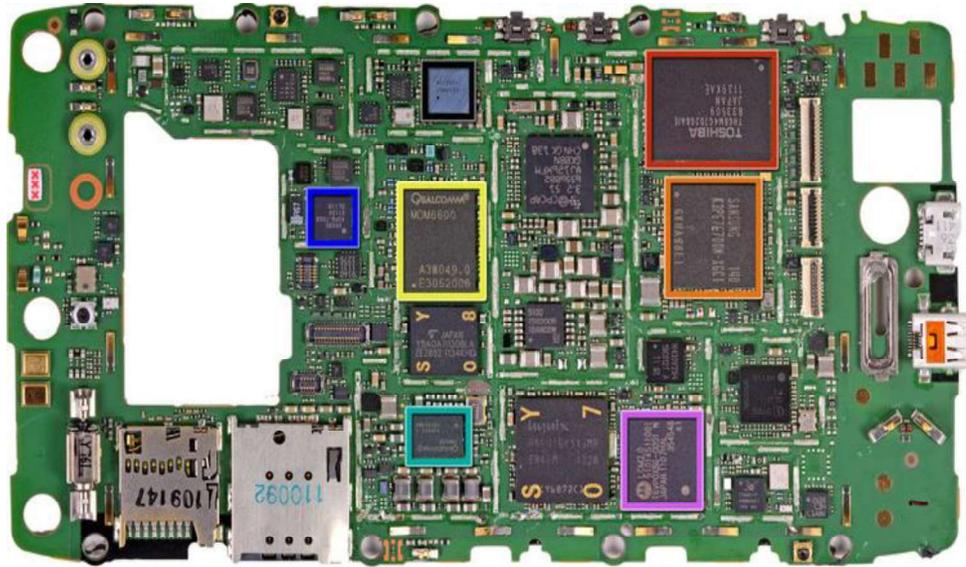

Figure-22 Internal Storage of Motorola Droid Razer (Red Rectangle) [3]

➤ **External storage**

User removal storage is called as the External storage due to the fact it can be removed by the user. Nowadays smartphone provides the facility to provide the external storage slot which is support to the microSD card.

Out of the different mobile operating systems such as iOS, Android and WP7, only Android mobile operating system supports to the removable storage. iOS devices which are developed by the Apple does not provide any facility to expand the external storage, instead they provide the internal storage which is used for the storing different applications, video and audio.

MicroSD card is available in three different sizes of the class. The original SD specification allows the size of the card up to 2 GB. SDHC

(SD high capacity) increased the size limit up to 32 GB. SDXC (SD Extended Capacity) increased the size limit up to the 2 TB.

Access speed of the external device is depend on to the Class of the MicroSD card such as class 4 written to at the minimum 4 MB/S, class 10 written to at the minimum 10 MB/S.

1.4.4 DISPLAYS

➢ **TFT-LCD**

TFT-LCD is called as the Thin Film Transistor Liquid Crystal Display. TFT-LCD display is used in the most budget smartphones. This display provides the higher resolution as compared to the previous LCD display. Disadvantage of TFT-LCD, This display provides the poor visibility in sunlight and it gives poor battery life for the large size display devices.

Figure-23 TFT-LCD display of SONY [4]

➢ **IPS-LCD**

IPS- LCD is called as the In-Placed Switching. IPS-LCD is superior as the TFT-LCD display. This display provides the wide viewing angles as well as the low power consumption. This display provides the better quality images as well as improved battery life.

Figure-24 IPS-LCD of Apple 4S [4]

➢ **Resistive touchscreen LCD**

Resistive touchscreen LCD is designed by the double layer of conductive material with small space left in between two layers. When screen is touched this two layers doing work together to complete the display circuit. This action sends command to the mobile operating system to perform the task.

Figure-25 Resistive touchscreen of Samsung [4]

➢ **Capacitive touchscreen LCD**

Capacitive touchscreen LCD is consist by single layer made by the transparent conductor (Indium Tin Oxide). When user touch to display the electrostatic field sends command to the mobile operating system to make the decision. Capacitive touchscreen display is more responsive which are providing the better user experience.

Figure-26 capacitive touchscreen of Samsung [4]

➢ **AMOLED**

AMOLED is called as Active Matrix Organic Light Emitting Diode. This display improved the quality and the performance of the device. This display provides the high level brightness and sharpness.

Figure-27 AMOLED display of Samsung [4]

1.4.5 CONNECTIVITY AND SENSORS

Different sensors are available for the smartphones such as Accelerometer, GPS, Gyroscope, Proximity, Magnetometer, Luxmeter and Microphone etc.

➢ **Accelerometer**

Accelerometer is used to measure the proper acceleration. Unit of accelerometer is m/s2 or g. latest smartphones accelerometer provides the high precision values. Apple iPhone 4S provides the 0.018g precision.
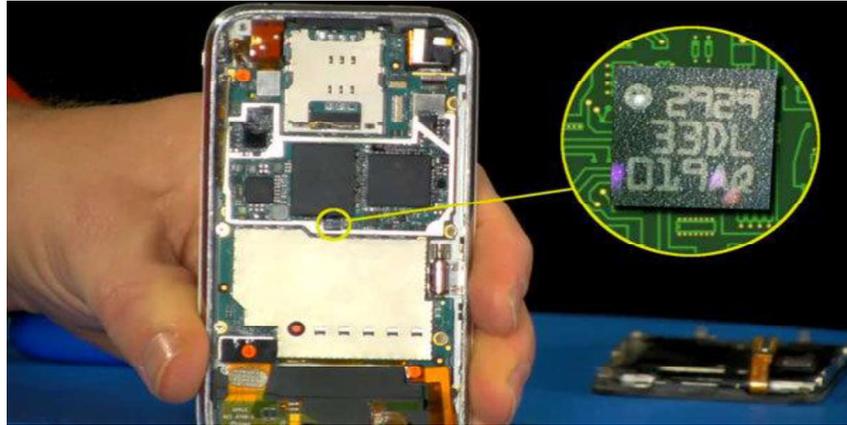

Figure-28 Accelerometer of smartphone [5]

➢ **GPS**

GPS sensor used to find out the location of the smartphone on to the google map. Connection with 3 satellites is required for fix latitude and longitude. Connectivity with more satellites is increase the precision of the position of the smartphone.

Figure-29 Position of device on to the map [6]

➢ **Gyroscope**

Gyroscope is used to find out the current orientation or changed orientation of the smartphone. Orientation is calculated with the help of the angular rate that is detected by the Gyroscope.
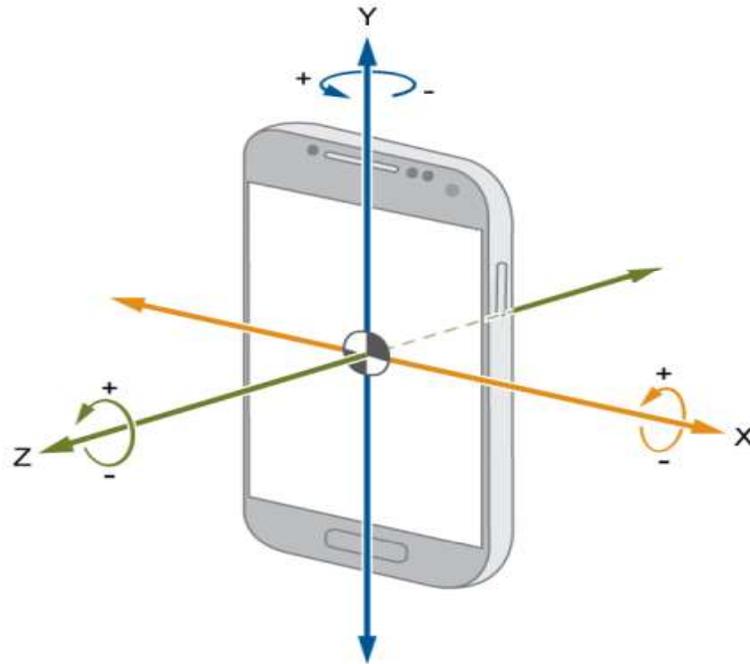
Figure-30 Gyroscope axis [7]

➢ **Magnetometer**

Magnetometer is used to find out the strength of the magnetic field. Strength of the magnetic field is measured in the tesla [T].

1.4.6 BATTERIES

Most common types of the smartphone batteries are listed below.

- Nickel-cadmium (NiCd)
- NiMH (NiMH)
- Lithium-ion (Li-ion)
- Lithium Polymer (Li-pol)

Latest smartphones are used the Lithium-ion battery. Lithium-ion battery is the packet of the extremely volatile chemicals and metals which are separated by the non-conductive, super thin layers which are prevents electrodes from the touching and triggering potential explosion reactions.

Figure-31 Lithium battery [8]

Lithium-ion is the common batteries for the portable devices with the high energy density.

A battery capacity is indicate, how much electricity provided to the device up to some time. For phones capacity is measured in mill ampere-hours (MAh). The larger capacity of battery provides the more electricity to smartphone up to the more time as compared to the smaller capacity battery. Proper charging of the mobile phone battery is useful to save the life of it.

- After completion of charging plug out the smartphone from the electricity network.
- Avoid the moisture on to the battery.
- Do not charge the battery if you bought from the freezing temperatures.
- Nickel-Cadmium and NiMH batteries must be charged only after full discharge while Lithium ion battery can charge regardless of the battery level.

1.4.7 CAMERAS

Camera is the one of the most important feature of the smartphone. Peoples want good camera quality of their phones to capture the quality images and videos. The front camera of smartphone is become important because of the trend of the selfies across the social network.

Figure-32 Camera of smartphone [9]

Smartphone camera module is includes two main components such as the sensor and the lens. This both components are packed together which are attached to the smartphones main board by using the ribbon cable. The sensor which is the part of the camera used to capture the images. Circuits of the camera include the photodetectors used to capture the light, plus amplifiers and transistors. Smartphone cameras are built over the CMOS (complementary metal-oxide-semiconductor) technology which is a form of active pixel sensor.
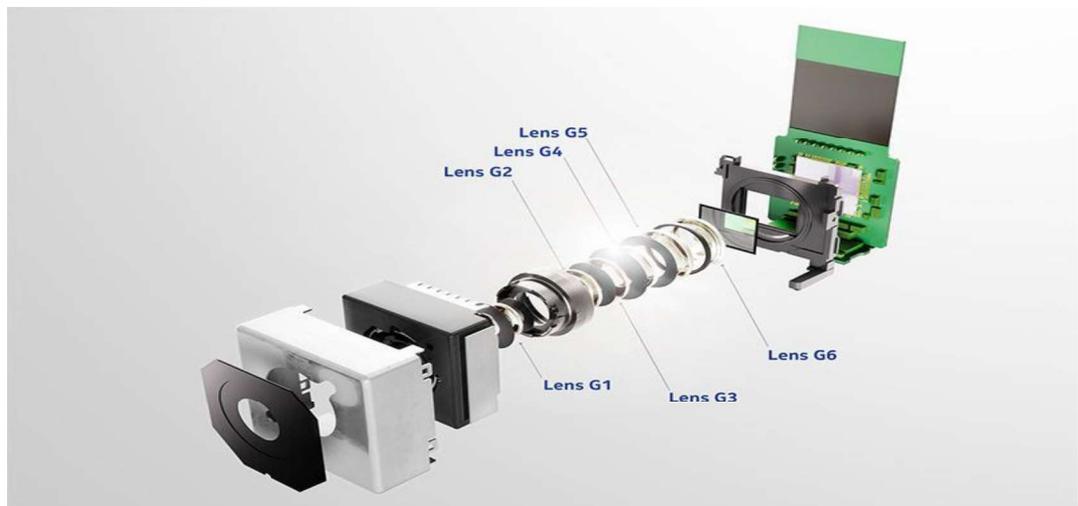

Figure-33 Construction of camera [9]

The lens is made up by multiple plastic or the glass elements. With the glass it provides the higher quality and sharpening. The lens elements work in conjunction with the small whole, which is before the sensor that the focused light travels through.

1.5 LET US SUM UP

Mobile devices are become the important part of human life. Every person use mobile device to make life easier. Mobile devices are used to voice call, text SMS, internet browsing etc. power management and hardware component management is difficult task in smartphones.

1.6 CHECK YOUR PROGRESS

1. Explain working of RX and TX in mobile hardware architecture?
2. What is mobile processor?
3. Explain the role of GPU in mobile devices?
4. Differentiate internal and external memory of smartphone?
5. Give the full form of RAM with its working principle?

1.7 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1. Refer 1.3
2. Refer 1.4.1
3. Refer 1.4.2
4. Refer 1.4.3
5. Refer 1.4.3

1.8 ASSIGNMENTS

1. What is GPS? Explain use of it?
2. Explain working of magnetometer?
3. Why use Gyroscope in smartphone?
4. Differentiate GPU and CPU?
5. Explain the power management in mobile devices?

1.9 ACTIVITIES

1. Make a case study on different display used in smartphones.

1.10 FURTHER READING AND REFERENCES

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2. https://atechjourney.com/list-of-smart-phone-and-tablet-mobile-processors.html/

3. https://www.neowin.net/news/guide-to-smartphone-hardware-37-memory-and-storage/

4. https://www.slashdigit.com/10-types-of-smartphone-displays/

5. https://www.engadget.com/2012/05/22/the-engineer-guy-shows-how-a-smartphone-accelerometer-works/

6. https://celltrackingapps.com/wp-content/uploads/2017/02/gps-phone-tracker.jpg

7. https://vidhyaanalytics.wordpress.com/2017/09/22/first-blog-post/

8. http://mygeekopinions.blogspot.com/2011/05/what-is-battery-calibration-and-when.html

9. https://www.techspot.com/guides/850-smartphone-camera-hardware/

Unit 2: Function of Mobile Operating System

<div style="float:right">**2**</div>

Unit Structure

2.1 LEARNING OBJECTIVE

To understand the functions of mobile operating system such as call management, notification management, resource management etc.

2.2 INTRODUCTION

Mobile operating system is used to run the smartphones, tablets and handheld devices. Mobile operating system combines the features of the computer operating system with other features which are useful to mobile devices as well as the hand held devices. Modern mobile operating system includes the Bluetooth, WI-FI, cellular, touchscreen, protected access, GPS (Global Positioning System) for mobile navigation, camera to capture the high quality video and images, speech recognition, voice recorder, music player and infrared blaster.

Mobile devices which having the ability to communication which are contain operating system such as the real time operating system support to the serving the real time applications that are process the data in real time mode. Real time operating system working on the basis of the time bound which has the well-defined fixed time constraints.

2.3 NEED OF MOBILE OPERATING SYSTEM

Mobile operating system is the system software which are control the mobile devices as well as it provides the interaction between the user and the hardware of the mobile. A good smartphones OS is boot quickly and provides the beautiful UI to the user for controlling the smartphone. Nowadays peoples are become very busy because of fast life they want to manage the personal information such as notes, calendar, to-do lists, alarms and reminders, this task are not possible without the mobile operating system. Every user wants to surfing the internet on to the smartphone which is not possible by the good mobile operating system.

2.4 HISTORY OF MOBILE OPERATING SYSTEM

- **1993**

    Mobile phone used embedded system to control the operations.

- **1993-1999**

  1993- Apple launched the Newton operating system for its portable
    computers.

  1998- Symbian OS is developed by the Symbian Ltd. This OS is used by
    different mobile phones.

  1999- Nokia S40 platform is introduced officially.

- **2000s**

  2000- Symbian becomes a first OS which are running on to the smartphones.

  2002- Blackberry launched its first smartphone.

  2005- Nokia developed Maemo OS running on the first internet tablet.

  2007- Apple launched iOS operating system for its iPod, mobile phone and
    internet communicator.

  2008- OHA released the Android 1.0 which is running on to the HTC dream
    as the first android smartphone.

  2009- Samsung developed the Bada OS.

- **2010s**

  2010- Windows Phone OS was released.

  2011- MeeGo mobile operating system is introduced by the Nokia, Intel and
    Linux foundation.

  2012- Apple launched iOS 6.

  2013- BlackBerry launched BlackBerry 10 mobile operating system.

  2014- Microsoft released windows phone 8.1.

  2015- Google released Android 5.1 "Lollipop"

  2016- Microsoft released windows phone 10 OS anniversary updates.

  2017- Google released Android 8.0 "Oreo".

  2018- Apple announced iOS 12.

2.5 FUNCTIONALITIES OF MOBILE OPERATING SYSTEM

➢ **Computing on Mobility**

  Mobile Computing is a technology in which transmission of data, voice and
  video by using a computer and other device without having to be connected to a
  fixed physical link. Mainly computing on mobility includes the mobile

communication. Mobile communication includes protocols, services, bandwidth and portals to support the stated services. Also data format is defined in that stage to ensure that there is no collision with other existing system.

➢ **Location Identification**

Location identification is the important task track the location of the mobile phone, whether moving or stationary. Location identification is done by using different mechanism such as location identification based on, radio frequency of cell towers of the network or simply by the GPS (Global Positioning System). To track the location of mobile based on to the multilateration of radio signals, it must emit at least the roaming signal to contact the next nearby antenna tower.

Location identification of mobile phones is done by different ways which are listed below.

- SIM-based

    Location identification is also done by using the SIM (subscriber identity module) in GSM and UMTS (Universal Mobile Telecommunications System), possible to obtain the raw radio measurements from the handset. Information is obtained from the SIM may be differed from that information which is obtained by the handset.

- Handset-based

    The location identification is done by using the handset with the help of client software installed on to the handset. If the handset is equipped with the GPS then it gives more accurate location.

- Wi-Fi-based

    Latest smartphone provides the facility to track the mobile phones by using the Wi-Fi. Many smartphones are combined with GPS and Wi-Fi positioning.

- Hybrid

    Hybrid technique is the combination of network based and the handset based technique for location identification.

➢ **Call Management**

Call management is the process and design of implementation of inbound call parameters which routing through the network. This process is used by the call centers and the corporations. Call management working according to the calling

features such as the IVR menus, Call queues, Recorded announcements and the hunt groups.

- Calling features

Call management features are varying from system to system. Different call recording software's are used to record the incoming and outgoing calls with the time, date and duration. A Hub group is the directory which includes the one or many destination numbers. Call queue is used to keep the call on to the hold until the one destination number is available on to the calling.

- Routing

Call routing is the internal mechanism which is included the path selection for the inbound telephones calls. Individual agents used the computer telephonic integration system to function within the network. Automated process includes the translation which is automatic routing of the inbound calls from on mobile number to other mobile number.

➢ **Notification Management**

Notification management includes incoming messages, calendar events and new incoming Gmail etc. notification working on the differently for different applications but they are easy to manage. Also notification management varies on different versions of the mobile operating systems.

- Status bar and notification drawer

When notification comes on to the smartphone it appears on to the status bar of the smartphone.

Figure-34 Notification icon

User can swipe down the status bar to open the new notifications and user is capable to take the action as per the requirements.

- Heads-up notification

In Android 5.0 the notification can appear on to the floating window called a heads-up notification. It appeared only if the smartphone is unlocked.
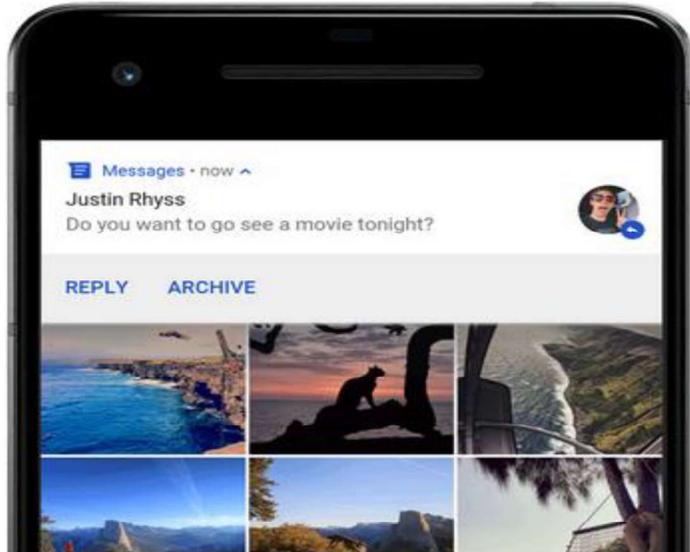

Figure-35 Heads-up notification [1]

- Lock screen

Notifications can appear on to the lock screen in Android 5.0. User can set the notification privacy from the setting such as hiding the sensitive data etc. User can use the system setting to choose the level of detail visible in lock screen notification.
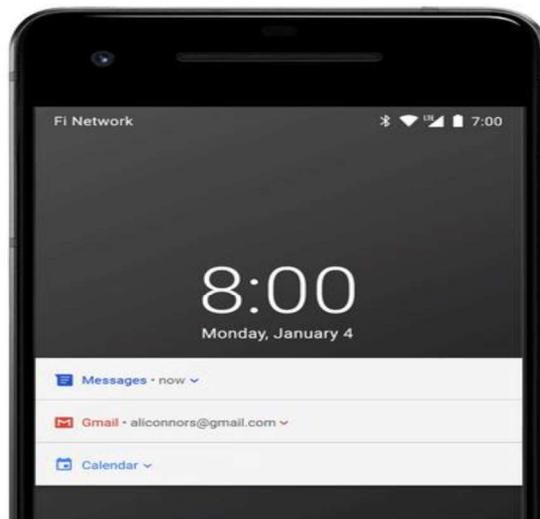
Figure-36 Notifications on lock screen [1]

Mobile Hardware Management

ARM processor used in the smartphone for efficient performance. It gives great performance with the low cost power. Processors which are used in mobile are quite different from those processors which are used in the laptop or in the computers. ARM processor becomes the popular processor because of its capabilities like, optimization of battery life with good performance. Modem processor is separated by the ARM processor.
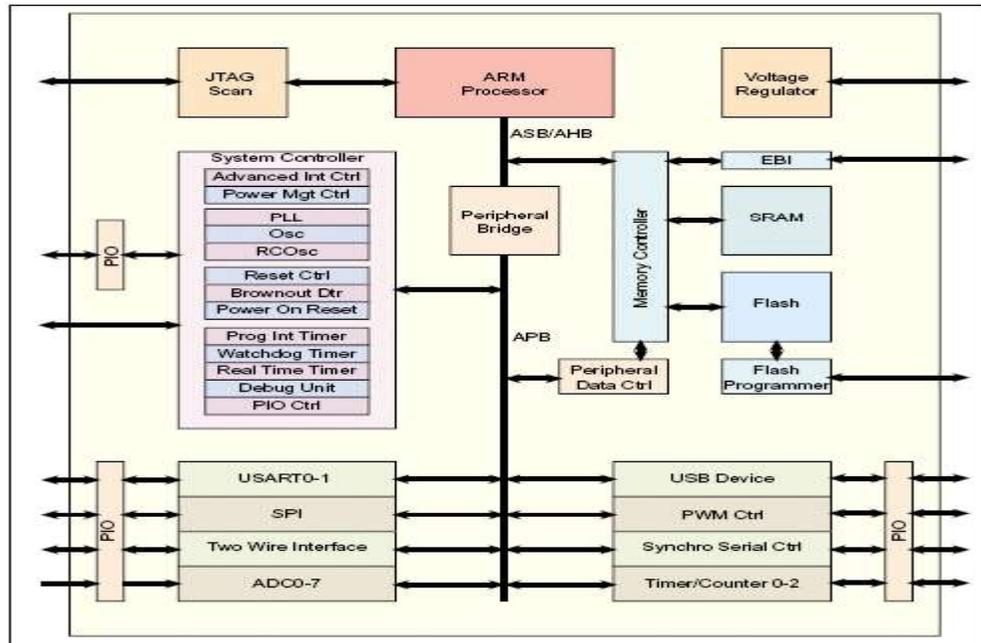
Figure-37 ARM architecture [2]

Mobile hardware management is the critical task. Challenges of the mobile hardware like consumer demands shifting away from the hardware performance. Raw performance may be losing the priority for new development of the smartphones.

