Chapter 2

Mobile Communication System

2.1. Introduction

"Communication – the exchange of Information – is essential both for the social life of mankind and the organization of nature" (Huurdeman, 2003, p. xv). The word *communication* is derived from the Latin word *communicatio.* In Latin, the word *communicatio* meant to denote "the process of information exchange, covers the human need for direct contact and mutual understanding" (Huurdeman, 2003, p.3).The limitation of human communication within his/her environment mainly because of the way his/her physiology and system has been developed he/she has always looked to enhance the communication medium. Smoke, fire and drum sounds were the first enhancement humanity looked to during the prehistoric time.

The basic electrical signaling system was first introduced in 1838 when the first telegraph signals were successfully tested. The seed for the mobile telecommunication was sown in 1973 although the first successful testing of INMARSAT, ship to shore satellite telecommunication is the precursor of all the satellite based communication systems of today. From what used to be cumbersome bulky gadgets of yesteryears, today's mobile phones are sleek and savvy and come with an array of services which envy a modern desktop. If invention of mobile telephones are considered to be the advancement of human exploration, then the rapid and speedy delivery of the mobile telephone services and fast internet services which deliver such services to the remote destinations are the ultimate imagination of human endeavor.

2.2. A Brief History of Telecommunications

Telecommunication is a term borrowed from Greek which loosely translates as "communicate at distance". The word *telecommunication,* adding *tele* which means distance to the word *communication* was first coined by Edouard Estaunié in the year 1904 in his book *Trait*é *pratique de t*él*écommunication electrique (t*él*égraphie-t*él*éponie).* Estaunié's definition for his new term was to denote information exchange by means of electrical signals" (Huurdeman, 2003, p.3). The International Telecommunication Union (ITU) officially recognized the term telecommunications in the year 1932 and defined it as "'any telegraph or telephone communication of signs, signals, writings, images and sound of any nature, by wire, radio, or other system or processes of electric or visual (semaphore) signaling. Currently, the ITU defines telecommunications as ''any transmission, emission, or reception of signs, signals, writings, images, and sounds; or intelligence of any nature by wire, radio, visual, or other electromagnetic systems." (Huurdeman, 2003, p.5).

It was always the desire for humanity to communicate to far distances and they used all the available sources like fire, drums and birds. When the technology was at its infancy and the science and industrialization were beginning to urge humanity to push forward, the telescopes were made use of to create an optical telegraphy which consisted of a basic mechanical construction of symbols. This was effectively used internationally by using optical telegraphic lines to communicate outside the borders of domains. The advent of electrical telegraphy especially using code-writing and telegraph sow the seeds of better telecommunication theories.

The starting point of all modern telecommunication can be attributed to the invention of the electric cell by Allessandro Volta in the year 1800. A portable electricity was the dream of

inventors and the possibilities of invention using the portable electric cell were enormous, which later assumed the name battery. Tomoas S. Sommering in 1809 proposed a telegraphic system using batteries and water and the experiments kept pouring in as more inventors started working on the possibilities of developing a more complete communication equipment of all times.

In 1843 Samuel Morse proposed a model with ternary code which provided the basis for future telecommunication inventions. Morse's symbol code was developed using Morse proposal and the advancement of technology. The major disadvantage of these inventions were that the idea could be used and implemented only by trained personnel who understood the codes and electronic symbols. Considering these shortcomings further research were done to introduce sounds instead of symbols in communication.

The theory of sound proposed by Helmholtz and other related concepts resulted in Alexander Graham Bell developing a prototype called telephone which loosely meant sound at a distance. The concept of telephone was further consolidated by the PSTN (Public Switched Telephone Network) which assumed the role of telephone exchanges which could receive and transmit telecommunication signals. The advent of ENIAC (Electronic Numerical Integrator and Computer) in 1946and the subsequent advancements in the microcomputer world pushed the telecommunication into mobile telecommunication system (Brian, 2016).

2.2.1 Mobile system overview

In order to understand the working of Mobile phones it is essential to understand how the system works. Massive Open Online Courses (MOOC) on mobile for development (M4D) describes the mobile system as "A system-on-chip architecture with three primary components" The three components are

1. An application processor executing the end-user's application software with assistance from the middleware and operating system (OS)

2. A modem or baseband processor with its own operating system components responding to the baseband radio activities (transmission and reception of audio, video, and other data contents)

3. A number of peripheral devices for interacting with the end-user

(Mobile for Development, 2016)

The Communication mechanism in a mobile telephone is made up of several steps. The receiver hardware in the mobile phone senses the incoming signal and signals the radio interface which begins the communication process which consists of the incoming audio/video processed by the modem processor. "For example, audio data captured by the microphone driver or an image or a video captured by the camera or a position information captured by the GPS device". (Mobile for Development, 2016). To activate any of these actions the Subscriber Identification Module (SIM) plays a vital role.