Mobile application management and synchronization management

Mobile application management gives the information about the software and service responsible for controlling access to internally develop and also commercial apps provided by the third party. The mobile application management provides the granular controls at the application level to protect the app data. Also some enterprise mobility management software's including the mobile application management functionality.

Synchronization management is the technique in which data of smartphone is synchronized with the applications of the computer. Mobile devices must have some way of loading applications, updates, and changes to their operating systems or settings. Even devices capable of wireless networking must have some way of loading software, if only to load what is needed to create the wireless connection in the first place. You can do this by synchronizing the device's operating system and applications with either a desktop management program or individual applications on a personal computer.

➢ **Battery power management**

Battery life of smartphone is the main area of its performance because without battery, smartphone is useless. Batteries in leading Android phone are bigger in every time but it's not possible to save the battery life with the applications support. Android operating system tries to develop the application which is supports to save the battery life for long lasting performance by the smartphones.

Also every smartphone provide the facility of battery saver mode to the user which is helpful to save the battery of smartphone in the emergency mode.
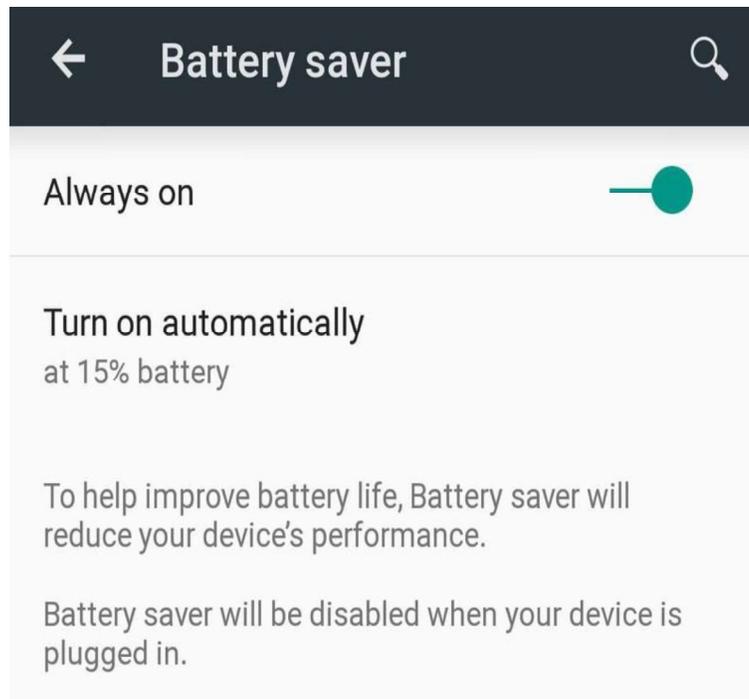

Figure-38 Battery saver [3]

2.6 CONSTRAINED OF MOBILE OPERATING SYSTEM

Design of the mobile operating system is differ from the design of the OS which are running on to the computers. Mobile operating system have some constrained which are listed below.

- Physical Constrained

    Battery- powered device- Power management of smartphone

    Display- Small screen varying resolution, shape and size.

    Memory – Memory Management is challenging in different handsets.

- Uncertainty Constrained

    Networks come and go- Discontinued internet connectivity.

    OS need to provide robust methods for handling connections and coping with service interruptions and ad hoc attempts to communicate.

2.7 LET US SUM UP

Mobile operating system plays important role to manage all hardware components of the mobile devices. Also mobile operating system manages the phone calls, text SMS etc.

2.8 CHECK YOUR PROGRESS

1. Explain history of mobile operating system?

2. Why mobile operating system is needed?

3. What is location identification?

4. Explain the call management in mobile operating system?

5. What is ARM processor?

2.9 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1. Refer 2.4

2. Refer 2.3

3. Refer 2.5

4. Refer 2.5

5. ARM processor used in the smartphone for efficient performance with low cost power.

2.10 ASSIGNMENTS

1. What is the operating system?

2. Explain notification management?

3. Which are constrained of mobile operating system?

4. Explain role of battery saver?

5. Explain Synchronization management technique?

2.11 ACTIVITIES

1. Make a case study on processor of smartphones.

2.12 FURTHER READING AND REFERENCES

1. https://edu.gcfglobal.org/en/androidbasics/managing-notifications-on-android/1/

2. https://www.networxsecurity.org/members-area/glossary/a/arm-architecture.html

3. https://www.androidcentral.com/android-l-preview-battery-and-power-management

Unit 3: Mobile Operating System   3

Unit Structure

3.1 LEARNING OBJECTIVE

To gain the knowledge regarding the different android mobile operating systems run on different devices.

3.2 INTRODUCTION

Mobile operating system is used to run the smartphones, tablets and handheld devices. Mobile operating system combines the features of the computer operating system with other features which are useful to mobile devices as well as the hand held devices. Modern mobile operating system includes the Bluetooth, WI-FI, cellular, touchscreen, protected access, GPS (Global Positioning System) for mobile navigation, camera to capture the high quality video and images, speech recognition, voice recorder, music player and infrared blaster.

Mobile devices which having the ability to communication which are contain operating system such as the real time operating system support to the serving the real time applications that are process the data in real time mode. Real time operating system working on the basis of the time bound which has the well-defined fixed time constraints.

3.3 TYPES OF MOBILE OPERATING SYSTEM

3.3.1 ANDROID

In 2005 Google bought the Android OS. After that Android mobile operating system is developed by the Google. It is the modified version of the Linux kernel and the open source software's. Firstly Android mobile operating system is developed for the touchscreen devices like smartphone and the tablets.

Figure-39 Current Android Logo [1]

Further Google is developed the Android operating system, Android Auto for car, Android TV for television and wear OS for the smartwatches. In September 2008 the first commercial android smartphone was launched and its name is HTC dream developed by the HTC Company.

Figure-40 HTC Dream [2]

On March 2019 Google released the Android Q version which is supportable to all pixel mobile phones. Android Q is the 17th version of the Android mobile operating system which supports to build in screen recorder, better support to the biometric authentications in the app and dynamic depth format for the photos.

Initially Android code is known as the Android Open Source Project licensed under the Apache. Android is also related to the closed-source software which is available only after the purchasing developed by the Google called the Google mobile services. Google mobile services are not a part of the Android Open Source Project. Android needs the Licensed from the Google to install the Google Mobile Services on to the Android device. Google Mobile services are preinstalled on to the Android devices such as Google chrome and the Google search. Android is the bestselling operating system in the world.

➢ **Features**

User interface is working on the basis of direct manipulation by using the touch input like swapping, tapping and pinching along with the virtual keyboard. Also physical keyboard and the game controls are support by using the Bluetooth and the USB. Android smartphone is boot to the home screen; home screen is working like as the computer desktop. Android device home screen is consisting by the app icons and the widgets. App icons are used to launch the specific app while widgets displaying the live and auto updating contents such

as Gmail inbox and the weather forecasting. Google play provides the facility to download the third party apps.

- ➢ **Android versions**
  - o Android 1.5: Android Cupcake
  - o Android 1.6: Android Donut
  - o Android 2.0: Android Eclair
  - o Android 2.2: Android Froyo
  - o Android 2.3: Android Gingerbread
  - o Android 3.0: Android Honeycomb
  - o Android 4.0: Android Ice Cream Sandwich
  - o Android 4.1 to 4.3.1: Android Jelly Bean
  - o Android 4.4 to 4.4.4: Android KitKat
  - o Android 5.0 to 5.1.1: Android Lollipop
  - o Android 6.0 to 6.0.1: Android Marshmallow
  - o Android 7.0 to 7.1: Android Nougat
  - o Android 8.0 to Android 8.1: Android Oreo
  - o Android 9.0: Android Pie

3.3.2 IOS MOBILE OPERATING SYSTEM

iOS mobile operating system developed by the Apple mainly for its hardware. iOS operating system is running on different devices such as iPhone, iPad and iPod Touch. iOS is the second popular mobile operating system after the Android mobile operating system. According to survey apple store contain 2.1 million iOS application in 2018 from that 1 million apps for iPad and this apps are downloaded more than 130 billion times.

iOS mobile operating system supports to multi gesture control which provides the better user interface, based on the direct manipulation. Interface controls the contents which are consist by using switches, buttons and sliders. User can interact with mobile operating system with the help of swapping, tapping and pinching. Inbuilt accelerometer support to some applications for shaking control or rotation control, gives good control experience to the user. In 2018 iOS released 12th version which are available for all iOS devices running on the basis of 64-bit processor.

Figure-41 Logo of iOS [3]
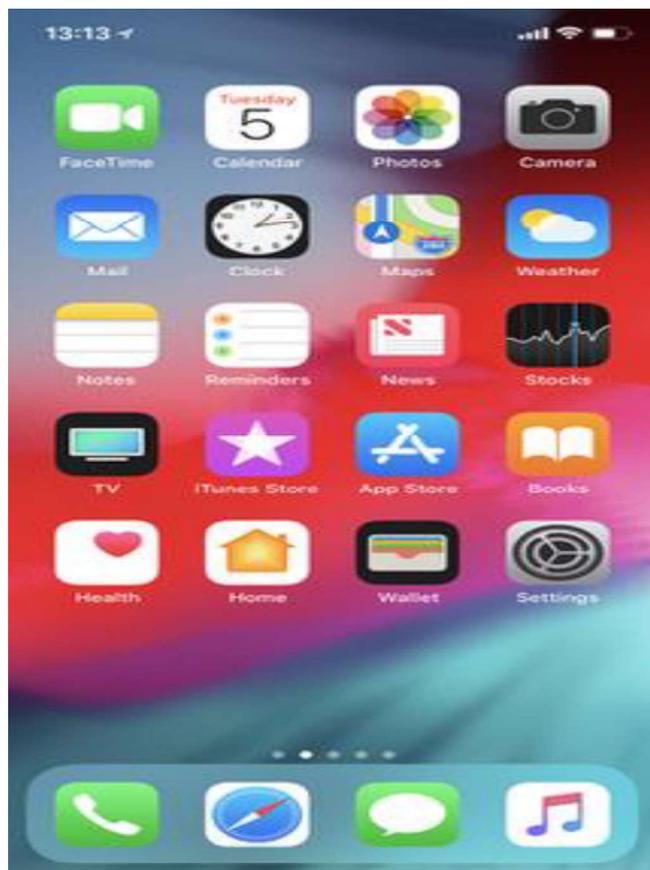
Figure-42 iOS 12 Running on iPhoneX [4]

➢ **Features**

● **Homescreen**

Homescreen display the application icons and the dock at the bottom where user can capable to ping its favorite applications. Homescreen is appearing when user unlocks the device.

- **System Fonts**

    iPhone 4 support to the Helvetica Neue. For iPhone 7 Apple move on to the Helvetica Neue Light as the system font. iOS 7 introduced the ability to scale the text. Apple changes the font in iOS 9 such as the San Francisco.

- **Folders**

    iOs 4 introduced the folder icons which are renamed automatically by its category. A title for folder is automatically selected as well as user is capable to rename the title of the folder. Folder on iPhone could include up to 12 apps while folder on to the iPad capable to include 20 apps on the folder.

- **Notification Center**

    Before iOS 5 notifications are delivered on to the modal window, in iOS 5 Apple introduced the notification center which allows viewing the notification history. Also user can capable to open the app by tapping on to the notification.

- **Accessibility**

    iOS offers deferent accessibility features to the users with the vision and disabilities. Voiceover is the major features provide voice reading information on to the screen includes buttons, links and icons. Apple developed new pronunciation editor features for the iOS 10 which are supportable to the voiceover feature.

3.3.3 BLACKBERRY

BlackBerry mobile operating system is a proprietary mobile operating system. It means BlackBerry mobile operating system is not open source mobile operating system like Android. BlackBerry mobile operating system is developed by Research in Motion for its BlackBerry line of smartphones. The BlackBerry is the best platform for native support for the corporate communication which allows wireless activation and synchronization of email, tasks, calendar and contacts.

Current version of BlackBerry device software is V5.0, BlackBerry 6 mobile operating system and the BlackBerry 7 mobile operating system. You can quickly manage the communicator by using the BlackBerry hub with instant actions.

- Email- Toggle the read status and files or delete a message with a single tap
- Transfer conversion- when composing an email, you can transfer the conversion to the voice call.
- Calendar- accept or reject the invitation without opening the calendar.
- SMS- Use quick reply to respond the SMS

3.3.4 WINDOWS PHONE

Windows phone is a proprietary mobile operating system developed by the Microsoft. Windows phone mobile operating system provides new design language previously called Metro UI. In 2011 Nokia announced to choose the windows phone mobile operating system for all its future smartphones. Windows phone mobile operating system provides good user interface because it use metro design language. Also windows phone mobile operating system provides the on screen virtual keyboard which has dedicated key to insert the emoticons. Windows phone mobile operating system support to the internet explorer which provides better web surfing experience to the user.

3.3.5 SYMBIAN OS

Symbian is a proprietary mobile operating system developed by the Symbian Ltd which developed the software as well as the mobile operating systems. Firstly Symbian operating system is developed for the PDA's. Symbian operating system is used in different branded phones such as Nokia, Samsung, Motorola and Sony Ericsson. AVKON is the native graphics tool kit used by the Symbian operating system. Symbian support to webkit based browser which is used in the Apple's safari browser. Symbian operating system is support for the 48 different languages.

3.3.6 BADA

Bada mobile operating system is developed by the Samsung electronics for the smartphones and the tablets. To adaptation of Bada mobile operating system, Samsung release the source code under the open source license. Bada mobile operating system also support to the smart TV. Samsung electronics is the South Korean multinational electronic company.

In 2012 Bada is merge with the Tizen project but meanwhile they used own Bada mobile operating system. All devices running on Bada branded under the Wave name except Samsung devices running on Android mobile operating system. Samsung announced at 2013 to stop the development of Bada mobile operating system.

Figure-43 Bada OS [16]

Bada is support to the real time operating system hybrid keranal(RTOS)) or the linux kernel. According to copyright displayed on to the Samsung Wave S8500, Bada used different codes from the FreeBSD, Net BSD and Open BSD. Bada mobile operating system supports to the different UI controls such as the Color Picker, List box and Tab. Bada OS supports to the Webkit based browsers. Bada OS also supports to the 3D graphics API under the OpenGL interface. Bada supports to the various sensors such as the motion sensing, accelerometer face detection, magnetometer, GPS and multi-touch. Applications are developed by using C++ with the Bada software development kit in the eclipse development environment. IDE contains the UI builder which provides support to developers to make efficient UI for their applications.
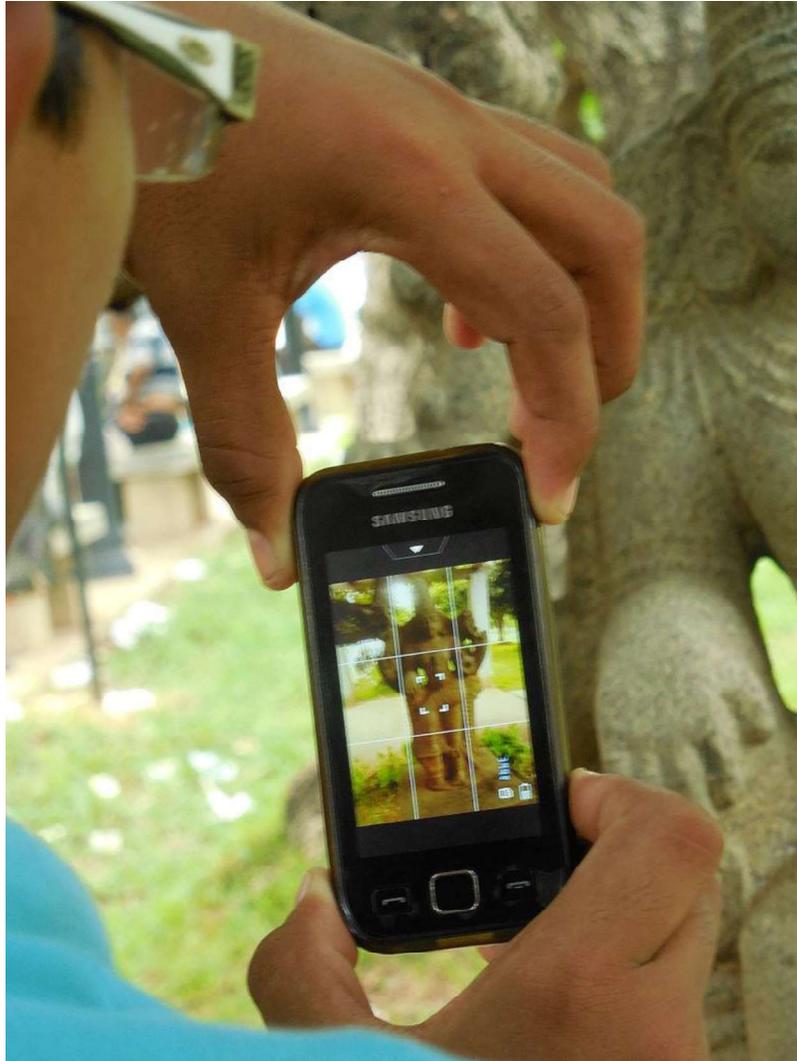
Figure-44 Image acquisition using Bada OS [16]

3.3.7 PALM

Palm operating system is also called as the Garnet OS, developed by the Palm, Inc. which is the American company. Palm Inc. are specially manufacture the PDA (personal digital assistants). Initially Palm OS only supports to the personal digital assistance but later versions of the Palm OS are supports to the smartphones.

Figure-45 Palm OS 4.0 [17]

- Simple and single tasking interface support to launch the full screen applications with the basic GUI sets.

- Support to the handwriting recognition.

- Supports to the 480x320 pixel resolution of the screen.

- Hotsync technology provides facility to data synchronization between device and computer.

- Support to the record and sound playback mechanism.

- Supports to the expandable memory card which provides more storage to the user.

- Support to the security mechanism, lock the device by password.

3.3.8 WEB OS

Web OS is also called as the LG web OS, is the Linux kernel based multitasking operating system to develop for the smart devices such as smart TV. After that web OS is extended which are supports to the smartphones. Initially web OS is developed by the Palm Inc. which is the American Company, later web OS sold out to the LG Electronics in 2014. web OS running on to devices such as the pre, pixi and veer smartphone. This OS support to the LG smartphone as well as the refrigerators and the smart projectors.

Figure-46 LG web OS [18]

Figure-47 LG OS on smart Watch [18]

- LG web OS introduced some new features which are used by the Apple and Microsoft such as the card interface.
- LG web OS supports to the multitasking interface by using the line cards.
- LG web OS supports to the gesture control with the help of magic remote. Also open web OS support to gesture control by using its touch screen and physical keyboard.
- LG web OS developed its app store which provides the different applications to the user.
- LG web OS is partially open source, but Open Web OS is fully open source and its blueprints and source code is freely available.
- Multitasking interface

- It supports to the gesture control with the help of multi-touch on to the screen. The interface uses the card to manage the multitasking mechanism.

- Synergy

- User can use the multiple Gmail accounts which are provided by different service providers.

- Sync

- Data synchronization is done by using could base approach rather than using the desktop client.

3.3.9 MEEGO

MeeGo is discontinued mobile operating system hosted by the linux foundation, using source code such as Moblin and Maemo. Moblin source code is developed by the Intel and the Maemo source code is developed by the Nokia. Initially MeeGo is developed for the hardware like netbook, tablet computers, nettops and mobile computing. Also MeeGo is used in the communication devices such as the smart TV, Vehicle infotainment devices and embedded systems.

Figure-48 MeeGo running on Netbook [19]

Linux foundation canceled the MeeGo OS in 2011 in the favor of the Tizen project. MeeGo provides the support for the ARM and Intel x86 processors.

- User Interface

    MeeGo operating system supports to the various graphical user interfaces called as UX (User Experiences).

    Netbook user interface is developed by using the Moblin interface, writing by using the clutter based MX tool kit. MeeGo OS support to running the applications at the background such as Gmail, calendar, Messenger and web browsers.

- Handset

   Handset UX is developed with the help of Qt with the GTK+ and the Clutter.
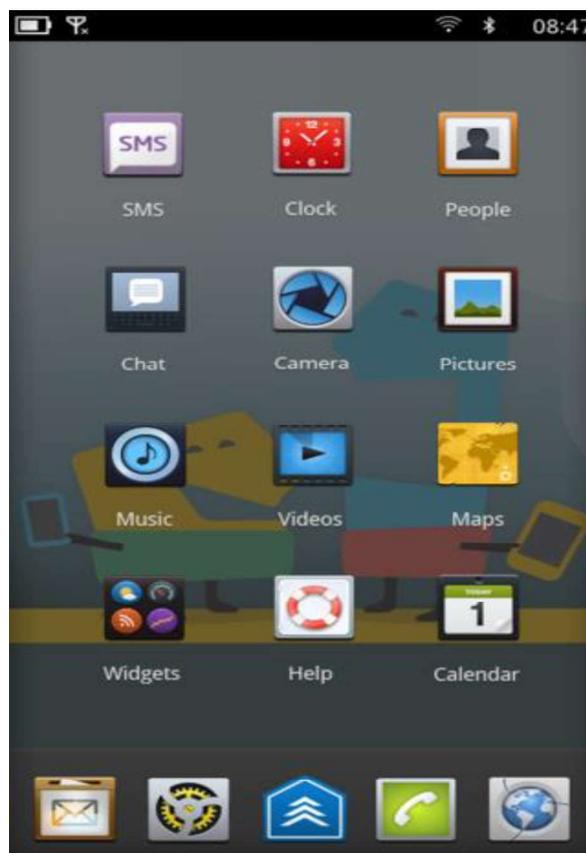
Figure-49 MeeGo on smartphone [19]

3.4 LET US SUM UP

Android mobile operating system becomes popular as compared to other mobile operating systems because android mobile operating system is open source and it supports to different hardware parts.

3.5 CHECK YOUR PROGRESS

1. What is android? Explain different android versions?
2. Explain use of ios mobile operating system?
3. Explain blackberry mobile operating system?
4. Give the features of the MeeGo OS?

3.6 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1. Refere 3.3.1
2. Refere 3.3.2
3. Refere 3.3.3
4. Refer 3.3.9

3.7 ASSIGNMENTS

1. Give brief history of Symbian OS?
2. Explain architecture of Bada OS?
3. What is Palm OS?
4. What is the use of Web OS?
5. Give the features of the MeeGo mobile operating system?
6. Differentiate between windows phone mobile operating system and android mobile operating system?

3.8 ACTIVITIES

1. Make case study on different Android version?

3.9 FURTHER READING AND REFERENCES

1. https://en.wikipedia.org/wiki/File:Android_robot.svg
2. https://en.wikipedia.org/wiki/HTC_Dream
3. https://1000logos.net/ios-logo/
4. https://en.wikipedia.org/wiki/IOS
5. https://www.cellunlocker.net/unlock-blackberry-10-os/instructions/
6. https://en.wikipedia.org/wiki/BlackBerry_10

7. https://en.wikipedia.org/wiki/BlackBerry_Z10

8. https://en.wikipedia.org/wiki/BlackBerry_Q10

9. https://en.wikipedia.org/wiki/Windows_Phone

10. https://en.wikipedia.org/wiki/Emoticon

11. https://en.wikipedia.org/wiki/Symbian

12. https://en.wikipedia.org/wiki/Microkernel

13. https://freebiesupply.com/logos/symbian-os-logo/

14. https://en.wikipedia.org/wiki/WebKit

15. https://en.wikipedia.org/wiki/Symbian

16. https://en.wikipedia.org/wiki/Bada

17. https://en.wikipedia.org/wiki/Palm_OS

18. https://en.wikipedia.org/wiki/WebOS

19. https://en.wikipedia.org/wiki/MeeGo

Unit 4: Generalized Mobile Operating System Architecture and comparison

4

Unit Structure

4.1 LEARNING OBJECTIVE

To gain the knowledge regarding the architecture of mobile operating system as well as the management of different hardware parts

4.2 INTRODUCTION

Now days, mobile phone used to voice call as well as different verity of services such as video calls, 2D and 3D games, GPS service, file sharing, location tracking etc. mobile operating system is play the important role to manage the hardware parts of the mobile phones like different sensors. System kernel, file server, memory management and device drivers are located at the base of the mobile operating system. The kernel manages the system resources and responsible for time slicing. Every operating system follows its own architecture. In the next section we will see the architecture of the most popular mobile operating system that is the Android mobile operating system running on different android smartphones as well as on different smart handheld devices.

4.3 GENERALIZE ARCHITECTURE OF MOBILE OPERATING SYSTEM

A mobile OS is a software platform on top of which other programs called application programs can run on mobile devices such as PDA, cellular phones, smartphone and etc.

- Low Level Hardware

  Mobile architecture is working on the basis of the RISC architecture. Processors are mainly two types such as ARM and MIPS. ARM is the 32-bit RISC processor architecture. ARM processor provides the low power consumption e.g.:- Qualcomm Snapdragon Marvell's XScale Texas Instruments OMAP series. MIPS processor is used in mainly embedded systems. e.g.:-TiVo, Playstation1 & 2.

- Mobile Memory

  The better memory management is offered by mobile operating system. ROM (Read only Memory) used for operating system and preinstalled programs. RAM (Random Access Memory) is a short term digital storage.

- Types of RAM
    - DRAM (Dynamic RAM): cheapest, used in mobile devices
    - EDO (Enhanced Data Output): more expensive but offers a speed increase over DRAM
    - SDRAM (Synchronous Dynamic RAM): a further 50% speed (iPAQ)
    - DDR (Double Data Rate) SDRAM is twice as fast as SDRAM
    - OUM (Ovonics Unified Memory): experimental

- Kernel

  Kernel is responsible to manage the different services such as security management, memory management and process management.

- Libraries & Application Framework

  These Libraries are exposed to developers through the application framework.

4.4 A COMPARISON BETWEEN MOBILE OPERATING SYSTEMS

Feature	Android	iOS	Windows 10	BlackBerry 10
Company	Google	Apple Inc.	Microsoft	BlackBerry ltd.
Current version	9.0.0	12.1.3	10.0.	10.3
Current version release dates	December 11, 2018	January 22, 2019	February 12, 2019	April 4, 2018
License	Free and open-source	Proprietary except for open source components	Proprietary, Commercial software	Proprietary
OS family	Linux	Darwin	Microsoft Windows	QNX
Supported CPU architecture	ARM	64-bit ARMv8-A	32-bit ARMv7-A and 32-bit ARMv8-A	ARM
Programed in	C, C++, Java, Kotlin	C, C++, Objective-C, Swift	.NET, C#	C/ C++

Table-6 Comparison between Mobile Operating System

4.5 LET US SUM UP

Kernel is the low level system software which plays important role in the architecture of mobile operating system such as to manage the all resources with the responsible time slicing.

4.6 CHECK YOUR PROGRESS

1.   What is kernel?

2.   Explain working of kernel?

3.   What are resource managements?

4.   What is the use of RAM?

4.7 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1.   Kernel is low level system software which is responsible to manage the different services such as security management, memory management and process management.

2.   Kernel is used to manage the all resources with the responsible time slicing.

3.   Resource management is the proficient and effective development of an organization's resources when they are needed.

4.   Random access memory (RAM) is used to store running programs and data for the programs.

4.8 ASSIGNMENTS

1.   Explain the mobile memory?

2.   Which are the different types of the RAM?

3.   Differentiate between Android OS and iOS OS?

4.   Why Android mobile operating systems become so popular?

5.   What is the ROM?

6.   Differentiate between RISC architecture and ARM architecture?

4.9 ACTIVITIES

1. Make a case study on comparison between different types of mobile operating system.

4.10 FURTHER READING AND REFERENCES

1. https://www.webopedia.com/DidYouKnow/Hardware_Software/mobile-operating-systems-mobile-os-explained.html

2. https://en.wikipedia.org/wiki/Comparison_of_mobile_operating_systems

Block–3
Android Operating System and iOS

Unit 1: Basics of Android Operating System   1
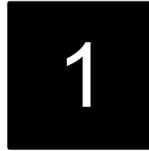
Unit Structure

1.1 LEARNING OBJECTIVE

After studying this unit, a student should be able to Understand:

- The history of the Android OS and various versions.
- The fundamentals Android application terminologies.
- The Minimum Privilege model implemented in Android and its relation with the programming aspects.

1.2 INTRODUCTION

Android is designed by Google for the touch screen devices. Android is the world's most popular mobile operating system, used in the billions of devices ranging from phones to watches, tablets, TVs, and more. The Open Handset Alliance (OHA) has played an important role in the overall development of the Android OS. The members of OHA are the mobile handset, chip, Network operators, Software developers, Component manufacturers, and some other mobile carriers. The OS contains a Linux-based Operating System (OS), middleware, and critical mobile applications. There are drivers like display, camera, flash memory, keypad, other sensors like accelerometer, gyroscope (and few other), Wi-Fi, GPS, Bluetooth, and audio. As like other kernels, here this kernel also serves as an abstraction between the hardware and the rest of the software on the phone. There are core services like security, memory management, process management, and the network stack.

Depending on the capability of the mobile handset Android OS version can be chosen. The Android OS provides the Application Programming Interfaces (APIs) in terms of Java and Kotlin. To utilize these functionalities, the one should have some knowledge of event handling (also called as the callbacks), and Extensible Mark-up Language (XML). Nowadays, Android Studio is available for Android App development. The Android Studio provides the fastest tools for building apps on every type of Android device. Android studio supports the installation on Windows, Linux, and Mac OS, in 32 bit and 64-bit versions. The https://developer.android.com is the web URL for the recent development updates in the Android OS.

1.2.1 IMPORTANT FEATURES OF ANDROID OS

Following are the essential key features that make the Android OS as more popular.

➢ The user of the Android OS gets informed timely through the Notification features. The user can take the appropriate action due to the notifications in the android. Every notification opens a suitable app for further action. Furthermore, the bundled notifications can be expanded.

➢ During the Android OS updates, the user can snooze the notifications.

➢ The multiple applications can be closed altogether.

➢ Android OS allows the customization of the android phone such as transferring the contacts, installing widgets, downloading the wallpapers, installing the customized keyboard, setting the default apps, the lock screen can be customized, and hiding apps.

➢ Majority of the Android users do not use the root users; however, it gives more flexibility to remove the apps. Through the process of rooting an Android OS, it is possible to access all settings and sub-settings deeply. It is similar to the administrative access to the Personal Computer. The rooting process allows removing the unnecessary apps provided by phone's carrier or its manufacturer, sponsored apps, unwanted apps called bootware. The rooted Android OS allows to block the spam and improve the performance. The bootloader should be unlocked to enable the rooting.

➢ Android OS provides features like multi-user PC, where one can lock or hide apps.

➢ Android OS allows capturing gestures performed on a device's fingerprint sensor. The fingerprint sensor is useful for authentication purpose.

➢ Google assistant provides lots of help through the media control commands given through the voice.

➢ The Latest innovations on the hardware fronts, like Near Field Communication (NFC), Telecommunications, and libraries of the other sensors are available.

➢ Android is available with free ads using Google Admob to monetize the apps developed for the android device and loaded with advertisements.

➢ Due to the flexibility and features of Android OS, there are a variety of handsets available with the different price ranges.

1.3 HISTORY OF ANDROID OS

In case of the PC OS, where the significant responsibilities to handle the x86 architectures, memory management, process management, process scheduling, peripheral management, multi-user management, and optimizations are the significant tasks. Also, there are network communication tasks like in the Local Area Network (LAN) and the Internet-connected environment. Usually, there are wired and wireless network connection to the PC and set of communication protocols, that the OS handles.

Similar to the PC OS, the mobile device OS handles the necessary access to the applications and process, to manage the cellular, network connectivity, and phone access. The mobile OS is tied to specific hardware. The mobile OS is different from the normal PC's OS where the mobile handsets have the ARM architecture microprocessor, and handsets are smaller in size. The mobile works on battery power; there is no separate keyboard or mouse. The user interface is a touch screen and no expandable RAM. There is no Ethernet cable; hence, the mobile must be able to communicate with other wireless protocols.   Similar to the different mobile OSs like iOS, Symbian, Blackberry, HP's WebOS, Microsoft's Phone OS the Android is another mobile OS with better functionalities.

The co-founder and former CEO of Android Inc. Mr. Andrew E Rubin has a nickname as Android. His co-workers gave the nickname Android due to his love for the robots. In 17th August 2005, Google acquired Android Incorporation. In 2007, Google announced the development of the Android OS.

1.4 VERSIONS OF ANDROID OS

At the time of writing this course material, the Marshmallow was available in most of the android devices. Table-1.1 shows the android versions, their code name and API levels. The important features got added into the newer version of the Android with Application Level Interfaces (APIs) levels. The developer has to take important consideration about the target devices where the app is going to be deployed. It will perform well with better functionalities, provided that the handset hardware capabilities are available with the same potential.

Codename	Version	API Level
Android Q	10	29
Pie	9.0	28
Oreo	8.0 & 8.1	26 & 27
Nougat	7.0 & 7.1	24 & 25
Marshmallow	6.0	23
Lollipop	5.0 & 5.1	21 & 22
KitKat	4.4	19
Jelly Bean	4.1 to 4.4	16 to 18
Ice Cream Sandwich	4.0.3, 4.0.4	15
Honeycomb	3.0 – 3.2.6	11to 13
Gingerbread	2.3.3 to 2.3.7	9-10
Froyo	2.2 – 2.2.3	8
Eclair	2.0 – 2.1	5 – 7
Donut	1.6	4
Cupcake	1.5	3
Petit Four	1.1	2
No Name	1.0	1

Table-7: The code name, Android version and API levels

The recent version of Android Pie having the following critical features:

➢ Multi-camera support and camera updates

➢ Indoor positioning with Wi-Fi Round-Trip-Time (RTT) which is based on IEEE 802.11mc Wi-Fi protocol

➢ Machine Learning & Neural Networks API Support

1.5 ARCHITECTURE OF THE ANDROID OS

As shown in Figure-50, the Android stack is consisting of Power Management features, Linux kernel, hardware abstraction layer, open source libraries, android runtime system, application framework, and at the top the Applications.

System Apps
Java API Framework

Native C/C++ Libraries	Android Runtime

Hardware Abstraction Layer
Linux Kernel
Power Management
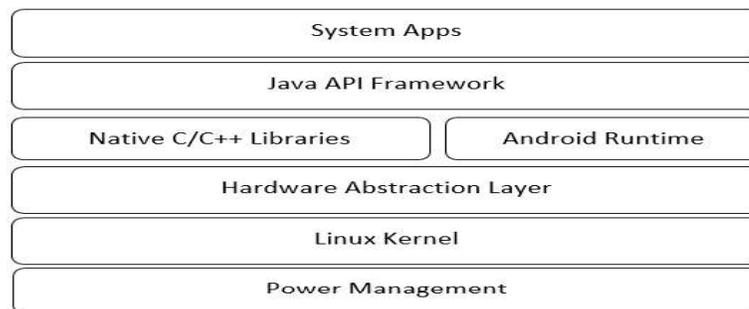
Figure-50 Layers in the Android Stack (Architecture)

1.5.1 POWER MANAGEMENT FEATURES

Figure-51 shows the power management strategies in the Android OS. One of the ways for power management is done through the App restrictions such as used with the help of the buckets.The app can be restricted in such a way that it should not consume the resources such as memory, CPU or other air interfaces. The app running in the background, accessing hardware or the processor highly consumes the energy.
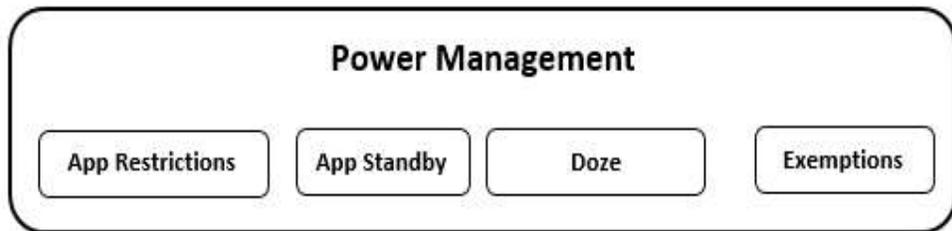
Figure-51 Power Management Strategies

The apps sending it in the standby mode so that, the app should not access the network activity and other jobs those not actively used by the user. The inactive applications are detected based on the longer clock time of the idle time. The sync activities are stopped for the app either for a day. The standby mode can be exited once the device is plugged in for the charging. The adb tool can be useful for application testing in case of the standby and active modes.

The Doze mode keeps the device CPU, and network activity completely stopped. The Doze mode also keeps the pending sync and job works. It can complete the work by entering into the maintenance window on the regular intervals.

1.5.2 LINUX KERNEL

Android was created on the open source kernel of Linux. It provides security, memory management, process management, network stack, and driver model. Linux kernel contains code for all the different chip architectures and hardware drivers it supports.

The Linux kernel having several drivers for display, camera, Bluetooth, shared memory, binder like Inter-Process Communication (IPC), USB, keypad, Wi-Fi, Audio, and power management purpose.

There are stable, and long term supported kernels for android. The latest features included in the Linux kernels are energy-aware scheduling, networking, SDCard, USB, System on Chip (SoC) for ARM64, and x86, etc. Figure-52 shows the Linux kernel drivers for the various hardware like camera, audio, display, USB, Shared memory, Wi-FI, Keypad, and IPC.
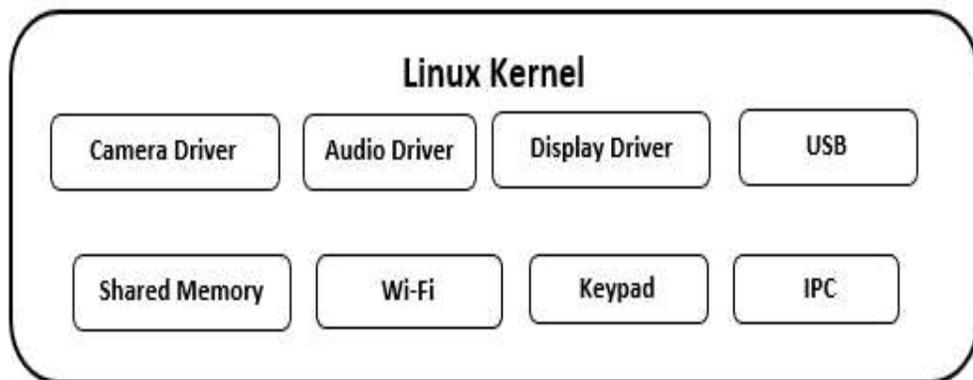

Figure-52 Linux Kernel and its sub-components

1.5.3 HARDWARE ABSTRACTION LAYER (HAL)
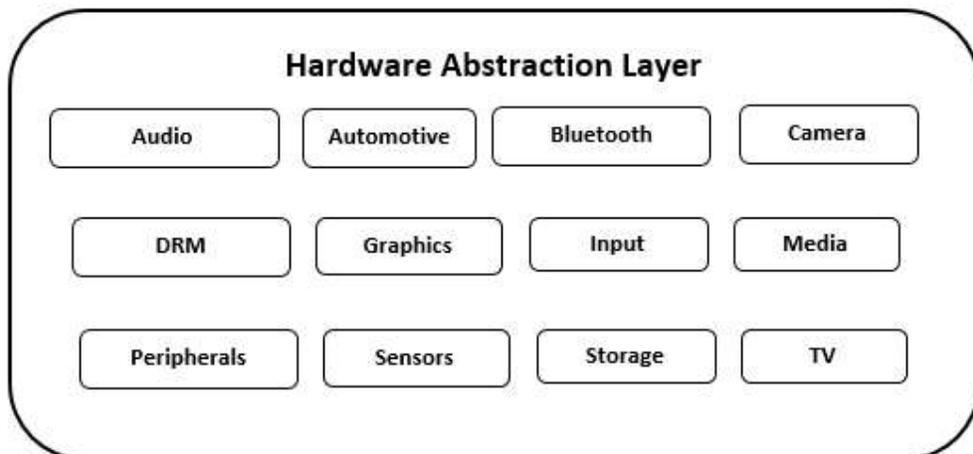
Figure-53: Hardware Abstraction Layer

Figure-53 shows the HAL and its sub-components. A HAL defines a standard interface for hardware vendors to implement, which enables Android to be agnostic about lower-level driver implementations. Using a HAL allows you to implement functionality without affecting or modifying the higher level system. You must implement the corresponding HAL (and driver) for the specific hardware your product provides.

The hardware abstraction layer is audio, Automotive, Camera, Bluetooth, GPS, radio, Wi-Fi, Sensors, storage, TV, peripherals, media, and graphics. The core libraries and Dalvik VM are part of Android run time.

1.5.4 NATIVE C/ C++ LIBRARIES

Native Development Kit (NDK) is a companion tool to write the critical performance code and makes it possible to write apps using C/C++ code. It is possible to mix existing C/C++ native libraries into an Android Java project. Without changing the fundamental Android application model, the C or C++ code can build activities, handle user input, use hardware sensors, access application resources, etc. It can be packed into the APK bundle. The direct low-level operations such as at hardware access, can be achieved through the native libraries, as well as the cross-platform functionalities such as iOS and Android, can be achieved. To utilize the native C++ libraries, the Run Time Type information (RTTI) is useful to find the run time information about the class such as finding the variables, methods, and other information about the state of the method and objects. This is similar to the Reflection APIs in Java.

Java Native Interface (JNI) allows accessing the native code from Java and vice versa. The native code written in C/C++ can be directly converted into the code understandable to the CPU. The functionality implementation is possible in the using C and C++ because it has a mechanism like Java Virtual Machine (JVM). To develop the Java project for the native support, it is required to click on the checkbox of C++ support. Figure-54 shows the option for NDK support.
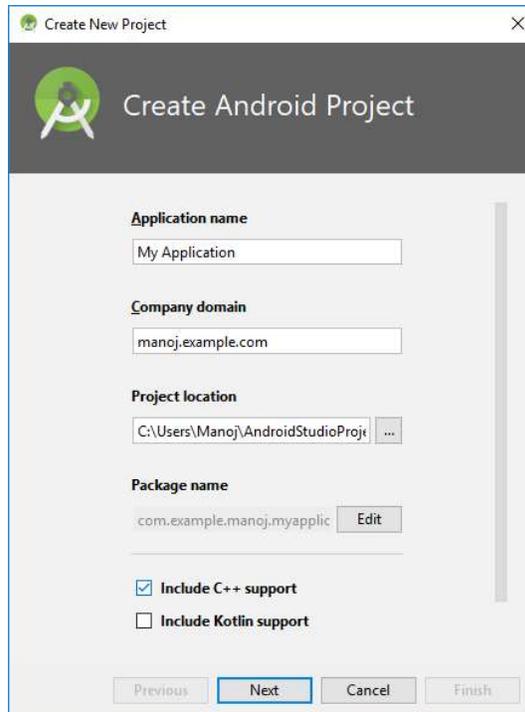
Figure-54: Starting a new NDK supported the project –including the C++

There are several applications to utilize the C/C++ native libraries such as to achieve the low latency applications in case of the games and the physics simulations etc. It is also an intention to reuse the existing libraries written in C/C++. CMake and LLDB debugger are useful tools for such application development.