Mobile phones use wireless technology where it uses electromagnetic energy to transmit a call or action from one node to another. It is estimated that with all the electromagnetic gadgets available for humans to use the mobile phones are the fastest growing gadget in the world. When a signal is sent from a mobile phone the microphone inside the handset converts the signal is into digital ups and downs (0 and 1) and transmits them to the air. The transmitted signals are rushed as radio magnetic waves through air and reaches the nearest cellphone mast at the speed of light. The mast receives the signals and transmits them to the designated base station which coordinates to send the signal to the cellphone network. On the receipt of such signal in a cellphone network the Subscriber Identification Module (SIM) inside the mobile phone captures

the signal if it is designated to that module and using the microchip converts these digital signals into numbers which in turn becomes data. (Woodford, 2016)

2.2.2 History of Mobile Communication System

The seed for the first ever mobile telephone was sowed in 1908 when N. B. Stubblefield applied for a patent for wireless telephone on May 12, 1908 (Wireless patent, 1908). The history of mobile communication system is a very long story as it goes back to the early part of 2nd world war. The invention of mobile telephone which can be used as a mobile communication device was a long struggle. In the early 1940s AT&T developed cells for mobile phones which seems to be the initial attempt to kick start the mobile telephone process.

The Motorola's effort into the first mobile phone in 1973 was considered to be the 0G (Zero Generation) which has now grown into 4G (4th Generation). The technology which was used at that time was called as zero generation 0G where it was mainly used for military communication. The first generation (1G) of cellular network was established in 1973, followed by the 2nd Generation in 1993 followed by the 3G in 2001. The latest in that is the 4G which became commercially accessible around 2012 and have become the enigma of all the telecommunication carriers. The Global System of Mobile Communication which is popularly referred to as GSM is widely spread and accessible.

2.2.3 Growth of Mobile Communication System

The growth of mobile users over the years is phenomenal. The total number of mobile phone users in 2009 was estimated at over 4 billion (www.budde.com.au/research/global-mobile-subscriber-statistics.html), which represented more than 50% of the global population. This

number has grown to 7.2 billion in the year 2015 which is around 97% of the world population. This phenomenal growth is attributed to the growth in mobile communication in India, China and Africa. Forbes reported on 4[th]January 2016 that India touched the1 Billion mobile user mark which is estimated to be around 18% of the world mobile phones. China crossed the 1 billionth mark in as early as 2012 and set to keep growing (Forbes, 2016). It is also estimated that close to 1.2 billion people access internet through their mobile devices and over 300,000 apps have been developed for the mobile phones.

A systematic analysis of the growth of mobile phone ownership over the years paint a very bright picture for the perceived bright future of mobile communication system. Table 2.1, Figure 2.1 and Figure 2.2 illustrate the growth of mobile phones starting from 2005 onwards. A closer look at the table and the figures show the steady growth in both the mobile ownership as well as in the mobile subscriptions per 100 people.

Year	Mobile Phone Ownership in Billions	Mobile Subscription per 100 People
2005	2.205	45.29
2006	2.744	55.53
2007	3.368	66.20
2008	4.028	75.67
2009	4.635	83.30
2010	5.294	89.57

2011	5.889	95.37
2012	6.260	99.65
2013	6.662	103.40
2014	7.005	105.17
2015	7.215	107.97