Table-8 shows a list of C/C++ libraries provided from the recent to the basic version of the Android OS.

C/C++ Native Library	Description
Surface Texture & Surface Manager	Surface connection with the OpenGL Responsible for rendering windows and drawing surfaces of various apps on the screen.
Shared Memory JNI	Upon creation of shared memory & a file descriptor used in the inter-process communication.
Neural Networks	Hardware acceleration for on-device machine learning operations. The API supports on-device model creation, compilation, and execution.
Hardware Buffer	pipelines for cross-process buffer management.
AAudio,	Read and Write the audio stream with low latency.

Native media	The image read and write operations.
OpenGL	Cross-Language, Cross-Platform Application Programming Interface (API) For Rendering 2D And 3D Vector Graphics.
Native Multi-network	Multiple networks operations.
Choreographer	Timing of Animations, Input, And Drawing in Native Code.
camera	Photo Capturing and other operations.
Vulkan	API for high-performance 3D graphics rendering.
Tracing	Write trace events to the system buffer.
OpenMAX AL	Multimedia Handling Is based on Khronos Group.
OpenSL	Native audio handling is based on the Khronos Group.
EGL	Native Platform Graphics Interface
Bitmap	Pixel Buffer
Dynamic Linker	Access to Dynamic Linker
Zlib	The zlib compression library provides in-memory compression and decompression functions, including integrity checks of the uncompressed data.
Logging	Log messages to Logcat from native code.
C/C++ library	<Stdlib.h> and <stdio.h>
FreeType	The library is used for rendering fonts.
WebKit	Library mainly provides Web Browsing engine and a lot more related features.
SQLite Library	Apps local database for lightweight operations.

Table-8: Summary of the Native Library in C/C++

1.5.5 ANDROID RUNTIME (ART)

ART translates the bytecode into the native instructions. ART is also called as the Application Runtime Environment. Previously, there was a Dalvik virtual machine which is not replaced by the ART. It uses the Ahead-of-Time (AOT) compilation process which compiles the entire application into the machine code upon the installation of the app. It reduces the Dalvik's procedure of interpretation and trace-

based Just-in-Time (JIT) Compilation, which enhances the overall execution efficiency and saves the battery power. The Android 5.0 Lollipop onwards the previous Dalvik is replaced by the ART. ART improves memory management and protects battery power. During the installation of the software, it takes time as it compiles the code from the APK bundle. However, it improves the overall performance of the applications, at the runtime.

ART adds the sampling profiler to supports the number of debugging options for monitoring the garbage collection process, threads, locks, stack traces, breakpoints, and watchpoints. Some techniques of Dalvik do not work on ART.

1.5.6 JAVA API FRAMEWORK

The application framework is consisting of a set of managers including activity, location, package, notification, resource, Telephony, and window manager. There are content providers and view system. Figure-55 shows the Java Application Programming Interface Framework.
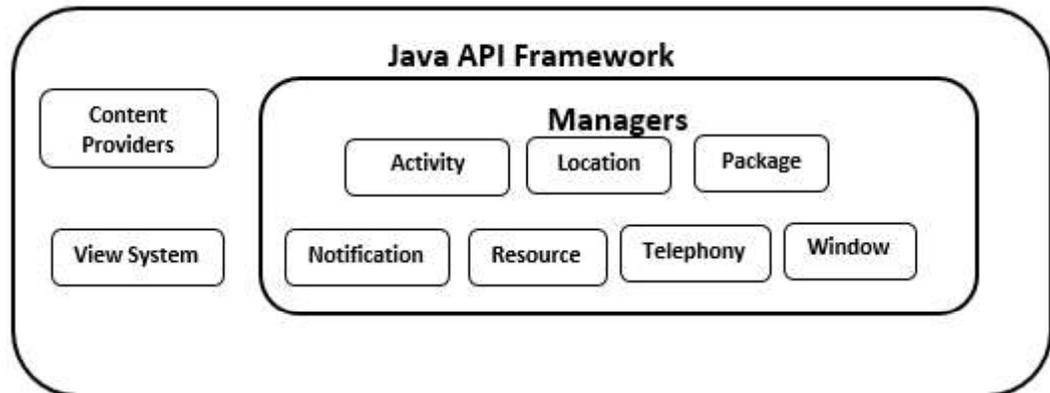

Figure-55 Java API Framework

1.5.6.1 VIEW SYSTEM

All the Android features can be utilized through the Java API Framework. The views, i.e. graphical user interface components can be used along with their events through the view system. The view also called as the widgets. Figure-56 shows the hierarchy of the View Group and Views.
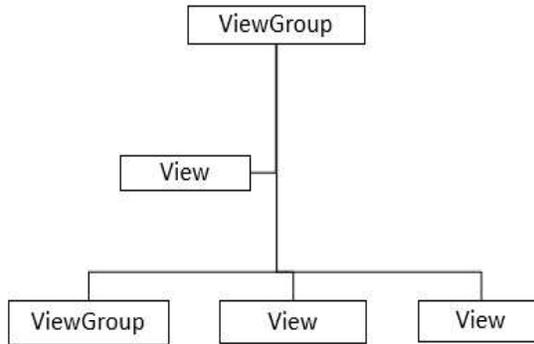
Figure-56 View Components and widgets Hierarchy

Here ViewGroup is the layouts such as Linear Layout, Constraint Layout, Frame Layout, or Table Layout. Sometimes it is a combination of more than one layouts. In the Android Studio, the design view shows the layouts. Figure-57 shows the various layouts; Figure-58 shows the various widgets.
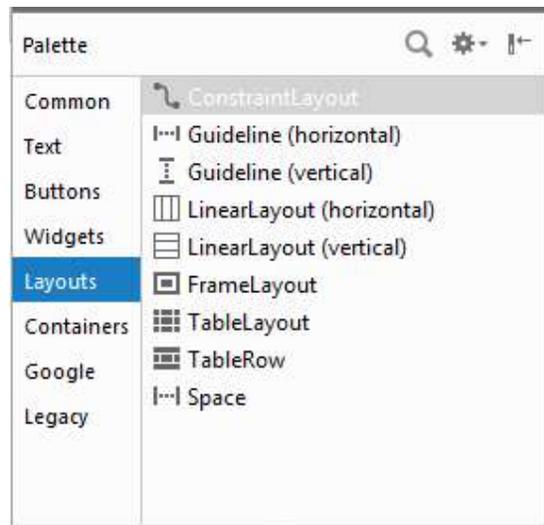

**Figure-57 View Group in Android Studio**
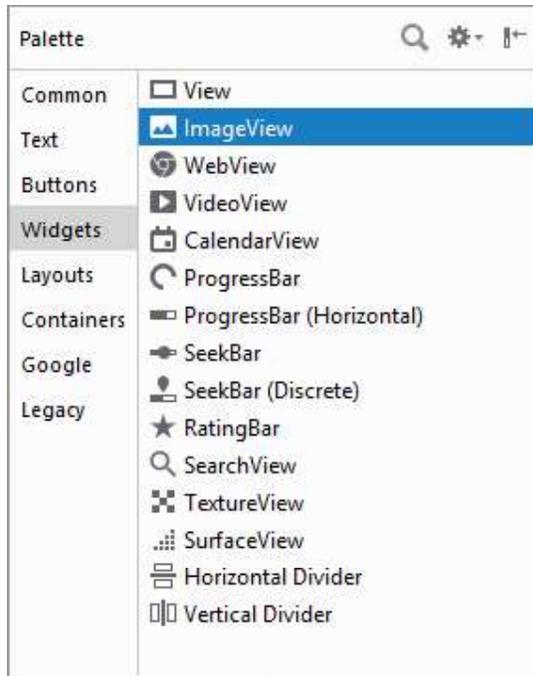
Figure-58 views, i.e. the widgets in android studio GUI

There are several widgets such as Image View, web view, video, calendar, progress bar, seek bar, Rating Bar, search view, Texture View, and Surface view. There are several text-based widgets similar to the readymade patterns. There are buttons like a toggle button, image, checkbox, radio button, switch, and floating action button.

1.5.6.2 CONTENT PROVIDERS

Content providers provide the mechanism to share the data from one widget to another, one data store to another, or between the different applications. The content provider can also work to supply data to the threads and their synchronizations and cursor.

1.5.6.3 ACTIVITY MANAGER

The Activity Manager is a class android.app.ActivityManager which Android System manages a stack of activities which are in different states (starting, running, paused, stopped, destroyed). An activity has one or more windows (e.g., dialogs). An activity becomes roughly a token. Activity Manager gives information about and interacts with, activities, services, and the containing process.

A window has one or more surfaces (e.g., surface views). However, in a window manager, a window is called a session. A surface is called a window.

1.5.6.4 WINDOW MANAGER

Window Manager is an interface responsible for organizing the screen. The window manager creates surfaces for the application. It allocates surface and decides where they(Applications) go and how they are layered. At create, a surface for all the applications and they draw directly into the surface without going through the Window Manager,Some basic things regarding activity, windows, and surfaces.

1.5.6.5 PACKAGE MANAGER

The abstract class provides essential information about package installation and its availability. All Java classes are part of a package. The package may consist of other packages and classes or interfaces. At the runtime, it is required to find out presence or absence of the package. The package manager plays an important role in package access related operations.

1.5.6.6 NOTIFICATION MANAGER

It is the class useful to handle the notifications to the device user. The happening of some event related to the app, sometimes in the background are notified to the user. These notifications are either in the form of the alerts, or the toast, blinking of the light, a sound, or vibrating the phone.

1.5.6.7 LOCATION MANAGER

The device location identifier where it takes the support of the GPS and proximity of the geographical location. The API such as addProximityAlert() takes the longitude, latitude and the radius to create the alert when the device enters into the proximity of the specified location.

1.5.6.8 TELEPHONY MANAGER

The android.telephony.TelephonyManager class provides information about the telephony services such as subscriber id, sim serial number, phone network type, etc. Moreover, you can determine the phone state, etc. The information related to International Mobile Equipment Identity (IMEI) number, subscriber ID, Sim card information, network information, type of the network such as Global System for Mobile (GSM) or Code Division Multiple Access (CDMA) can be easily accessed through the Telephony Manager Class.

1.5.6.9 RESOURCE MANAGER

Resource Manager manages resources such as icons, styles, colors, strings, layout, and drawable.

Following code shows the string resources separately maintained in the XML file.

```
<resources>
    <string name="app_name">Interchange</string>
    <string name="title_activity_second">SecondActivity</string>
</resources>
```

The style can be applied similar to the cascaded style sheet for HTML code. A style resource defines the format and looks for a UI. A style can be applied to an individual View (from within a layout file) or an entire Activity or application (from within the manifest file). Android studio creates the style.xml file to maintain the style.

The colors can be maintained in the separate file with the name color.xml.

```
<?xml version="1.0" encoding="utf-8"?>
<resources>
    <color name="colorPrimary">#3F51B5</color>
    <color name="colorPrimaryDark">#303F9F</color>
    <color name="colorAccent">#FF4081</color>
</resources>
```

1.5.7 APPLICATIONS
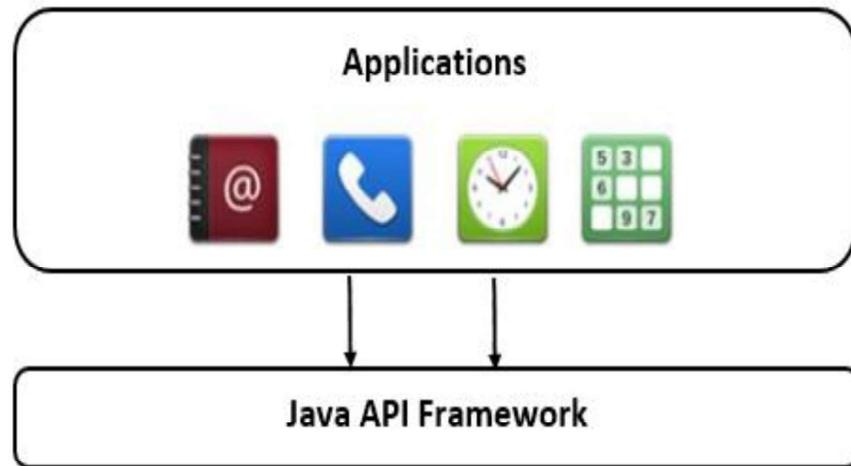
Figure-59 The applications are at the top layer

The top layer is of applications such as email, alarm, calculator, camera application, contacts, media player, SMS, MMS manager, and photo album. Figure-59 shows the application layer interacting with the Java API framework layer.

Android studio utilizes the Software Development Kit (SDK) with API libraries and developer tool necessary to build, test and debug apps for Android. You can download Android Development Tools (ADT) bundle, ADT plug-in, Android SDK tools, Android platform tools, Latest Android platform, latest Android system image for the emulator.

All the code in a single APK file is considered to be one application and is the file that Android-powered devices use to install the app. Once an application is installed, on a device, each Android application lives in its security sandbox. An Android OS is a multi-user operating system in which each application is a different user. By default, the system assigns each application a unique Linux user ID (the ID is used by the system and is unknown to the application). The system sets permissions for all the files in an application so that only the user ID assigned to the application can access them.

1.6 APPLICATION & TASK MANAGEMENT IN ANDROID OS

1.6.1 APPLICATION TERMINOLOGY

An Android application consists of one or more activities, services, listeners, and intent receivers. Each process has its virtual machine (VM), so an application's code runs in isolation from other applications. By default, every application runs in its own Linux process. Android starts the process when any of the application components need to be executed, then shuts down the process when it's no longer needed, or when the system must recover memory for other applications. It implements the principals of least privileges. Each application by default has access only to the components that it requires to do its work and no more. It creates a very secure environment in which an application cannot access parts of the system for which it is not given permission. User can share data with other application and for an application to access system services. All the application permissions must be given at install time.

View: In Android, the View is the foundation of everything that shows up on the screen. Buttons, toolbars, and inputs, everything is a View.

Activity: It is a single focused thing that a user can do. An activity is the entry point for interacting with the user. It represents a single screen with a user interface. For example, an email app might have one activity that shows a list of new emails, another activity to compose an email, and another activity for reading emails. To create an activity, the Activity class should be extended. To add an activity in the Android Studio right click on Project Window -> Select activity. It shows several readymade options like Gallery with options like Basic activity, Empty Activity, Login Activity, Master Detail activity, and other navigation and scrolling activity. Figure-60 shows the various activity types.

Difference between Basic and Empty Activity

Empty Activity is the same as Blank Activity is the simplest activity which you can create. Empty activity can use fragment. Android Studio creates the separate two layout files for it. Basic Activity is more advanced than Empty/Blank Activity because have the toolbar and one button (Floating Action Button - FAB).
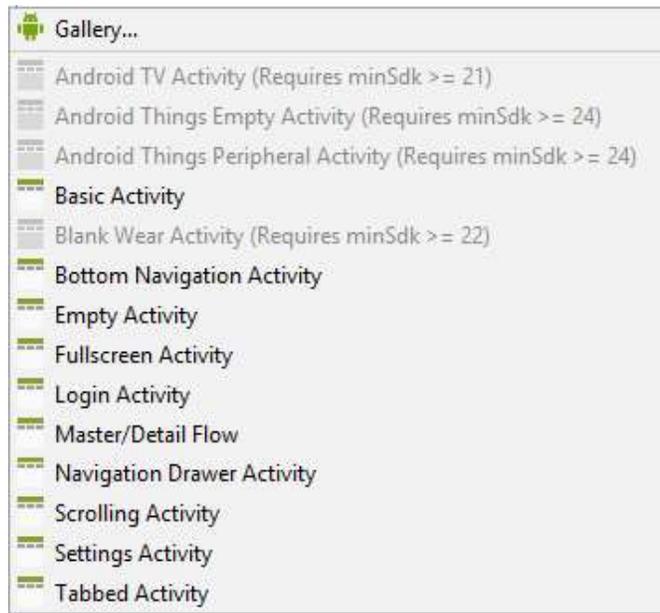
Figure-60 Different activities for the app development

Fragment: It is the portion of the user interface (subsection or module section) used to design the multi-pane meaningful user interface. The fragments can be reused in multiple activities. A fragment is having its own lifecycle and receives the events.

Service: A service is a general-purpose entry point for keeping an app running in the background for all kinds of reasons. It is a component that runs in the background to perform long-running operations or to perform work for remote processes. A service does not provide a user interface. For example, a service might play music in the background while the user is in a different app, or it might fetch data over the network without blocking user interaction with an activity.

Listener: Listeners are generally the interfaces in Java programming. They are the abstract methods with an empty body, and final and static variables (usually called as constants). It is the responsibility of the class which implements the Listener interface. There are several listeners associated with the Graphical User Interface (GUI) Components such as ActionListeners and an ItemListener. There are widgets in the Android such as Button, CheckBox, RatingBar, ProgressBar, ImageView, TextView, EditText, etc. To attached the events with the widgets, the programmer should register them with each other.

Broadcast Receiver: A broadcast receiver is a component that enables the system to deliver events to the app outside of a regular user flow, allowing the app to respond to system-wide broadcast announcements. Because broadcast receivers are another well-defined entry into the app, the system can deliver broadcasts even to apps that aren't currently running.

Resources: There are resources in the Android animation, color state list, layout, menu, string, style, and font. There are static resources like bool, color, dimension, ID, Integer, Integer Array and Typed Array.

1.6.2 ANDROIDMANIFEST.XML FILE

Manifest File AndoridManifest.xml is the important file which maintains the minimum privileges model of the Android OS. ".apk" is the Android application package file, which is compiled and packaged in a single file that includes all of the application's code (.dex files), resources, assets, and manifest file. Android programs are compiled into ".dex," i.e., Dalvik Executable files. The. dex files are zipped into a single .apk file on the device.

1.6.3 SECURITY FEATURES OF ANDROID APP

Each app lives in the security sandbox. Android is the multi-user Linux system in which each app is a different user. Each process has its own VM to run in isolation. The system assigns each app a unique Linux user ID. The system sets permissions for all the files in an app so that only the user ID assigned to that app can access them.

It provides the encrypted file storage, to avoid loss in case of the stolen or lost devices. The Java security features implemented on cryptographic algorithms can be used while creating the apps. The permissions can also be given at the run time.

1.6.4 PRINCIPLE OF LEAST PRIVILEGE

Each app by default has access only to the components that it requires to do its work and no more. For example, if the developer wants to develop an app where the Bluetooth is going to be accessed to share the data then it has to be mentioned in the AndroidManifest.xml file.

<uses-permission android:name="android.permission.BLUETOOTH" />

Similarly, if the app is going to access the Internet following line should be added to AndroidManifest.xml.

<uses-permission android:name="android.permission.INTERNET" />

To add the Wi-Fi Access permission following lines can be used.

<uses-permission android:name="android.permission.ACCESS_WIFI_STATE" />
<uses-permission android:name="android.permission.CHANGE_WIFI_STATE" />

The examples given are the static permissions assigned in the androidmanifest.xml file. However, at runtime also the permissions can be given and revoked using the APIs checkSelfPermission(), requestPermissions() from the ActivityCompact and ContextCompact class.

1.7 APPLICATION LIFE CYCLE

By assuming Java as a programming language and automatic garbage collection feature, the application and the processes can be killed. The processes or application not required for the further usage need to be killed and the memory and other resources have to be reclaimed. The automatic garbage collection system decides the inclusion of the activity, service, and broadcast receiver role while continue running an application working or to stop. Hence the application and process life cycle is not in the control of the user and developer. However, there is an Activity life cycle, which includes the various stages and corresponding events. The stages include the activity launch, activity running, and activity shut down.

There is core set of callback methods like onCreate(), onStart(), onResume(), onPause(), onStop(), and onDestroy(). Whenever new activity comes in the foreground then onPause() method gets called. Whenever the user returns to the activity back then onResume() method is called. If the application is in the pause mode and if the higher priority method requires memory, then the app process gets killed. When the activity is no longer visible then onStop() method is invoked. If the activity is finishing or is being destroyed by the system then onDestroy() method is invoked. Whenever the user navigates, then onRestart() method is gets invoked. Figure-61 shows the activity life cycle stages.
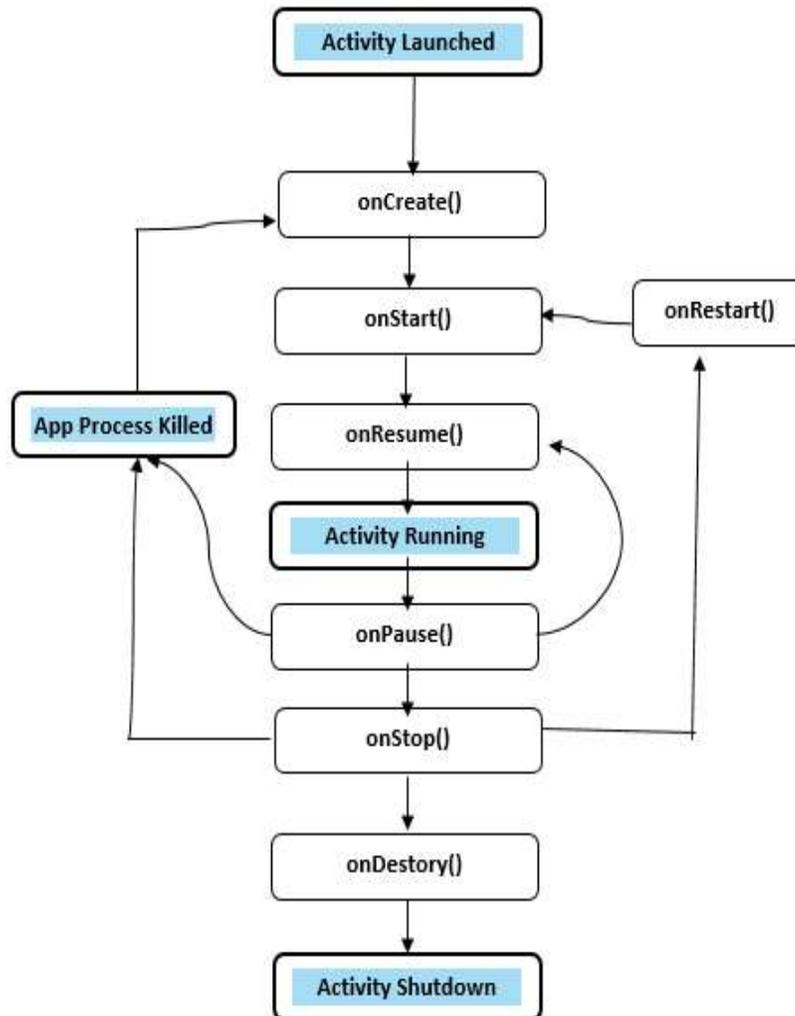
Figure-61 Activity Life-cycle methods

1.10 LET US SUM UP

➢ The Android architecture and its different layers are studies in the detailed.

➢ The discussion on the Linux Kernel functionalities and its subcomponents are discussed.

➢ The application terminologies like Activity, Service, Intent, and Broadcast receivers have been discussed.

➢ The comprehensive discussion on the power management techniques (e.g. bucket creation) in android architecture is done.

➢ The discussion on the Least Privileges model is done.

1.8 CHECK YOUR PROGRESS

> ➢ **Answer the following in True / False statements.**

1. Android is a Linux kernel based OS.
2. Androidmanifest file is written in HTML.
3. Flutter can be useful for UI development in Android app development only.
4. The permissions can be added to the Androidmanifest.xml only at the design time.
5. The functionality achieved using the NDK similar to Java API framework from the latency point of view.
6. @overrides is just a useless token in Java.
7. Constraint Layout is a Widget.
8. The more restrictions are imposed on the android apps when a mobile device is in battery mode.

> ➢ **Match the columns correctly**

Group A		Group B
Andrew Rubin		Version 6.0
Pie		Android Nickname
Marshmallow		Version 9.0
FreeType		Python
Statically Typed		Rendering fonts
Dynamically Typed		Java
Zlib		Logcat Messages
Logging		Compression Library

> ➢ **Fill in the blanks.**

1. The code name of the Android 8.0 is _____.
2. The method useful to add the runtime permissions is _____.
3. The _____ in C++ is similar to the Reflection mechanism in Java.
4. The five different buckets to categorize the apps to save battery power are

   _____, _____, _____, _____ and _____.

➢ **Choose the correct option(s).**

1. Which of the following is the statically typed programming language?

    a) Kotlin   b) Python   c) Javascript   d) Java

2. Semicolons are optional in

    a) Kotlin   b) Java   c) C++   d) Python

➢ **Answer the following Questions in one or two sentences.**

1. What is APK?

2. Name the languages supported for Android development.

3. Names of the dynamically typed languages?

4. What is the meaning of the dynamically typed languages?

5. Name of the statically typed languages?

6. What is the meaning of the statically typed languages?

7. What is material Design?

8. What is Flutter?

9. Write the permission line to perform the read and write operation through the android app.

1.9 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

➢ **True/False Answers**

1. True

2. False

3. False (Flutter can be useful for UI development in Android and iOS both).

4. False (The permissions can be added at runtime also.)

5. False (As it is native to the CPU, it is faster.)

6. False (Causes a compilation error if the method is not found in one of the parent classes or implemented interfaces).

7. False (Constraint Layout is a View Group.)

8. True.

➢ **Fill in the blanks**

1. Oreo

2. requestPermissions()

3. RTTI (Run Time Type Information).

➢ **Multiple choice**

1.   Kotlin, Java

2.   Kotlin, Python

➢ **Answer of the short Questions**

1.   Android Package Kit

2.   Kotlin, Java, C++ & C

3.   Groovy, JavaScript, Lisp, Lua, Objective-C, PHP, Prolog, Python, Ruby, Smalltalk, and Tcl.

4.   Dynamic type checking is the process of verifying the type safety of a program at runtime.

5.   Ada, C, C++, C#, Java, Fortran, Haskell, Pascal, and Scala.

6.   A language is statically-typed if the type of a variable is known at compile time instead of at runtime.

7.   Material Design is a visual language that synthesizes the classic principles of good design with the innovation of technology and science.

8.   Flutter allows you to build beautiful native apps on iOS and Android from a single codebase.

9.   <uses-permission

        android:name="android.permission.WRITE_EXTERNAL_STORAGE" />

1.11 FURTHER READING

1.   https://material.io/design/introduction/

2.   https://flutter.dev/docs/get-started/flutter-for/android-devs

3.   https://www.kernel.org/category/releases.html

1.12 ASSIGNMENTS

1.   What are the battery saving techniques you apply for your mobile handset, discuss in details.

2.   What are the different sensors available in your mobile handset?

3.   What are the advantages and disadvantages of the rooted Android OS?

1.13 ACTIVITIES

1. If you have an Android phone then find its OS version number and corresponding code name?

2. Enable the developer option in your android phone.

3. Install recent Android Studio on your personal Computer.

1.14 CASE STUDIES

Case Study 1:

Install any e-Wallet app and enlist the functional and non-functional requirements for developing it using Android Studio.

Case Study 2:

Calculate the cost required to create an imaginary android app for a news agency which shows the text, image, and videos. Evaluate the technical feasibility and difficulties to achieve the functionalities for the visually impaired person. Is the recent Android version providing the text to speech conversion APIs?

Case Study 3:

Find what are the major thrust areas in the testing of mobile app? How the testing of the mobile app differs from the normal website testing?

Unit 2: Internal Mechanism of Android OS 2

Unit Structure

2.1 LEARNING OBJECTIVE

After studying this unit, a student should be able to Understand:

- The in-built mechanism in Android OS for better power management.
- The fundamentals Dalvik Virtual Machine and its evolution.
- The details of the process of compilation using DVM.
- The Android Runtime and Just-in-Time Compiler.
- The Application frameworks and corresponding application programming Interfaces for Android OS.

2.2 DALVIK VIRTUAL MACHINE (DVM)

A Virtual Machine (VM) is an emulation of a computer system which is created from the physical resources like disk, CPU, RAM, and other resources of the machine. The virtual disk can be created to install more than one of the guest OSs, over the one host operating system. Generally, the hypervisors are useful to create the VM either in the full virtualization or para-visualization approach.

Normally, the standard applications in the java follow the step as shown in Figure-62. The source code file with extension ".java" is compiled and the intermediate code called as the byte code is generated. The byte code file is having a .class extension. To run this code, the java interpreter tools are used.
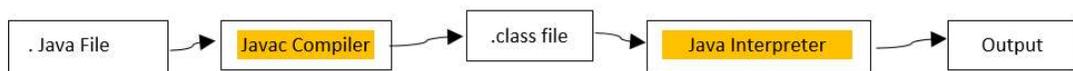

Figure-62: Normal procedure to run java program

The modern JVM is high performance and provides excellent memory management. But it needs to be optimized for low-powered handheld devices as well. Hence it is re-written for the mobile device and applications.
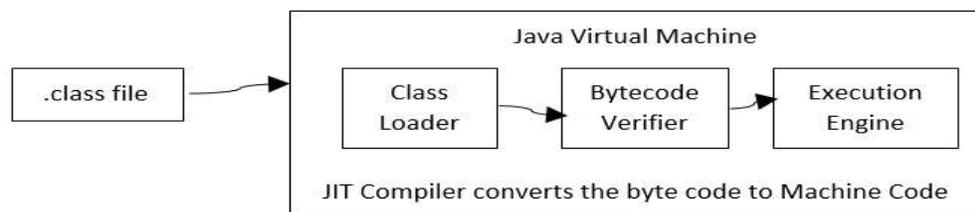

Figure-63 Java interpreter and JVM role in the execution of the byte code

As shown in Figure-63, the Just-in-time (JIT) compiler is converting the byte code to the machine code. Unlike the C or C++, there is no linker in case if there are multiple .class files. In C or C++ there are .obj files created which are linked together using a linker.

The Dalvik Virtual Machine (DVM) is an android VM optimized for mobile devices. It optimizes the VM for memory, battery life and performance. Dalvik is the name of a town in Iceland. Dan Bornstein wrote the Dalvik VM. The Dex compiler converts the class files into the .dex file that run on the Dalvik VM. Many class files are converted into one dex file. Figure-64 shows the Dalvik VM Compilation process.
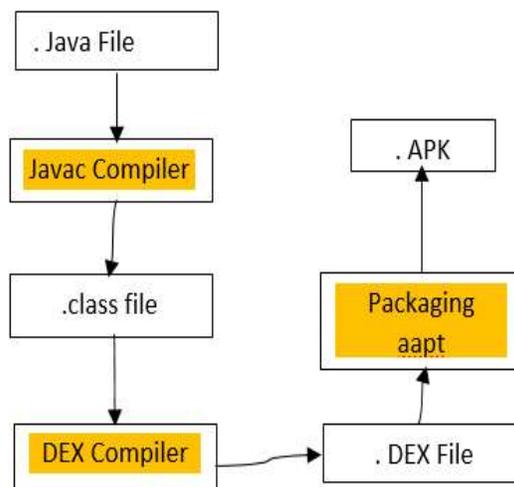
Figure-64: Dalvik Virtual Machine Compilation Process

Dalvik is the Android platform's VM. The Dalvik VM is an interpreter-only VM that executes files in the Dalvik Executable (.dex) format, a format that is optimized for efficient storage and memory-mappable execution. The VM is register-based, and it can run classes compiled by a Java language compiler that have been transformed into its native format using the included "dx" tool. The VM runs on top of POSIX-compliant OSs, which it relies on for underlying functionality (such as threading and low-level memory management). The Dalvik core class library is intended to provide a familiar development base for those used to programming with Java Standard Edition, but it is geared specifically to the needs of a small mobile device.

2.3 KERNEL OF ANDROID OS

For any OS, the kernel is the bridge between the hardware and the applications. Kernel plays several roles including the memory management, file system, interrupt handling, and input-output handling. The CPU, Memory, and devices can be accessed through the kernel. The OS puts the CPU into the kernel mode, which allows the execution of the special instructions. The user mode has fewer privileges as compared to the kernel mode. Usually, there are only two modes. However, when the virtual machine monitor (VMM) comes in the picture, then it works like a user process but having certain additional functionalities. Figure-65 shows the typical OS system call mechanism in the user mode and the kernel mode.
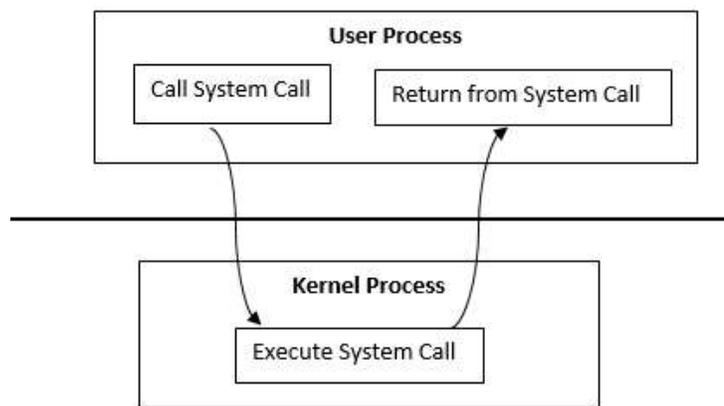

Figure-65 Typical OS - CPU Working in the user and kernel mode

The Android kernel is monolithic type (and modular kernel) where it has the benefits like direct implementation, fast, fewer overheads, system calls are used, and achieves the high performance. The monolithic kernel is one single program that contains all of the code necessary to perform every kernel related task. It is also having some challenges such as hard to develop the extra functionality, complicated programming APIs, Not necessary as secure, and larger kernel size. However, the android kernel overcomes the limitation mentioned here through the systematic steps such as kernel hardening, testing of the features, and use of the stable release of the kernel. To overcome the security challenges, there are several security mechanisms are available in the java based packages. The Android kernel is efficiently performing inter-process communication (IPC). The modular kernels of android are needed as the OEM and ODM have to do their work as per the production needs. The driver writing becomes easier due to the modular kernels.

The alternative microkernel is not used for the Android kernel development, which is having its separate address space from the user address space. It is faster and easy to add new functionalities. It is considered that the microkernel is slower, no multi-processing, and complicated process management. In the case of the microkernels, the device drivers are outside the kernel space inside the user space and so to communicate most microkernels use a message passing system. The requirements are sent through the port basis, which increases the memory footprints.

In Android, the kernel is the modified version of the Linux kernel. At the end of 2016, the size of the Linux kernel was just over 56 thousand files, consisting of 22 million lines of code, build scripts, and documentation [1]. Stable kernel releases are based directly on Linus Torvalds' releases and are released every week [2]. Stable kernels are maintained for the length of the current development cycle. After Linus releases a new kernel, the previous stable kernel release tree is stopped, and users must move to the newer released kernel. LTS (Long Term Stable) kernel releases average 6-8 patches accepted per day, while the normal stable kernel releases contain 10-15 patches per day.

There are several reasons behind making the choice of the stable kernel because there are important operations and procedures have been done before the release of the particular stable kernel. Like, configuration, hardening (to mitigate kernel vulnerabilities and find bugs in kernel drivers), interfaces (required for proper system calls and file system format storage), modular kernels, debugging, network testing, SuashFS, etc.

The modular kernels are developed for the requirements of the original equipment manufacturers (OEM) and the original device manufacturers (ODM). The modular kernel creates the separate tree structure so that OEM and ODM can work in isolation.

Once the kernel is ready for the stable release, it is necessary to test the networking stack as if the available release will not work properly; then it may not connect with Wi-Fi and similar networking features. There are several networking tests carried out where the user acceptance test criteria should be satisfied, as per

the user story. Similarly, there will be the test cases called as the test plans are executed in the network testing for the particular kernel release.

SquashFS is useful to file system for the storage of the compressed files in the less storage space. This feature is handy in case of the kernel used in the smartwatches. The SquashFS is also useful in case of the low flash memory access problems. The kernels of the android are going through such a systematic procedure to maintain battery life and power management.

2.4 MEMORY ALLOCATIONS AND USAGE

2.4.1 IMPORTANCE OF MEMORY MANAGEMENT

The memory management is an extremely important feature of any OS. Efficient memory management improves the performance of the device or PC. The device can run faster with limited memory if efficient memory management techniques are implemented in the OS. This section discusses the memory allocation in the Android OS and its many folds.

The paging mechanism is used by Dalvik Virtual Machine (DVM) and Android Runtime (ART) in the Android OS for memory management. The paging is useful to store and retrieve the data from the secondary memory to bring it in the main memory to use it. It is required when the main memory is not sufficient to bring all content of the file stored on the disk. The block of fix size called a page is used to accommodate the contents from the disk. If some program instruction is trying to access the page not available in the memory, the page fault occurs. To resolve page fault, the OS connects with the address on the disk and brings it into the page of the main memory. If the page content is not used for a long time, then the least recently used (LRU) algorithm is used to bring it out.

The older style of the memory management is swapping, where it brings the content to memory from the disk and again keeps it back. The commonly used content can be placed in the overlay memory, such as in the case of android screen display contents shared by many apps.

In Android OS as the deallocation of the memory is happening through the automatic garbage collection. As soon as the memory objects are no longer used, then the memory is reclaimed on the heap. The execution of the garbage collector is not in the control of the user.

Another memory management technique used in the Android OS is a memory mapped file. A memory mapped file is a segment of virtual memory that contains the direct byte-for-byte correlation with some portion of a file or file-like resource. Once the mapping is done, the virtual memory and the resources can be treated similar to the primary memory. The memory mapped technique Increases the performance in case of the large files. The input-output performance is faster as the internal mechanism used in memory mapping is paging. It utilizes less RAM due to lazy loading.

The memory mapping can be persisted or non-persisted. The persisted is one where the large file is in use, and memory is associated with the physical file on the disk. Once the last process is finished, the data is saved on the disk. In some cases, where the inter-process communication is happening, then the non-persisted mode is suitable for memory mapping. The file on the disk is not mapped, and data will not be saved as the last process finishes its task.

2.4.2 ZYGOTE

Generally, the process creates child process through the fork () operation. The fork() is a system call that returns the process ID. The fork () generally returns the numbers either negative, positive or zero.

Each android app process is forked from an existing process called Zygote. The Zygote process starts when the system boots and loads common framework code and resources (such as activity themes). To start a new app process, the system forks the Zygote process then loads and runs the app's code in the new process. This approach allows most of the RAM pages allocated for framework code and resources to be shared across all app processes.

2.4.3 GARBAGE COLLECTION

Java follows the automatic garbage collection mechanism. The mechanism for reclaiming unused memory within a managed memory environment is known as garbage collection. Garbage collection has two goals: find data objects in a program that cannot be accessed in the future, and reclaim the resources used by those objects. There are active objects, younger generation objects, older and permanent generation objects. The garbage collector takes a different amount of time depending on the generation of the object.

As compared to the manual garbage collection where the users or programmer's responsibility to reclaim the memory, the automatic garbage collection is having its advantages as well as disadvantages. Automatic garbage collection improves the performance by free-up the memory, while as if it is automatic then, when the collector will reclaim the memory is not in the control; For example, if while doing some important task, if the collector starts its work, then it will degrade the performance.

2.4.4 ANDROID JIT

Android runtime (ART) includes a just-in-time (JIT) compiler with code profiling that continually improves the performance of Android applications as they run. Figure-66 shows the JIT compilation process.
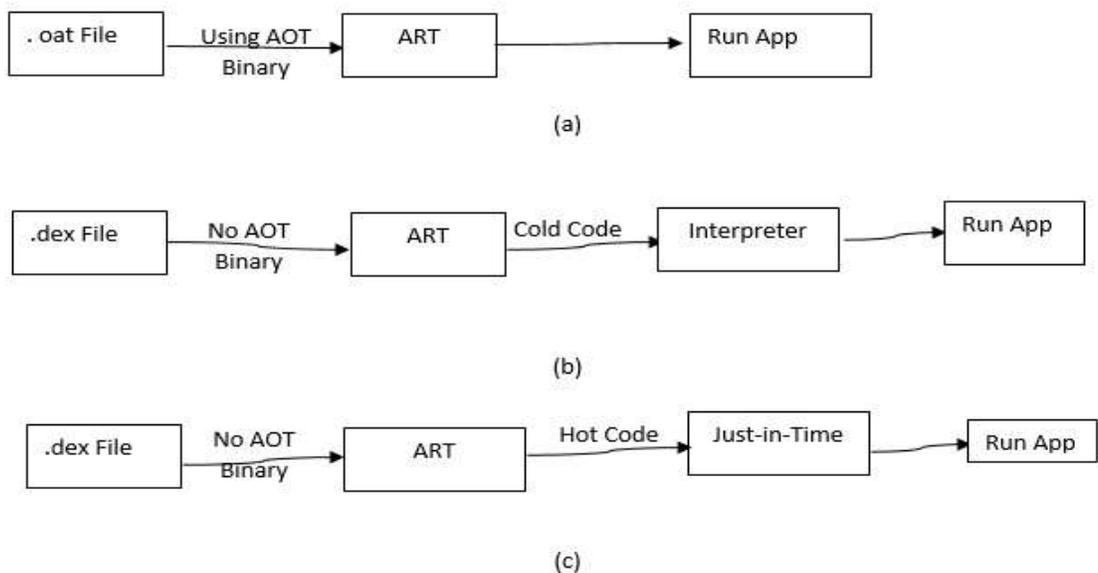

Figure-66 JIT compiler process

When the user runs the app; internally ART load the. dex file. If the .oat file i.e. the AOT binary for the .dex file is available, ART uses it directly. Although. oat files are generated regularly; they don't always contain compiled AOT binary code. If the. oat file does not contain compiled code, ART runs through JIT and the interpreter to execute the .dex file. The JIT profile data is dumped to a file in a system directory that only the application can access. The AOT compilation (dex2oat) daemon parses that file to drive its compilation.

2.5 POWER MANAGEMENT

2.5.1 POWER MANAGEMENT STRATEGIES

The battery is the most important aspect of the mobile user's experience. All the functionalities will be waste if battery is not available. To save battery life, it is important to make the app as lazy. As discussed in Unit 1, there are several techniques to manage the power as app restrictions applied based on the bucket classification, standby mode of the app, Doze, and exemptions. Figure-67 shows the various power management strategies.

There are two essential features for power management.

- ➢ App Standby Bucket
- ➢ Battery Saver

There are following buckets for better power management.

Bucket Name	Active	Working set	Frequent	Rare	Never
Profile	User is currently using the app	An app is in the working set bucket if it runs often, but it is not currently active. E.g., Social media app.	App used regularly but not every day. Like work-out app	Some travel ticket booking app for a person who seldom books tickets	The app is installed but never run.
Restrictions imposed	The system does not place any limits on the app's jobs, alarms, or messages.	Restrictions on its ability to run jobs and trigger alarms.	Imposes stronger restrictions to run jobs, trigger alarms.	Restrictions to access the Internet.	Many Restrictions

Table-9 The buckets, their profile, and restrictions imposed for battery saving

The five different buckets are assigned to the apps, namely active, working set, frequent, rare, and never. Depending on the current state of the app, the buckets can change. The restrictions on the app are more applicable when the device is running on the battery. These restrictions are not applicable when the handset or device is charging. The Firebase Cloud Messaging system is used in for the messaging and notification services. If the device is in the battery mode, then restrictions are applicable; otherwise, in the charging mode, there are no restrictions.

The battery saver features put the app in standby mode; instead of waiting to app become an idle state. The background execution limit to an app can save battery. It is disabling the location services when the screen is off, as it uses the Global Positioning System (GPS), which heavily power-intensive application. The network is not accessible to background apps.

Figure-67 Power Management Strategies

➢ Making the app lazy means, avoiding redundant operations and try to use the cache data. Such as less use of the radio interface.

➢ Defer the operations such as backup on Cloud, until the battery is recharged.

➢ Instead of sending the messages separately for each app, the batch of apps can interact with the radio interface.

➢ Performing the battery consuming operations such as the use of radio interface, screen (wake-up and sleep) and the read-write operations on the disk, in a deferred and batch-wise manner.