Table 2.1 Growth of Mobile Phones 2005 – 2015

The forecast for mobile ownership for 2016 and beyond is unimaginably more. In spite of mobile ownership has crossed 100% mark which shows the multiple device ownership and by 2020 the entire globe is set to have completely mobile.
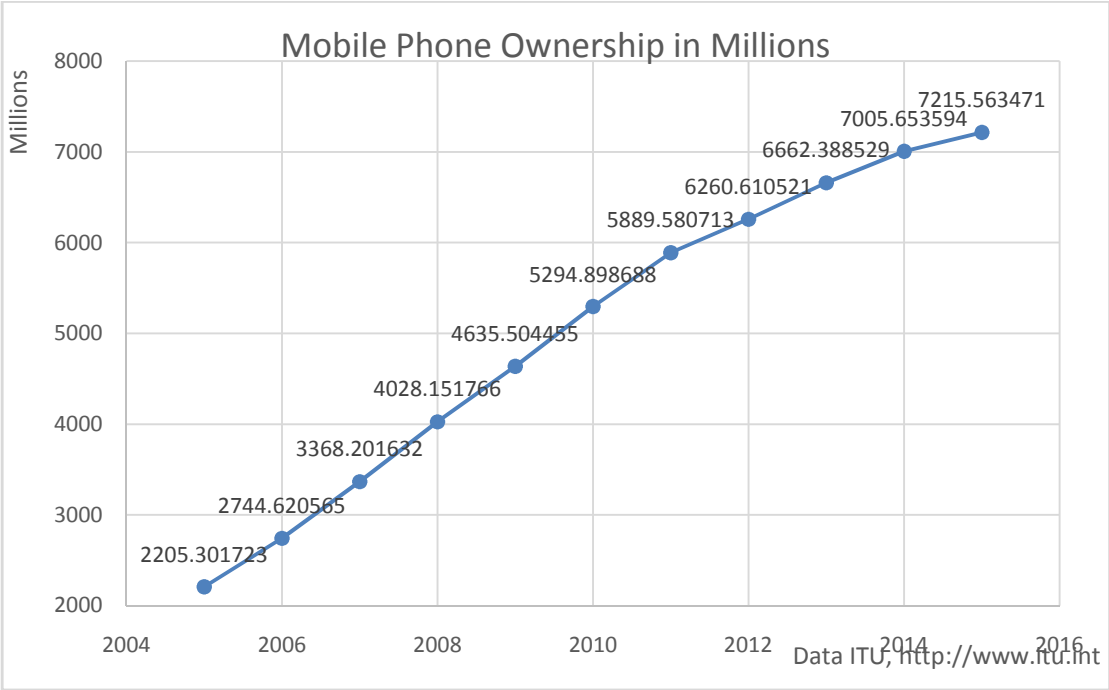

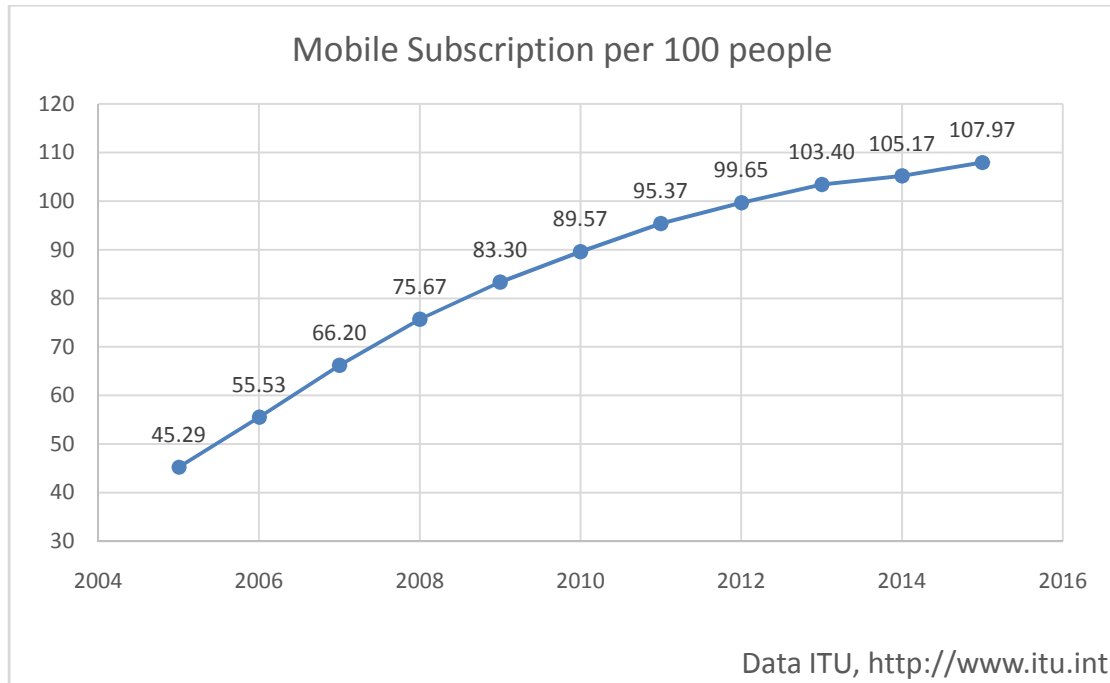Figure 2.1. Mobile Phone Ownership Graph

Mobile Subscription per 100 people

45.29	
55.53	
66.20	
75.67	
83.30	
89.57	
95.37	
99.65	
103.40	
105.17	
107.97	

Data ITU, http://www.itu.int

Figure 2.2. Mobile Subscription per 100 people Graph

2.2.4 Future of Mobile Communication System

It is predicted that the future of mobile phones look much brighter with promises of a wider reception and coverage areas with technical advancements such TDMA (Time Division Multiple Access), CDMA (Code Division Multiple Access) and GSM providing much clearer calls. There will be increased internet accessibility with DSL and broadband with possibilities of video conferencing and other related web 2.0 services which will resemble an ultra-mobile personal computer. It is anticipated that the launch of WiMax technology and the 4G LTE will bring a revolutionary change in mobile communication world. The Next Generation Mobile Network Alliance which oversee the growth and development of mobile communication system feels that the 5G revolution will be in place as early as 2020. In the 5G platform importance will be given