➢ Use of the intelligent job scheduling Application Programming Interfaces (APIs).

➢ Android internally puts the

➢ Generally, the apps shifted to the standby mode when they are idle. However, this approach is also consuming the battery until a certain time span elapses. Hence in the API level 28 onwards, the Android keeps apps in the standby mode, to save the battery.

➢ Managing how apps behave when a device is not connected to a power source.

2.5.2 DOZE

Doze reduces battery consumption by deferring background CPU and network activity for apps when the device is unused for long periods. If a user leaves a device unplugged and stationary for some time, with the screen off, the device enters Doze mode. In Doze mode, the system attempts to conserve battery by restricting apps' access to network and CPU-intensive services. It also prevents apps from accessing the network and defers their jobs, syncs, and standard alarms. Periodically, the system exits Doze for a brief time to let apps complete their deferred activities. During this maintenance window, the system runs all pending syncs, jobs, and alarms, and lets apps access the network. App Standby defers background network activity for apps with which the user has not recently interacted.

2.5.3 FIREBASE CLOUD MESSAGING (FCM)

FCM is a cross-platform messaging solution that facilitates the reliable delivery of the messages. FCM supports Android, iOS, C++, Unity, and web-support. It is highly useful in the task of sync when there is email, or similar messages are ready for client applications. It allows the 4KB of the message for the chat, acknowledgment, and device or group of devices.

2.6 PROCESSES AND THREADS IN ANDROID OS

The program in active execution mode is called as the process. The sub-processes can be created using the threads generation. The threads run in the time sharing in the simultaneous mode, where multiple threads share the same time slot of the CPU. The time given to each thread execution is divided among all threads, and how much time one thread takes is dependent on the operating system scheduling as well as the priority set by the programmer.

If someone tries to write a thread in Java then there is a class called Java.lang.Thread. One can write a run () method in overridden fashion to execute the thread. The start () method starts the thread execution. The priorities can be assigned to the thread in the range of 1 to 10. The treads can be suspended in between or can be kept on the holding state. The thread can start again when getting a chance of execution either calling explicitly or after specified time interval is

finished. To achieve the multi-threading the java.lang.Runnable interface can also be utilized.

All the components in the Android application run in the same process and thread. However, the programmer can run the separate thread if want to execute the separate threads. The android:process is the attributes which help to decide the components process. There is a main thread in the app called the UI thread. The main thread is having the responsibility to pass the event of the particular component.

The event handling of the different components is highly dependent on the working of the threads. The main thread is not thread-safe. Hence, it is recommended that it should not be terminated or operated through the child thread components. Threads are also important for inter-process communication (IPC) and the remote procedure (RPC) calling.

2.7 BUILT-IN APPLICATION FRAMEWORK API

The developer needs the APIs for the development of the various apps functionalities. The APIs includes Android Support Library, AndroidX, AndroidX Test, Architecture Components, Automotive Library, Databinding Library, Material Components, Constraint Layout Library, Android Test Support Library, Android Wearable Library, Android Things Library, Play in-app Billing Library, Play Core Library, Play Install Referrer Library. These APIs are extremely important for the developer to access and utilize the functionalities from the Android framework. These libraries are available in the form of packages consisting of the built-in classes. The APIs can be utilized by creating the objects of the particular class.

2.8 SECURITY FEATURES IN ANDROID

Android has application sandboxing where each app has its own sandbox, which is positive security features. Android OS implements the memory randomization is from Jellybean onwards. Android having disk encryption. However, there are few limitations such as there is no code signing technology. Android is having some data storage formats that can be in the external storage and can be

accessible by unwanted code. The antivirus can be downloaded from the android market. The virus can attack since no protection before the web source is downloaded [3] [4] [5].

2.9 LET US SUM UP

- ➢ The importance of the Android Runtime over Dalvik Virtual Machine is discussed.
- ➢ The chapter summarizes the advantages and disadvantages of micro and monolithic kernels and suitability of the modular monolithic kernel for Android.
- ➢ There is detailed discussion is done on the Process and threads mechanism in the Android app.
- ➢ The importance of the Firebase Cloud Messaging in the notification services is discussed.
- ➢ The battery power management techniques like Doze, five buckets of the apps, and standby mode, lazy app are discussed.

2.10 CHECK YOUR PROGRESS

- ➢ **Answer the following in True-False statements.**

1. Each component in the app creates its own Process by default.
2. Dalvik and ART both exist at the same time in higher versions.
3. A monolithic kernel is better than microkernel for the android app development.
4. SquashFS is useful for compressed data and files.
5. The main thread and the UI thread are different threads.
6. The UI thread is thread-safe.

- ➢ **Answer the following Questions in short.**
1. What is firebase Cloud messaging?
2. Why is the modular monolithic kernel developed for android?
3. What is the procedure to create the long-term stable kernel for android?
4. What is thread-safe?

2.11 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

➢ **True/False Answers**

1. False

2. False

3. True

4. True

5. False

6. False

2.12 FURTHER READING

1. https://material.io/design/introduction/

2. https://flutter.dev/docs/get-started/flutter-for/android-devs

3. https://source.android.com/devices/tech/dalvik/jit-compiler

2.13 REFERENCES

1. https://source.android.com/devices/architecture/kernel/, Accessed on 24th April 2019.

2. https://source.android.com/devices/architecture/kernel/releases.html. Accessed on 24th April 2019.

3. Mohd Shahdi Ahmad, Nur Emyra Musa, Rathidevi Nadarajah, Rosilah Hassan and Nor Effendy Othman, (2013). Comparison Between Android and iOS Operating System in terms of Security, 8th International Conference on Information Technology in Asia (CITA), IEEE.

4. Fattoh AI-Qershi, Muhammad AI-Qurishi, Sk Md Mizanur Rahman, and Atif AI-Amri .(2014). Android vs. iOS: The Security Battle, IEEE.

5. Muneer Ahmad Dar, Syed Nisar Bukhari and Ummer Iqbal Khan(2018), Evaluation of Security and Privacy of Smartphone Users, 4th International Conference on Advances in Electrical, Electronics, Information, Communication and Bio-Informatics (AEEICB-18), IEEE.

Unit 3: iOS Operating System

<div style="float:right">3</div>

Unit Structure

3.1 LEARNING OBJECTIVE

After studying this unit, the student should be able to Understand:

- iOS architecture, subcomponents, and its working mechanism.
- Comparing the iOS with Android architecture and various layers.
- Jailbreaking and related issues.
- Comparison between Android and iOS.

3.2 INTRODUCTION

iOS is a mobile OS created and developed by Apple Inc. It is the second most popular mobile OS after Android. Xcode is an integrated development environment (IDE) for macOS containing a suite of software development tools for developing software for macOS, iOS, watchOS, and tvOS. iOS is based on the Mach microkernel and Darwin system. programmers use Objective-C and Swift to create software for iOS platforms.

1.2.1 IMPORTANT FEATURES OF IOS

Following are the important key points that make iOS as a unique choice for certain users.

- ➢ Consistency user interface that facilitates the sense of control, familiarity, and reliability. The consistency in iOS is governed by the human interface design guidelines, similar to the material design in Android OS. The consistency intern increases the usability and minimizes the confusion.
- ➢ The consistency prioritizes the content , make it navigational, logical structured, and evokes the positive emotional response.
- ➢ ios is providing stability due to the use of only signed apps. Untrusted binaries are not allowed, and hence no worry about the malware. As iOS is intended only for the devices by Apple, hence they do not deal with the multiple compatibility issues.
- ➢ It follows the strict guidelines of user interface design.
- ➢ Control central in iOS provides quick access to the most frequently useful functionalities. iOS 11 gives customization to the control center.

- 3D touch (Force Touch) functionality supports the pressure sensitive screens, and introduces two new standard gestures - Peek and Pop, in addition to the swipe, pinch and tap. Press the screen with medium strength and you perform a Peek; push it harder, and you perform a Pop. For example, Peek allows previewing the contents of an email without opening the app involved. The Pop opens the item in its relevant app.

- There are few apps come first on the iOS, e.g. Instagram, snapchat, Augmented Reality mobile game Pokémon Go, etc.

- As soon as the apple produces the updates the users receive it.

- iTunes media player developed by Apple Inc. for play, download, and organize digital multimedia files, including music and video.

- Apple provides a Cloud-based storage service, called iCloud, that makes it possible for us to sync our documents, photos, videos, files across all of our iPhone, iPad, and Mac devices. iCloud dependent on the Amazon cloud services and also Google cloud, and Microsoft Azure.

- With the advantages, the new release of the iPhones, the old phones also get good value.

- iOS battery optimization is better. To save the battery power, it is required to Turn off Background App Refresh, and the low signal should be turned into airplane mode. In a low power, mode Mail will not download content in the background, AirDrop, iCloud sync, and Continuity will be disabled. Wi-fi access uses less battery power than the cellular network. The permissible temperature for battery life is 0°C to 35 ^{o}C. The battery works better with the latest updates of the software, the settings for the auto-brightness, and low power mode.

- Security and multi-tasking are excellent in Ios.

3.2.2 DISADVANTAGES

- The hardware limitation in one of the constraints in the case of iOS. The hardware manufacturer and the OS developer is same and hence less flexibility to use hardware with varied features.

- ➢ To maintain stability and consistency, the internal quality assurance cell spends time and efforts, which increases the cost of the product. The budget constraint is one of the limitations.
- ➢ The kernel of the iOS is having microkernel, which is a contrast to the monolithic kernel of the Android OS.
- ➢ High amount of restrictions on the customization, and no app installation other than the apple app store keeps the user is very much in control.
- ➢ iOS is not open source, apps are costly and no widgets.
- ➢ No hybrid SIM card support.
- ➢ Battery performance is reduced when used with 4G.
- ➢ No Near Field Communication or Radio support.

3.3 IOS ARCHITECTURE

3.3.1 INTRODUCTION TO IOS LAYERS & FRAMEWORKS

As shown in Figure-68, the iOS architecture is having five layers, including Coca touch, media layer, core services layer, core operating system layer & kernel, and Device Driver layer.

```
┌─────────────────────────────────────┐
│           Coca Touch                 │
├─────────────────────────────────────┤
│           Media Layer                │
├─────────────────────────────────────┤
│           Core Services              │
├─────────────────────────────────────┤
│           Core OS                    │
├─────────────────────────────────────┤
│      Kernel and Device Drivers       │
└─────────────────────────────────────┘
```
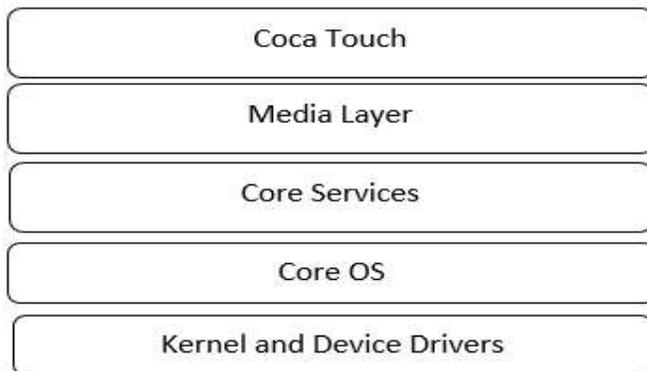
Figure-68 Layers in the iOS Stack (Architecture)

3.3.2 COCOA TOUCH LAYER

Cocoa is a collection of tools, libraries, frameworks, and APIs used to build applications for the Mac OS.   It provides the rich quality functionalities for drawing to display, working with text, saving and opening data files, interacting with the operating system, and network.   The Cocoa frameworks include classes for user

interface and classes for memory management, networking, file system operations, and time management.

Cocoa Touch is a modified version of Cocoa with device-specific libraries for the iPhone and iPod Touch. Cocoa Touch works in conjunction with other layers in the iPhone and iPod Touch OS. Cocoa Touch provides an abstraction layer of iOS, the OS for the iPhone, iPod Touch, and iPad. It is based on the macOS Coca API toolset. Cocoa Touch allows the use of hardware and features. It follows the Model-View-Controller (MVC) architecture. Cocoa Touch contains a different set of graphical control elements to Cocoa. The iOS SDK consists of the Tools for developing applications based on Cocoa Touch.

The features and technologies of the cocoa touch and framework are App Extension, Handoff, Document Picker, AirDrop (File Transfer using Bluetooth and Wi-Fi), TextKit (classes to control the layout of text), UIKit Dynamics, Multitasking, Auto Layout, Storyboards, UI State Preservation, Apple Push Notification Service, Local Notifications, Gesture Recognisers, and Standard System View Controllers. The cocoa touch framework Foundation Kit Framework, UIKit Framework (based on Application Kit), GameKit Framework, MapKit Framework, Address Book UI Framework, EventKit UI Framework, Message UI Framework, Notification Centre Framework, PushKit Framework, and Twitter Framework.

Gamekit is set of classes to develop the games for more than one player. It allows to play games, share scores, dashboard through the network sharing. The player can allow other player to join the game, challenge the player, and show the accomplishment of the players. The PushKit is useful for the notifications based on VoIP invitations.

3.3.3 COCOA TOUCH FRAMEWORKS

The cocoa application layer is responsible for the responsiveness and appearance of the user interface of the app. Cocoa layer implemented the Notification Center, full-screen mode, and Auto Save options. Cocoa is the application layer and programming interface for app development. Auqa is the term used for the appearance of the iOS app development. The layout, color, and texture, along with the human-computer interface guidelines, make the user interface beautiful and compelling.

Appkit is useful for the various operations at this layer, including menu management, window management, document management, open and saves dialogue, pasteboard, and clipboard behavior. There is a font, color, image graphics, gesture, typography, and font operations.

Most Cocoa classes in Cocoa are subclasses of NSObject. In UIKit, all classes that respond to user input inherit from UIResponder. There are UI kit classes having base class as UIResponder and other child classes UIApplication, UIView, UIWindow, UILabel, UIpickerView, and other UI classes. Moreover, there are controller, value objects, and device classes.

The Foundation layer of Cocoa Touch provides the abstraction for the core elements of the OS. It handles the object behavior, memory management, inter-object notification mechanism, event dispatching, accessing file bundles, internationalization, and localization of resources including text, string, and images. It also supports file handling and SQLite data management tools. The object wrappers are similar to the wrapper classes in Java. It also has value objects, XML, Strings, URL handling, inter-processing communication, locking, and thread management.

3.3.4 MEDIA LAYER

The beautiful graphics and high-quality multimedia is the point of attraction for Ios. Media layer provides the 2D & 3D graphics, animation, image effects, and professional grade audio and video functionality.

The media layer supports web streaming protocols like HTTP, RTP, and RTSP. It also supports the iTunes .m4v format, and other standard formats such as AVI, AVR, DV, M-JPEG, MPEG-1, MPEG-2 other many formats. It also supports the various image, audio, and data file format. Figure-69 shows the media layer subcomponents and libraries.
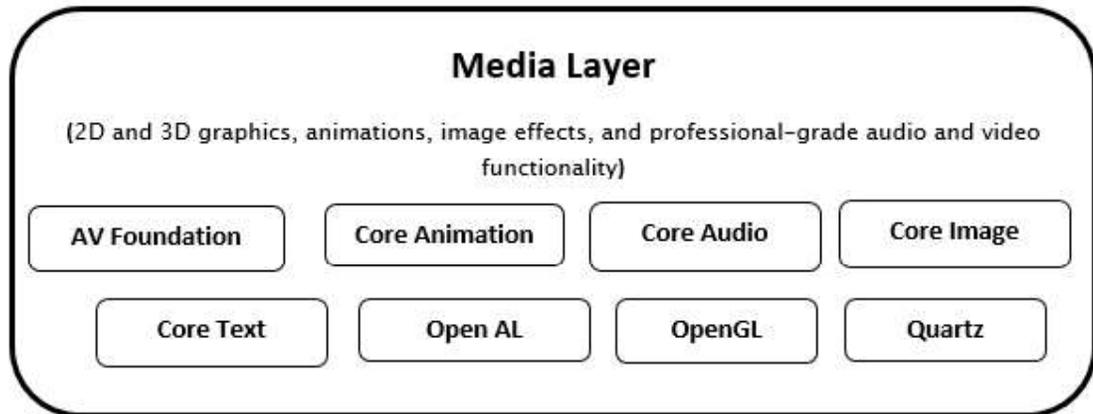
Figure-69 Components of the Media layer

3.3.5 MEDIA LAYER FRAMEWORKS

The AppKit framework provides the Quartz 2D and drawing primitive shapes such as lines, rectangles, ovals, arcs, and Bezier paths. Metal programming provides the maximization of the graphics. There are other core graphics like Quartz-2D, 2D vector, image rendering, and device independent capabilities. There is also a core animation Quarts framework. The Spriekit, Scene kit, Metal kit, OpenGL, GL kit are the other libraries.

The APIs are also available for the color, Text, Typography, and fonts operations. The image operation frameworks are also available. There are printing facility APIs are available. The audio technologies support for high-quality audio recording, synthesis, manipulation, and playback. The AV Foundation framework, OpenAL, Core Audio frameworks are available. There is video technologies AVKit, AV Foundation, Core media framework, Core video framework.

3.3.6 CORE SERVICE LAYER

The core services provide accounts and social media services such as Facebook and Twitter. It gives the iCloud storage service API where the user can store the documents, key-value pair, and core data storage. Sometimes the user can store the state of the complex game.

The Cloudkit is another important control mechanism to Save, search, and fetch data for specific to an individual user, and in public area shared by all users. CloudKit has minimal caching and relies on a network connection.

The file coordination service manages the file access mechanism when more than one users try to access the same file. If both users access the same file in reading mode, then there is no issue. Whereas, if the first user is trying to save the changes and another user is trying to read the same document then the write operation should be performed to maintain the consistency. If the two users are trying to write the same file, then the locking mechanism is performed, and file coordination plays an essential role. The NSDocument and NSFilePresentor are the two important classes for the programmer.

Bundles and packages are essential mechanisms for software distribution. The Bundle is the single encapsulated entity mechanism for software distribution, whereas there are hierarchical files located inside. The package is also called as the installation package. The package consists of the files and directories inside. User can double click the package and install the app.

There are internationalization and localization support available for the app such as the text, images, and another look of the app is available in the local languages then it will be more attractive. To support several languages, the Unicode is popular nowadays due to which the text can be converted into the local languages. The important factors such as format numbers, currencies, dates, and times need in the local languages. There is some strings resources provision available in this layer for such support.

Similar to the lambda expression in the java, and serverless computing in the Cloud Computing concepts, the closure or block or lambda expression is also available in the C, C++, and Objective C language.

The multiple threading mechanism tries to achieve the fake parallelism on the single CPU capability. However, if the CPUs are with multiple cores, then it is the skill of the programmer. The Grand Central Dispatch (GCD) is a more efficient mechanism similar to the Threads creation, where the dispatch queues are used instead of the Threads. The task can be executed serially or concurrently. The NSOperationQueue class is useful for achieving the multiple queue usage for the task accomplishment. The queue can be synchronous or asynchronous queue. The queues are useful to assign on the particular core of the CPU.

The Bonjour is the implementation of the zero-configuration networking architecture, i.e., a robust system for publishing and discovering services, devices, and computers over an Internet Protocol (IP) network. It assigns the IP without the Dynamic Host Configuration Network Protocols (DHCP). Network-based devices such as printers, scanners, Redundant Array of Independent Disks (RAID) servers, and wireless routers can be configured without using the Domain Name System (DNS) server. Bonjour works on multiple subnets.

The security services provide user authentication, keys, Kerberos, certificates, trust services, user authorization, secure transport, and Smart cards with the CryptoTokenKit framework. This security framework provides all the dimensions of the security, including the privacy, authentication, authorization, integrity, non-repudiation, encryption, decryptions, message digest, and digital signature.

The mapkit framework provides the Display map or satellite imagery directly from the app's interface. The location and map-based services can be efficiently provided based on the longitude and latitude of the location. Also the iBeacon and Bluetooth (BLE) low energy services can contribute to the various applications.

The address book is an essential element of any mobile device to access contacts, emails, street address, etc. quickly. The developer has to integrate and access the address book information. There is a CardDAV protocol for functionality purpose and synchronization.

The critical part is the text to speech, speech to text and speech synthesizer mechanism useful for normal as well as to the person with certain disabilities such as vision, and attention.

There are identity services management and Access Control List (ACL) gives fine-grained access to file-system objects. The time machine support provides the automatically backing up data to a different hard drive, in an efficient way.

Keychain Services provides a secure way to store passwords, keys, certificates, and other sensitive information associated with a user. Users often have to manage multiple user IDs and passwords to access various login accounts, servers, secure websites, instant messaging services, and so on. A keychain is an encrypted container that holds passwords for multiple apps and secure services.

Access to the keychain is provided through a single master password. Once the keychain is unlocked, Keychain Services–aware apps can access authorized information without bothering the user.

The SQLite database which is also used by the other mobile application development platforms such as Android can be used as like a local database in iOS. You can create local database files and manage the tables and records in those files. The library is designed for general purpose use but is still optimized to provide fast access to database records. XMLParser and Distributed notification services are important services in this layer.

3.3.7 CORE SERVICE FRAMEWORKS
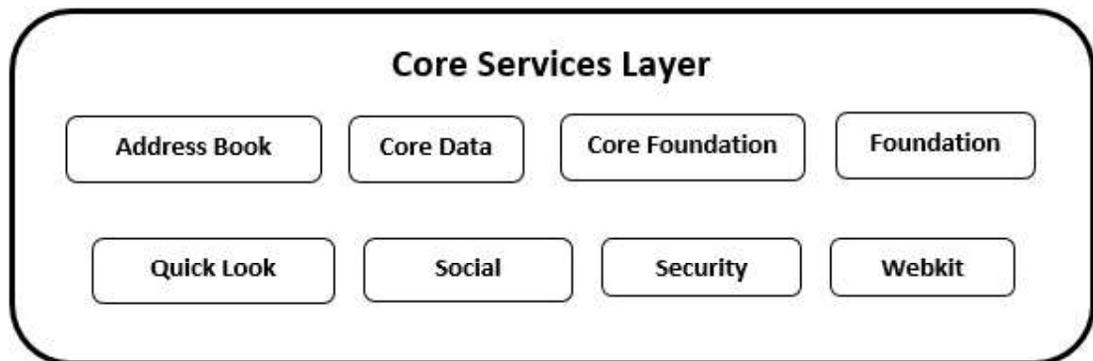
Figure-70 Components of the Core Services layer

Launch Services gives a programmatic way to open apps, documents, URLs, or files with a given MIME type in a way similar to the Finder or the Dock. The Launch Services framework also provides interfaces for programmatically registering the document types your app supports. Launch Services is in the Core Services umbrella framework. Figure-70 shows the components of the Core services layer.

The Metadata framework helps you to create Spotlight importer plug-ins. It also provides a query API that you can use in your app to search for files based on metadata values and then sort the results based on certain criteria. (The Foundation framework offers an Objective-C interface to the query API.)

Search Kit provides the fast search, summarize, and retrieve documents, and contents written in most human languages in an app. This framework is part of the Core Services umbrella framework.

Web Services Core provides support for the invocation of web services using CFNetwork. The available services cover a wide range of information and include things such as financial data and movie listings. Web Services Core is part of the Core Services umbrella framework.

Dictionary Services lets you create custom dictionaries that users can access through the Dictionary app. Through these services, your app can also access dictionaries programmatically and can support user access to dictionary look-up through a contextual menu.

The Accounts framework (Accounts.framework) provides a single sign-on model for supported account types such as Twitter and Facebook. Single sign-on improves the user experience because it prevents your app from having to prompt a user separately for login information related to an account. It also simplifies the development model for you by managing the account authorization process for your app.

There is an address book, Automator, core data, Event Kit, Foundation and core foundation, quick look, social framework, storekit, and WebKit are few more to mention in this list. The Other Frameworks in the Core Services Layer includes Collaboration, Input Method Kit, and Latent Semantic Mapping

3.3.8 CORE OS LAYER
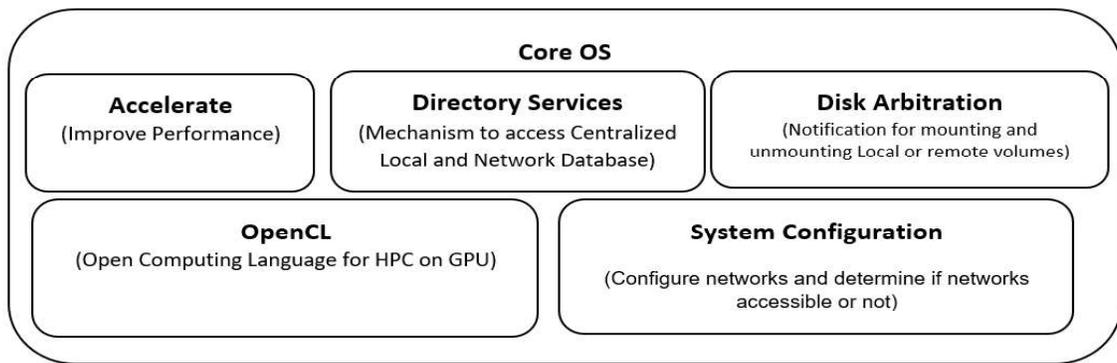
Figure-71 Components of the Core OS

The core OS Layer is low-level services related to hardware and networks. These services are based on facilities in the Kernel and Device Drivers layer. There are high-level app security features such as gatekeeper, app sandbox and code signing. The gatekeeper keeps the app safe by avoiding the installations of apps other than the Mac app store and unknown developers. The app must have the Developer ID certificate and code sign your app. Whenever someone developing a new app the necessary Developer ID and code sign must be done from the Mac Store. Figure-71 shows the components of the core OS.

The app sandbox provides the security to the app from stolen, corrupted, or deleted user data if malicious code exploits your app. The code signing is useful to avoid the accidental code change of the app, and it protects from the malicious code change. The X-code IDE facilitates the necessary security through the various options.

The Accelerate framework contains APIs that helps to accelerate complex operations. Hardware-based vector units boost the performance of any app that exploits data parallelism, such as those that perform 3D graphics imaging, image processing including the digital signal processing, video processing, audio compression, and software-based cell telephony. The linear algebra and other computationally expensive mathematical operations are performed using the vecLib and vImage libraries.

Disk arbitration framework is useful for the disk mounting and unmounting operations.

The Open Computing Language (OpenCL) makes the high-performance parallel processing power of Graphics Processing Units (GPUs) available for general-purpose computing. The OpenCL can also be useful for the CPU and GPU combination utilizing the vector and scalar operations. The parallel operations using data parallelization for the various applications such as signal processing, image manipulations, finite element analysis can be successfully performed using OpenCL.

Open Directory is a directory service about users, groups, computers, printers, and other information that exists in a networked environment in local or

network database. Open Directory provides some APIs to interact with the Light-weight Directory Access Protocols (LDAP), NetInfo, AppleTalk, SLP, Server Message Block (SMB), Domain Name System (DNS), Microsoft Active Directory, Bonjour protocols and few more.

The system configuration is the framework useful in case if the app is trying to connect the particular network. The present situation of the network to be compared as well as the dynamic changing parameters of the network are identified and used using the system configuration framework. It allows the necessary configuration of the network before the connection to the network.

3.3.9 KERNEL AND DEVICE DRIVERS

The inter-process communication (XPC) is integrated with Grand Central Dispatch (GCD). The Cache APIs are important for the performance of the app. The cache APIs are useful to manage the available memory for all kind of operations. If the demand exceeds the available memory, then free the memory efficiently is possible through the libcache. There is kernel level video capture APIs where the important class IOVideoDevice is useful written in C++.
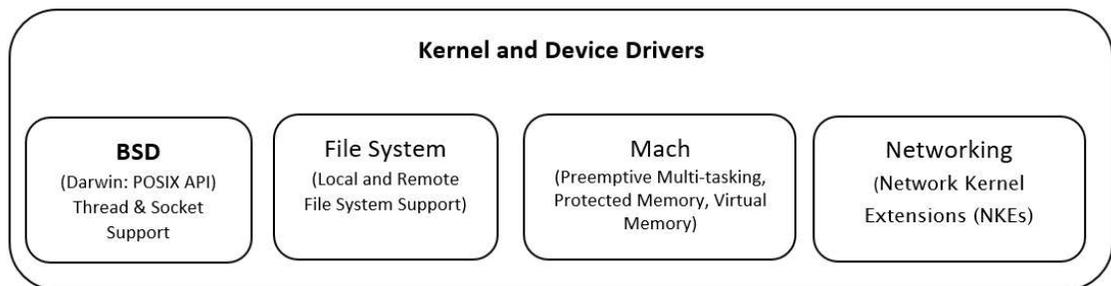

Figure-72 Components of the Kernel and Device Driver Layer

The basic OS operations such as provided through the Mach such as pre-emptive multitasking, protected memory, virtual memory operations, and low latency real-time operations are supported. Figure-72 shows the components of the kernel and device drivers.

There is device driver support in the form of the C++ APIs for the input and output operations such as plug and play, dynamic device management, power management features. The Network Kernel Extensions (NKE) provides control over the data-link and networking layer of the ISO-OSI model for the monitoring and

modifying the traffic. The NKE provides the notifications for the changed conditions of the network.

There is Berkeley Software Distribution (BSD) OS which provides the process model such as process IDs, signals, and so on. Necessary security policies such as file permissions, user and group IDs, threading support (POSIX threads) and networking support (BSD sockets).

The IPC and notification related services such as file system events, kernel queues and kernel events, BSD notifications, Sockets and Ports, Streams, Pipes, shared memory, etc. are also part of the Kernel.

There is kernel support for protocols and services such as Dynamic Host Configuration Protocol (DHCP), Transport Layer Security (TLS), Hyper-text Transfer Protocol (HTTP), HTTP with Security (HTTPS), Point to Point Protocol (PPP), SLP, SSH, TCP/IP, UDP/IP, and Remote Procedure Call (RPC). The support for the network technologies such as Ethernet with all versions, routing, network diagnostics, a file system with various formats, and file sharing protocols.

There is scripting language support like through the Darwin for the Perl, Python, Ruby, Ruby on Rails and others. The cocoa classes can be accessed through the scripting languages.

3.4 APPLICATIONS AND TASK MANAGEMENT IN IOS

The task management in iOS is Manage your app's work and how it interacts with system services like Handoff. The operations such as undo and redo can be performed using UndoManager. To perform this undo and redo operation, it has to be registered first for the Undo operations. The to revert to the state of the last undo operation, the undo () method is called. UndoManager saves the operations you reverted to so that you can call redo() automatically.

The is the possibility that the task can progress slowly. The progress of the task can be reported to the user using the class ProgressReporting. There is the Operation, OperationQueue, and BlockOperation class which represented the code and data of the task. It also shows the state of the operations such as started,

finished, executing, or waiting. The Timer is the class to fire after a certain time interval has elapsed, sending a specified message to a target object. The timers work with loops for the scheduling purpose and can be validated or invalidated.

The activity sharing called as the hand-off can be performed for task management. The hand-off can create, send, and receive user activities directly. Generally, the hand-off terminology is used in the mobile communication when the handset owner (mobile station) can travel and relocate from one hexagonal cell to the another then the hand-off can happen between the two base stations. Here in case of the Apple iOS it is hand-off of the app's operations to continue between the devices. There is system interaction, and the user notification classes are part of the task management in iOS.

3.5 JAILBREAKING

There are many happy and satisfied users of iPhone. They happily use the available features but there are many other users, those who wish to use the other restricted apps on their iPhone. They try to take control on the phone using the process of jailbreaking. The restrictions usually emphasize to install apps only from the app store. There are several reasons to jailbreak such as, if you are owner of the phone you want to customize it, install the apps other than default apps, want to change the look and feel of the phone.

There are certain restricts and rules defined by the Apple for app installation. These are provided in the form of the level of the user escalations. However, users may use the kernel patches to access the root user to install the apps that are not available on the Apple App Store. Formally, this kind of practice is not supported by Apple, by stating that the device may go to the unstable state. The jailbreaking can be tethered, un-tethered, semi-teetered, or semi-untethered. The activity of jailbreaking is illegal in few countries. Jailbreaking modify a smartphone or other electronic device to remove restrictions imposed by the manufacturer or operator, e.g. to allow the installation of unauthorized software, and to get more control on the device. However, Jailbreaking finishes the contract with the vendor, and invalidate your warranties. [5]

3.6 DIFFERENCE BETWEEN ANDROID OS AND IOS

Features	Android OS	iOS
Developer Website	https://developer.android.com	https://developer.apple.com
IDE	Android Studio	Xcode
Programming Language	Java, Kotlin, C++	Swift Compatible with Objective-C
Current Version	Android 9 Pie, Android Q (Beta Version April 2019)	iOS 12.2 (March 2019)
Consistency and Stability	Consistent and Stable	➢ Better Consistency and stability. ➢ Phone hanging or the crashing is very less in iOS. ➢ Refined experience
Notification	Better notification	-
Phone price range	Available in all price range	Premium expensive phones
Customization	Better Customization	Low to Moderate Level
Power Management	Recent version having better battery optimizations	Better battery optimization
Updates	Frequent updates but available in some intervals	Not frequent but available to the user on an immediate basis
Touch Functionality	2D Touch Functionality	3D Touch Functionality
Security	Linux kernel security	No worry about malware.
Notable features	➢ Better AI Assistant ➢ More functionality ➢ Many choices	

Table-10 Difference between Android and iOS

3.7 SECUIRTY FEATURES IN IOS

The Ios, all apps share the same sandbox. It has the code signing technology, and hardware encryption. It do not have external storage and it is difficult for unwanted code to access built in storage. iOS do not require antivirus since there is checking been done in the apps store [1] [2] [3] [4].

3.8 LET US SUM UP

➢ The iOS compared with the Android in general and the architecture.

➢ The architecture of the Android and iOS are more or less similar however the kernel development approaches are opposite i.e. Android having monolithic modular and iOS micro-kernel.

➢ The quality in the iOS app development is high priority whereas the recent android versions releases have given interesting features.

➢ The iOS architecture is having five layers including Coca touch, media layer, core services layer, core operating system layer and kernel and Device Driver layer. The detailed discussion on the sub-components and libraries of the iOS architecture has been done.

➢ Concept of Jailbreaking is discussed.

3.9 CHECK YOUR PROGRESS

➢ **Answer the following in True or False.**

1. The closure or block in Objective C is similar to the anonymous function in Java.
2. Network Kernel Extensions can take control on the Data link and Network layer.
3. Grand Central Dispatch is not performing well over the threading system.
4. CryptoTokenKit is useful for the geographical location monitoring.
5. OpenCL can extend the CPU processing functionality up-to GPU.
6. Address Book, Webkit, Social are the components of the core services layer.

➢ **Answer the following Questions in short.**

1. What are the dis-advantages of jailbreaking iPhone?

2. What is the difference in architecture of the Android and iOS?

3. What are the libraries available in Media layer?

4. Explain the different classes for the app and task management?

5. What is the code signing, how it affects the security of the app?

6. What is difference between multi-threading and GCD?

3.10 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

➢ **True/False Answers**

1. True

2. True

3. False

4. False

5. True

6. True

3.11 FURTHER READING

1. Toby Boudreaux, Programming the iPhone User Experience, O'Reilly Safari, available at https://www.oreilly.com/library/view/programming-the-iphone/9780596805760/ch01.html [Accessed on 30th April 2019].

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2. Fattoh Al-Qershi, Muhammad Al-Qurishi, Sk Md Mizanur Rahman, and Atif Al-Amri, .(2014). Android vs. iOS: The Security Battle, IEEE.

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5. Feng Liu,Ke-sheng Liu, Chao Chang, Yan Wang, (2016). Research on the technology of iOS jailbreak, Sixth International Conference on Instrumentation & Measurement, Computer, Communication and Control, IEEE, PP. 644-647.

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Block–4
Other Mobile Operating System

Unit 1: Windows Phone 1

Unit Structure

1.1 LEARNING OBJECTIVE

To gain the knowledge regarding the different mobile operating systems with its features, run on different devices.

1.2 INTRODUCTION

Windows phone is the mobile operating system developed by Microsoft for smartphones. Mobile operating system is used for phones, tablets, smartwatches and other mobile devices.

Figure-73 Windows Phone OS [1]

Microsoft is the American multinational company who developed the windows phone operating system. Also it developed, manufactures, licenses, support and sell to computer software, consumer electronics and personal computers. This company developed best software product which is known as Microsoft windows which is line of operating system.

Name	Description
Developer	Microsoft Corporation
Written in	C, C++
OS family	Microsoft Windows
Source model	Closed-source
Kernel type	Hybrid (Monolithic in Windows Phone 7)
Platforms	Qualcomm Snapdragon (based on ARMv7)
License	Commercial proprietary software

Table-11 Windows phones 8.1 OS [1]

Windows phone provides new user interface which derived from metro design language. Metro design language is developed by Microsoft. This design language works on the basis of typography and simplification of icons which is helpful to user. Also it works on the basis of geometric shapes. Typography is the technique which is use to arranging the typing beneficial to make written languages in the form of readability and appealing the languages when it is displayed. The arrangement of type includes the typefaces, line length and point size. Typesetter helps to typography to accomplish the work.

Windows 7 was the first launched by Microsoft in 2010. After that windows 8.1 is launched in 2014 and the latest launched by Microsoft is windows 10 in 2015. Windows 10 mobile was announced on 2017.

1.3 History

Update to windows mobile was started in 2004 under the codename "photon" but unfortunately they terminate the project.

➢ **Development**

In 2008 Microsoft reorganize the group of windows mobile and started the work on new mobile operating system. Windows phone operating system is

developed very quickly by Microsoft which is new operating system for mobile phones. Windows phone 8.1 does not support to updates on 2017. It means it does not support to any system update, feature update or any security update until user does not upgrade the windows 10.

➢ **Partnership with Nokia**

Microsoft CEO Steve Ballmer and Nokia CEO Stephen Elop announced a partnership on 2011 in between their companies. In which windows phone become a primary operating system for Nokia which are replaced to Symbian mobile operating system.

Microsoft provides some services on Nokia mobile which are mention bellow.
1. Bing is used as a search engine across the Nokia mobile.
2. Bing map are integrated with the Nokia maps.
3. Nokia's OVI store integrated with the windows phone store.

Bing is the web search engine which developed by Microsoft. Bing is the powerful search engine which provides different services includes web, video, map and image search products. Bing is developed by using ASP .Net programing language. OVI store is the brand of internet services of Nokia. OVI services are used from the mobile or computer by using OVI suite or by web. Windows phone store is the former app store which is developed by Microsoft for windows phone. Windows phone store is developed along the windows phone 7 on 2010. Microsoft rebranded windows phone marketplace to windows phone store on 2012. After that windows phone store was replaced by windows store.
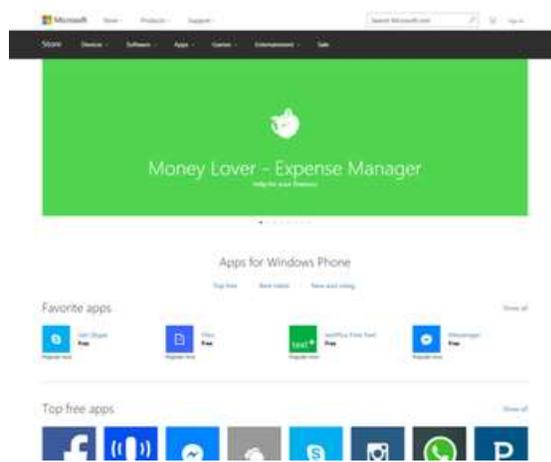

Figure-74 Windows phone Store [2]

Windows phone store support to services such as Operator billing and ad-supported contents. Also Windows phone store provide support to download the 3D games. Windows phone store support to content policy which is restricted the access of content.

The first Nokia Lumia windows phone is announced in 2011. It includes Lumia 800 and Lumia 710. Nokia Lumia 900 was first windows phone which are support to LTE.

➢ **Versions**

• **Windows Phone 7**

Windows phone 7 was announced on February 2010 and it was available publicly on November 2010 in the United States. Microsoft released windows phone 7.5 in 2011. The update includes internet explorer 9 for browsing. Windows phone 7 does not upgrade to windows 8 phone because of hardware limitations.

Figure-75 Logo of Windows Phone 7.5 [1]

• **Windows Phone 8**

Windows phone 8 was released on October 2012 which is Advance generation of operating system. Windows Phone 8 Replaced Old Windows CEA Architecture which are based on Windows NT Kernel.

Figure-76 Logo of Windows phone 8 [1]

• **Windows Phone 8.1**

Windows phone 8.1 was release on April 2014. It includes new features like notification center, internet explorer 11 and separate volume control.

Windows Phone also includes the Cortana (Virtual assistance) which replaced the features of Bing search engine.

Figure-77 Logo of Windows Phone 8.1 [1]

- **Windows Phone 10**

Windows Phone 10 was released on January 2015. This operating system is running on ARM architecture. Windows Phone 10 includes some new features like Skype (Useful to video chat and voice calling between Computers, mobile phones and tablets.). Also it includes updated office app which provides better experience to user.

Figure-78 Logo of Windows phone 10 [1]

1.4 Features

1.4.1 FEATURES OF WINDOWS PHONE 7

Windows phone mobile operating system provides different features such as user interface, text input, web browser, contact, E-mail, multimedia, games etc.

➢ **User interface**

Windows phone 7 provides the user interface working on the base of design system called as METRO. Its home screen is made by using live tiles. Tiles are linked to the functions, features and the different applications. User has authority to add and remove the tiles. Some key features of Windows Phone 7 are organized in Hub which is synchronizing the local and online contents. Also Windows phone 7 is integrated with Twitter, Facebook and the Windows Live. Windows phone 7 working on the basis of multi-touch technology. Also user can capable to select the theme according to its interest.

➤ **Text input**

Virtual keyboard is useful for user to give text input as per its need. Also this keyboard support to emoticon which is helpful to share the expressions without text. Virtual keyboard is the software which is use to give text input without any physical keyboard. Emoticon is the short form of emotional icon which includes the facial expressions represented by using characters such as punctuation mark, numbers and letters.

Figure-79 Graphical Representation of smiley [3]

➤ **Messaging**

Windows phone 7 working on the basis of threading. This provides conversation with peoples on multiple platforms such as Facebook, Messenger and windows live.

➤ **Web browser**

Windows phone 7 provides internet explorer mobile which gives better web browsing experience to user. User can maintain its favorite web pages and tiles linking web pages to home screen. Browser support up to 6 tabs, can load parallel manner. Also browser provides smooth zoom in/out animations. It supports to download the images which are appearing on the web pages. User can capable to share downloaded web pages via email.

➤ **Contacts**

People hub provides the facility to organize all the contacts in the windows phone. User can manually enter the contacts; also contacts are imported form the social network like Facebook, twitter, LinkedIn, Gmail and Windows Live contacts. Live tile of the contact shows the user's status and profile picture of the social network.

➤ **Email**

Windows phone 7 supports to Outlook.com, Exchange, and Yahoo! Mail. Gmail supports to the services such as POP and IMAP protocol. Contact and calendars are

synchronizes by using Gmail. Users are capable to search in the Gmail like subject, body, sender and receiver.

➢ **Multimedia**

Music and video hub provides facility to user to access the music and video. User can buy the music from Xbox Music store. This store also provides the rent facility to user on the basis of subscriber pass. User can search the music by using the artist name and also capable to see the biography and photos of artist which are provided by the Xbox Music store.

➢ **Media support**

Windows phone support to different file formats such as WAV, MP3, WMA and AMR. Also support to image file format like JPG, PNG, GIF, Bitmap and TIF. Mango update provides the facility to customize the ringtone. Ringtone is under the 1 MB and it is less than 40 second long.

➢ **Games**

Xbox Live provides the online game plying developed by the Microsoft. Games hub provides support to access the online games along with the Xbox Live.

➢ **Search**

Windows phone 7 provides the search button on the front of device which is use for different actions. Search button allow searching any content if there is other application are running. Windows phone 7 is also providing the voice recognition facility powered by TellMe network which is American company. It is allow to perform the Bing search, call and launching the applications. In windows phone 7 Bing is the default search engine which is deeply integrated with OS. Windows phone 7 also provides the GPS navigation known as turn-by-turn navigation. Also it shows the places which are nearest to user like attractions and restaurants. Bing audio is capable to match the song by its name as well as Bing video is capable to read the QR codes, tags and barcodes.