to speed, volume and coverage. With an estimated speed of 1 Gb per second simultaneously for every user in a crowed floor the future of mobile communication looks very bright.

2.3. Types of Mobile Devices

Basically a mobile device is nothing but a portable mobile equipment with a microprocessorand added capabilities and enhancements. There are four broad categories of mobile devices. They are:

1. Mobile phones / Smartphones
2. Tablets
3. Mobile notebooks
4. Mobile GPS gadgets

2.3.1. Mobile Phones / Smart phones

At the time when the growth of mobile users has reached its zenith, the long journey of mobile phones witnessed a high degree of metamorphosis. From the bulky and large cellphones of 1973 when Motorola first introduced its mobile phone which weighed close to 2 pounds to the smallest mobile phones released recently with a weight of less than a cigarette case there seems to be a mobile communication revolution. When Martin Cooper, the senior engineer from the Motorola telecommunication called his rival company on April 3, 1973 using a bulky mobile phone he and his company was aware that they are making a small step into the giant world of telecommunications. But what they didn't realize was the enormity and rapidity of their invention. Corbeil and Valdes-Corbeil (2007) summarize mobile phones and smart phones as "a phone combines, telephone capability with a PDA, camera, video, mass storage, MP3 player,

Internet access, and networking features in one compact system". (Corbeil and Valdes-Corbeil, 2007, p. 53).

2.3.1.1 Inside of a Digital Mobile phone

The architecture of the digital mobile phone is made-up of the following components:

- o A circuit board consists of the following:
  - Analog to Digital and Digital to Analog conversion cip
  - A microprocessor
  - ROM (Read Only Memory)
  - Flash memory
  - Radio frequency and Power section
  - RF Amplifier
- o An Antenna
- o Battery
- o Input / Output devices
  - LCD / Retina Display
  - Physical / virtual Keyboard unit
  - Microphone
  - Speaker
  - Camera
- o Optional Memory unit slots

2.3.2. Tablets

Tablets are wireless devices which are a bit bigger than the mobile phones and at the same time a bit smaller than the notebook computers. The idea of a tablet was first visualized by Alan Kay in 1971 and Apple commercialized the tablets by introducing its flagship tablet called Newton. Since tablets are wireless the entire package is bound with the display unit, input unit and the

power unit. Most popular tablets which are currently available are iPads from Apple, Galaxy range of tablets from Samsung and Surface from Microsoft. iPads use the iOS operating environment, Samsung Tabs use Android and Surface use Microsoft OS.

The inside of a tablet will almost resemble the architecture of a personal computer with the main microprocessor and controllers for input and output devices. The added enhancements will be the addition of accelerometer and gyroscope which helps in the determination of the orientation of the tablets. Apart from that there will be Wi-Fi and cellular chips and antennas, speakers, touch-screen controller chips and camera sensor chips to enhance the working capacity of the tablets.

2.3.3. Mobile Notebooks

Mobile notebook computers are battery operated notebook computers which has the capacity to be used as mobile devices with built in accelerometer and gyroscope chips to determine the orientation. Unlike tablets the input and output devices of the mobile notebooks will be visible and with a docking station the mobile notebooks can be converted into personal computers.

The display of mobile notebooks are often using thin film transistor or active matrix with mouse, touchpad and trackball technology to point to the screen with no or relatively low chance of touch screen capability. An important component which makes the mobile notebook a mobile device is its Wi-Fi and cellular chips and antennas and the network interface which comes along with it.

2.3.4. Mobile GPS Gadgets

The Global Positioning System (GPS) is a satellite based navigation system which was originally developed and deployed by the United States Department of Defense for its military operations.

It consists of 24 satellites based in an orbit of 12 parallel channels, thus it transmit the exact coordinates to pin point the accurate position of the GPS receiver. A mobile device which is predominantly used for GPS purpose with a Wi-Fi and cellular chip and antenna are known as Mobile GPS device.