➢ **Office suite**

Office hub provides the facility to organize the all Microsoft apps and documents. Power point mobile, Excel mobile and Word mobile allows viewing and editing the different Microsoft file formats. Microsoft office provides facility to open the files from Skydrive and office 365.

- ➢ **Multitasking**

Windows phone 7 provides the card based application switching which is shows the last 5 apps.

- ➢ **Removed features**

Many new features are added in windows phone 7 but some features are removed from windows phone 7 which are present in windows phone 6.5 such as the calling list of past phone is the single now and cannot separated like missed calls, inbound and outbound.

1.4.2 FEATURES OF WINDOWS PHONE 8

- ➢ **Web**

Internet explorer 10 is the default web browser provided by windows phone 8 which gives nice web surfing experience to user. It provides the simple navigation interface mechanism. Browser support to swipe, allows moving from one page to another page.

- ➢ **Multi-tasking**

Windows phone 8 supports to Multi-tasking, run the app at background and resume instantly. User can switch the active task by pressing the back button. User can close the applications by opening multitasking panel and by clicking on 'X' button, right handed side at each application.

- ➢ **Kids Corner**

Windows phone 8 provides the facility of kids corner working on the basis of 'guest mood'. User can play games without touching data of the main user.

- ➢ **Rooms**

Rooms are the most important features which provide the group messaging and communication. User can see the status of Facebook and Twitter which are updated by the group members created by using Rooms.

- ➢ **Driving Mode**

Windows phone 8 is supportable to connect with car via Bluetooth which activate the driving mode in which user can operate the special UI designed for the mobile devices while driving.

➢ **Data Sense**

Data sense provides the facility to set the limit to the data usage based on their plans. Data sense restrict the data usage when it's near to limit of data usage which are set by user.

➢ **NFC and Wallet**

Windows phone 8 supports to NFS which provide the wireless sharing of data between two devices.

1.4.3 FEATURES OF WINDOWS 10 MOBILE

➢ **Start and Action center**

Windows 10 mobile supports to update all live tiles at once. Each app includes the small header which provides more space in the notification room.

➢ **User interface**

In windows 10 mobile Back button on lock screen are replaced by camera button. Media control UI is added on to the lock screen for better user experience. 'Good bye' message is stay visible for user until device is not shut down completely.

➢ **Microsoft Edge**

Microsoft Edge provides supports to back and forward by swiping. Also 'X' button is larger than previous version of windows phone operating system. Before starting the downloading a prompt is pops up. Download notification includes the filename, download status and site domain.

➢ **Setting**

Windows 10 mobile provides support to customize the app notification which is more important to the user. Users are capable to manage the order of quick actions in the action center. Users are capable to hide the quick actions in which user are not interested. Windows 10 mobile supports to the visual voicemail. WI-FI data refreshing rate is become faster as compared to previous version of operating system.

- ➢ **System**

Windows 10 mobile provides the one handed Japanese kana keyboard support. Also provides supports to USB Ethernet. Users are capable to run 16 apps at the background which is useful to switch form one app to another. Emoji set is completely updated in windows 10 mobile operating system. Bluetooth provides more reliability in the car.

1.5 ARCHITECTURE OF WINDOWS PHONE

Microsoft was released windows phone 8 operating system. Windows phone 8 operating system successfully replaced its previously windows based CE architecture which is working on the basis of Windows NT kernel.

1.6 LET US SUM UP

Different mobile operating system running on different hardware devices and every mobile operating system provides the different features.

1.7 CHECK YOUR PROGRESS

1.   Give the technical specification of windows phone 8.1 OS?

2.   Give the brief history of windows phone mobile operating system?

3.   Explain the features of windows 7?

4.   Explain the features of windows 8?

5.   Explain the features of windows 10?

1.8 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1.   Refer 1.2

2.   Refer 1.3

3.   Refer 1.4.1

4.   Refer 1.4.2

5.   Refer 1.4.3

1.9 ASSIGNMENTS

1. Explain the architecture of windows phone mobile operating system?

2. What is user interface in windows phone mobile operating system?

3. What is text input in windows phone mobile operating system?

4. Explain driving mode in windows phone mobile operating system?

5. What is the multitasking in windows phone mobile operating system?

1.10 ACTIVITIES

1. Make case study different types of windows phone mobile operating system.

1.11 FURTHER READING AND REFERENCES

1. https://en.wikipedia.org/wiki/Windows_Phone

2. https://en.wikipedia.org/wiki/Windows_Phone_Store

3. https://en.wikipedia.org/wiki/Emoticon

Unit 2: BlackBerry   2

Unit Structure

2.1 LEARNING OBJECTIVE

To gain the knowledge regarding the Blackberry mobile operating systems with its features, run on different devices.

2.2 INTRODUCTION

Canadian company, BlackBerry Limited developed the BlackBerry mobile operating system for its BlackBerry smartphones. Initially this company was known as Research in Motion. They develop the former BlackBerry brand of smartphones. Also its products are used in different country in the different sectors like in the government agencies and car makers. They include BlackBerry Cylance's which is cyber security solution based on artificial intelligence. BlackBerry Cylance's is the software firm that developed the different computer software's as well as antivirus programs which are used to detect the malware and viruses. BlackBerry company developed the emergency communication system which are supports to the one way and two way emergency communication between the individual and the group of people.

BlackBerry company developed the BlackBerry 10 is the proprietary mobile operating system for BlackBerry line of smartphones. BlackBerry 10 mobile operating system is working on the basis of QNX. QNX is the Unix-like real-time operating system specially developed for the embedded systems. Blackberry 10 is the support for the application framework QT. Qt is the open source software used to design the graphical user interface as well as the used to develop the cross platform applications. All applications are supports to the different operating systems like Linux, windows, mac OS, android and embedded system. BlackBerry 10 is support to gesture and touch based interaction for the navigation and control which supports to control the device without touch the any physical button except the power button to switch on and switch off the device.

On 2015 BlackBerry announced there would be another two years support for BlackBerry 10 mobile OS and BlackBerry OS. BlackBerry does not support to BlackBerry OS after 2019.

Figure-80 BlackBerry 10 OS [1]
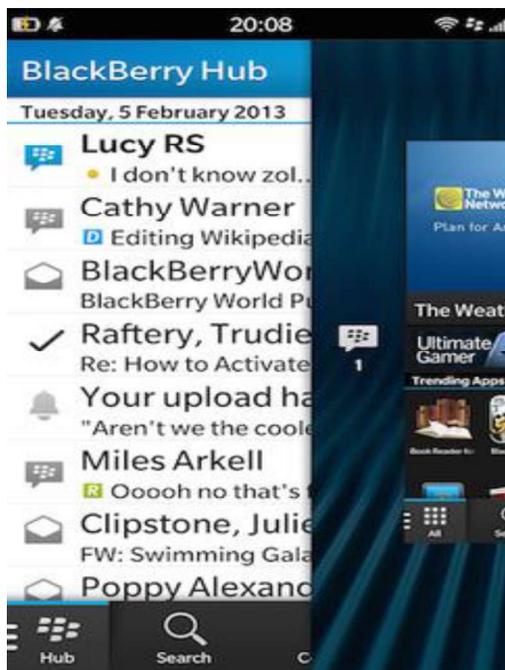
Figure-81 BlackBerry hub [2]

2.3 HISTORY

BlackBerry 10 mobile operating system was originally called BBX. After blocking of BBX they replaced the name by BlackBerry operating system. CEO Thorsten Heins announced a January 2013 to launch the BlackBerry 10 mobile

operating system which is run on to the first smartphone. Also BlackBerry designed the two devices known as Z10 and the Q10. BlackBerry Z10 is the touchscreen smartphone developed by the BlackBerry company which are previously known as the RIM. BlackBerry Z10 is the first smartphone which are presented at the BlackBerry 10 events held on January 2013.

Figure-82 BlackBerry Z10 Smartphone [3]

Q10 is another smartphone developed by the BlackBerry which is unveiled at the BlackBerry 10 event on January 2013.

Figure-83 BlackBerry Q10 [3]

BlackBerry developed BlackBerry playbook tablet which is receiving updates of the BlackBerry 10. BlackBerry Play Book is the mini tablet computer developed by the BlackBerry and made by the Quanta Computer which is the manufacturer company of notebook computers and the other hardware components.

2.4 FEATURES

➢ **Controls**

Users are using the touch screen to give the input because touch screen is the predominant method of input in the BlackBerry 10 OS. This OS supports to the gesture control and keyboard shortcuts to control the smartphone. Also user can unlock the device by swiping the button from the top. Gesture control provides some additional features like same gesture is used to read the notification and enter in BlackBerry hub by moving finger in curve shape. Physical keyboard is used to open the specific application as per the users' requirements.

➢ **Multitasking**

BlackBerry 10 operating system support to the multitasking, when from the application user return to the home screen, the application is minimized called as active frame. An active frame is called as the miniaturized window because it keeps the applications in the running mode at the background. User can capable open the previous application by tapping the active frame or user can close the application by clicking on to the 'X' button. Active frame are support to the like widget functionality, similar to the widgets on android operating system. Calendar application provides the facility to show the upcoming events and meetings. BlackBerry 10 operating system varies the limit of running application as per the different devices.

➢ **BlackBerry Hub**

BlackBerry Provides facility of BlackBerry Hub which is used to organize the Gmail, SMS/MMS, notifications and phone calls. It shows the date wise sorted list of all notifications and messages in the continuous list.

➢ **Miscellaneous Features**

- Virtual keyboard is support to gesture control and predictive typing.
- BlackBerry support to the virtual assistance based on the voice control.
- BlackBerry link support to the data synchronization between the device and the computer which is useful to share the data, also it supports to the update and backup of the device.

2.5 LET US SUM UP

BlackBerry operating system provides the better security as compared to the other mobile operating systems.

2.6 CHECK YOUR PROGRESS

1.   Give the technical specification of BlackBerry OS?

2.   Give the brief history of Blackberry mobile operating system?

3.   What is the BlackBerry hub?

4.   Give the explanation of BlackBerry Z10 smartphone?

5.   Which company developed the BlackBerry OS?

2.7 CHECK YOUR PROGRESS:POSSIBLE ANSWERS

1.   Refer 1.2

2.   Refer 1.3

3.   BlackBerry Hub is used to organize the Gmail, SMS/MMS, notifications and phone calls.

4.   BlackBerry Z10 is the touchscreen smartphone developed by the BlackBerry Company previously known as the RIM. It is the first smartphone which are presented at the BlackBerry 10 events held on January 2013.

5.   Canadian company, BlackBerry Limited developed the BlackBerry mobile operating system.

2.8 ASSIGNMENTS

1.   Explain the architecture of BlackBerry mobile operating system?
2.   What is user interface BlackBerry mobile operating system?
3.   What is text input in BlackBerry mobile operating system?
4.   Explain Controls in BlackBerry mobile operating system?
5.   What is the multitasking in BlackBerry operating system?

2.9 ACTIVITIES

1.   Make a case study on BlackBerry operating system.

2.10 FURTHER READING AND REFERENCES

1.   https://en.wikipedia.org/wiki/BlackBerry_10
2.   https://en.wikipedia.org/wiki/BlackBerry_10
3.   https://en.wikipedia.org/wiki/BlackBerry_Z10

Unit 3: Symbian **3**

Unit Structure

3.1 LEARNING OBJECTIVE

To gain the knowledge regarding the different features of the Symbian mobile operating systems.

3.2 INTRODUCTION

Symbian is the mobile operating system developed by the Symbian Ltd On 1998. Symbian was company who developed the software as well as the mobile operating systems. Firstly Symbian operating system is developed for the PDA's. Symbian operating system is become popular because it used in different branded phones such as Nokia, Samsung, Motorola and Sony Ericsson. Symbian operating system includes two components such as one is the micro-kernel based operating system with its supportable libraries and another one is the user interface which is working on the basis of the shell atop the OS.

Figure-84 last version of Symbian [1]

Micro-kernel is the software which provides the mechanism which is support to implement the operating system. Micro-kernel mechanism includes the thread management, address space management and inter-process communication.

Monolithic Kernel based Operating System

Microkernel based Operating System
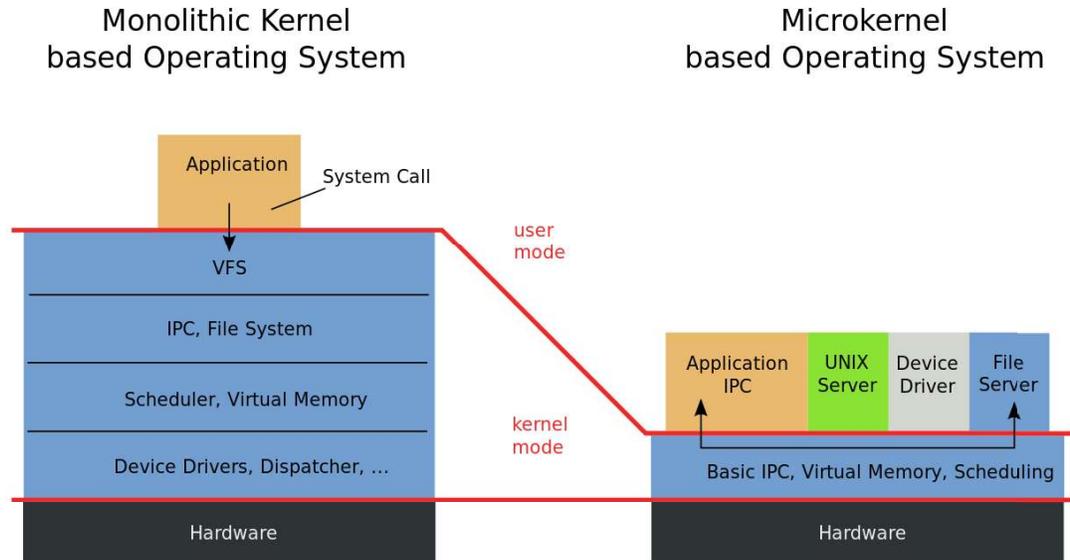
Figure-85 monolithic and microkernel [2]

S60 is the software platform which is designed for the smartphones that are run on to the top of the Symbian mobile operating system. Nokia was developed the S60 (Series 60 User Interface). S60 software is support to develop the applications by using the python, java and C++. S60 phone provides the facility to install the applications after the purchasing.

Figure-86 Logo of Symbian OS [1]

In 2010 the Symbian foundation is disintegrated and Nokia took the control to develop the OS. After that Nokia moved on to the closed licensing mobile operating system.

3.3 HISTORY

Symbian operating system is based on the EPOC mobile operating system developed by the Psion Company in 1990's. In 1998 Psion software becomes the Symbian Ltd. Symbian Company and the phone manufacturing company such as Ericsson, Motorola, and Nokia has the joint venture. After that different software's

are created for Symbian operating system like S60 for Nokia, Samsung and LG. Symbian is difficult to the programmer for development of java applications. Nokia announced the acquisition of Symbian Ltd in Jun 2008 and the new Symbian foundation was established. Nokia is the major contributor in the Symbian code. Since the Nokia maintain its own repository for the platform development. Symbian developed its community in 2008 which is led by the Symbian foundation and the objective of Symbian foundation is to publish the source code for entire platforms which are used to the development. In February 2010 Symbian platform is officially available as an open source code. Also some important components of Symbian mobile operating system were the licensed of third party which is useful to prevent to publish the full source code under the EPL (Eclipse Public License) by Symbian foundation. Qt is the open source frame work introduced to the Symbian operating system in 2010. According to market condition Symbian foundation announced, it would transition to a licensed only organization. Symbian announced the partnership with Microsoft in 2011 that would see the Nokia adopt the windows phone which is the first smart phone platform of Nokia. In April 2011, Nokia ceased the open source portion of Symbian software and reduce the collaboration with the small groups. Under EPL source code is available in third party repository. Nokia made agreement with the Accenture in Jun 2011 for an outsourcing program. Accenture is the global management consultancy and professional services which are provide the digital, technology, consulting and operations services. Accenture provides the support to development of Symbian software and support service to Nokia.

In January 2014, Nokia announced to terminate the support for the Symbian software, after that refuse the publishing and any change in the Symbian applications.

3.4 FEATURES

User interface

AVKON is the native graphics tool kit used by the Symbian operating system. AVKON is formerly known as series 60. S60 is designed to manipulate the keyboard like interface called as the metaphor, such as 15-key augmented telephone keypad, or the mini QWERTY keypad. Symbian version 3 includes the Qt framework which

was the new user interface tool kit. Also Qt is support to the older Symbian devices. Touch based interface is support to the Symbian version 4 known as the 'UI Extensions for Mobile'. This is designed by using the Qt widget. Currently Nokia recommended to the developers to use the Qt Quick with the QML, The new high level UI and scripting for creating the touch screen interface that allows the development for the Symbian mobile operating system.

Browser

Symbian support to webkit based browser. Webkit is the browser engine which is used in the Apple's safari browser. Webkit also work on the basis of experimental browser includes amazon kindle e-book.

Figure-87 Logo of Webkit [3]

Multiple language support

Symbian provides the strong localization support to the Symbian applications. Current Symbian operating system is support for the 48 different languages.

- Arabic (Arabic),
- Basque (Latin),
- Bulgarian (Cyrillic),
- Catalan (Latin),
- Chinese [PRC] (Simplified Chinese),
- Chinese [Hong Kong] (Traditional Chinese),
- Chinese [Taiwan] (Traditional Chinese),
- Croatian (Latin),
- Czech (Latin),

- Danish (Latin),
- Dutch (Latin),
- English [UK] (Latin)

Application development

From 2010 the SDK of Symbian is consist from the standard C++ with the Qt which is used with the Qt creator or carbide. WRT (Web Run Time) framework is used for creation of new widgets on the S60 platform. It is the extension of the Webkit browser which are allowing to the launching of multiple web browsers.

Figure-88 Symbian Belle FP2 in landscape mode [1]

A phone simulator allows to testing the apps by using the Qt. Applications are developed by using the C++ or QML. C++ Programing language is used to development of Symbian mobile operating system with the help of Symbian software's. Before the Qt SDK the Symbian has the standard development environment. There are multiple platforms based on the Symbian mobile operating system which is provides the multiple software development kits. Software development kit contains the documentation, header files and the libraries which are needed to development of Symbian mobile operating system. New application binary interface is used in the Symbian OS version 9. Also software development kit includes the GNU compiler collection which is supportable to development of the software's. Symbian C++ requires the special techniques like active object, descriptors and the cleanup stack. Integrated software development environment is useful to development of Symbian C++ programing language. Carbide is replaced to the code worriers in 2006. C++ is available in four different versions such as developer, express, professional and OEM, with increasing the level of capacity.

3.5 LET US SUM UP

Symbian mobile operating system was developed by the Symbian Company in 1998. Firstly Symbian mobile operating system developed for the PDAs.

3.6 CHECK YOUR PROGRESS

1. Give the technical specification of Symbian mobile OS?

2. Give the brief history of Symbian mobile operating system?

3. What is the application development?

4. Give the list of languages supported by Symbian mobile OS?

5. Which company developed the Symbian mobile OS?

3.7 CHECK YOUR PROGRESS: POSSIBLE ANSWERS

1. Refer 1.2

2. Refer 1.3

3. Application development is the process of creating a computer program or a set of programs to perform the different tasks. In context to Mobile Application Development it is the action or process by which a mobile app is developed for mobile devices, For example personal digital assistants, enterprise digital assistants or mobile phones.

4. The list of languages supported by Symbian mobile OS are as below:

- Arabic (Arabic),
- Basque (Latin),
- Bulgarian (Cyrillic),
- Catalan (Latin),
- Chinese [PRC] (Simplified Chinese),
- Chinese [Hong Kong] (Traditional Chinese),
- Chinese [Taiwan] (Traditional Chinese),
- Croatian (Latin),
- Czech (Latin),
- Danish (Latin),
- Dutch (Latin),
- English [UK] (Latin)

5. Symbian mobile operating system developed by the Symbian company on 1998. Symbian company developed the software as well as the mobile operating systems.

3.8 ASSIGNMENTS

1. Explain the architecture of Symbian mobile operating system?
2. What is user interface in Symbian mobile operating system?
3. What is text input in Symbian mobile operating system?
4. Which browser supported to Symbian mobile OS?
5. Explain multiple language support in Symbian mobile OS?

3.9 ACTIVITIES

1. Make a case study on Symbian mobile operating system.

3.10 FURTHER READING AND REFERENCES

1. https://en.wikipedia.org/wiki/Symbian
2. https://en.wikipedia.org/wiki/Microkernel
3. https://en.wikipedia.org/wiki/WebKit

યુનિવર્સિટી ગીત

સ્વાધ્યાયઃ પરમં તપઃ
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સ્વાધ્યાયઃ પરમં તપઃ

શિક્ષણ, સંસ્કૃતિ, સદ્ભાવ, દિવ્યબોધનું ધામ
ડૉ. બાબાસાહેબ આંબેડકર ઓપન યુનિવર્સિટી નામ;
સૌને સૌની પાંખ મળે, ને સૌને સૌનું આભ,
દશે દિશામાં સ્મિત વહે હો દશે દિશે શુભ-લાભ.

અભણ રહી અજ્ઞાનના શાને, અંધકારને પીવો ?
કહે બુદ્ધ આંબેડકર કહે, તું થા તારો દીવો;
શારદીય અજવાળા પહોંચ્યાં ગુર્જર ગામે ગામ
ધ્રુવ તારકની જેમ ઝળહળે એકલવ્યની શાન.

સરસ્વતીના મયૂર તમારે ફળિયે આવી ગહેકે
અંધકારને હડસેલીને ઉજાસના ફૂલ મહેંકે;
બંધન નહીં કો સ્થાન સમયના જવું ન ઘરથી દૂર
ઘર આવી મા હરે શારદા દૈન્ય તિમિરના પૂર.

સંસ્કારોની સુગંધ મહેંકે, મન મંદિરને ધામે
સુખની ટપાલ પહોંચે સૌને પોતાને સરનામે;
સમાજ કરે દરિયે હાંકી શિક્ષણ કેરું વહાણ,
આવો કરીયે આપણ સૌ
ભવ્ય રાષ્ટ્ર નિર્માણ...
દિવ્ય રાષ્ટ્ર નિર્માણ...
ભવ્ય રાષ્ટ્ર નિર્માણ

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