2.4 Mobile Communication Standards

Mobile technology makes use of the wireless technology. As seen from the history of the mobile technology the standards grew along with the growth and development of the wireless technology. Since its evolution, mobile wireless technology progressed at a very rapid speed and the standards also grew along with it. Most important aspect of this growth is that each generation of mobile phones had its own standards. The following sections are the amplification of the progression of such standards.

2.4.1 Zero and First Generation Technologies

The 0 Generation had technologies such as PTT (Push to Talk), MTS (Mobile telephone System), IMTS (Improved Mobile Telephone Service), AMTS (Advanced Mobile Telephone System) to name a few. Most importantly these systems are distinguished by the closed radiotelephone systems of the past years. The First Generation (IG) had systems which were called as NMT (Nordisk MobilTelefoni or Nordiska MobilTelefoni-gruppen, Nordic Mobile Telephone in English), AMPS (Advanced Mobile Phone System), Hicap, CDPD (Cellular Digital Packet Data), Mobitex and DataTAC.

2.4.2 Second Generation Technologies

The Second Generation (2G) used the much talked about system called GSM (Global System for Mobile Communications). The arrival of first digital cell phone technology signaled this huge jump from the first generation to the second generation. This is the first popular standard for mobile phones in the world used by more than 2 billion people across 212 countries and territories. The ubiquity of this standard makes it easy for any phone to be on international roaming because of its common usage. The data system which is available for GSM phones is called GPRS (General Packet Radio Service) which provides a moderate speedy data interchange. EDGE (EGPRS) (Enhanced Data rates for GSM Evolution) is the digital mobile phone technology that followed GPRS and acted as an enhanced technology to boost the data transmission and reception.

2.4.3 Third Generation Technologies

Third Generation (3G) mobile systems came into the mobile topology for the speedy access to data. It experimented with a wide range of standards such as UMTS, W- W-CDMA (Wideband Code Division Multiple Access), FOMA (Freedom of Mobile Multimedia Access) and HSDPA (High-Speed Downlink Packet Access). The following generation of mobile systems promised to optimize on all the above standards to provide an open standard to give better mobile services. The 3G networks had and still have the potential to provide a transfer rate of close to 3Mbs per second which was a phenomenal advantage in transferring video and audio content over the mobile system. (Mobile Technologies and Standards, 2016)

2.4.4 Fourth Generation Technologies

The Fourth Generation (4G) which is in practice since 2006 can be called as the culmination of man's desire to provide faster data download and the pressure of the mobile industry which wanted to replace the desktop computing into mobile computing. For most mobile service providers the current technology in mobile communication systems is 4G. It predominantly uses WiMAX (Worldwide Interoperability for Microwave Access) technology which is based on 802.16 wireless standard (Brain et. al., 2016), though other technologies such as LTE (Long Term Evolution) and HSPA (High Speed Packet Access +) are also used. The 4G networks are expected to provide approximately around 40Mbps which is a phenomenal rate to provide streaming video and High Density (HD) video services.

2.4.5 Fourth Generation LTE Technologies

4G LTE is the current standard which are followed in many countries which seems to be setting the standard for mobile communication system. 4G LTE is the continued development of the Long Term Evolution standards which promises to provide close to 86 Mbs per second of data transfer. LTE can operate on a wide range of band frequencies and it can operate along the 3G and 4G networks.

2.5 Mobile Application Platforms

The application platforms were not in the horizon up until the first Personal Digital Assistants were introduced in the market as early as the 1987 by Apple computers. The first platform which emerged as a platform was known as *Apple Newton*. According to Helel et. al. (2012), *Newton* was not a commercially successful platform as it lacked the basic functionalities, but it created a

revolutionary idea of a viable tablet market with the introduction of stylus (a pen used as touch device) and handwriting recognition.

Using the model of *Newton* as a platform, Motorola Company developed a mobile version of Newton called *Envoy* which was not very successful. This was followed by *Palm Operating System* which was an exclusive operating system for *Palm* devices which were manufactured by Palm Inc. The same time a number of companies produced hand held devices and made use of the *Windows CE* operating system which provided the much needed competition of entry by Microsoft into the handheld market. The introduction of *Nokia communicator* in 1996 marked a definitive mobile platform evolution as it provided a number of add on applications such as phone, fax and host of other applications to spice the beginning of mobile platform.

2.5.1 Evolution of Mobile platforms

The entry of smartphones into the mobile industry and the availability of internet dependent applications into the mobile technology gave birth to a number of platforms in the first generation of mobile platforms. Palm OS, Symbian, Windows mobile and Blackberry were the most influential operating systems of the initial mobile platform. These platforms allowed applications to be developed using C and C++. The evolution of WebOS in 2009 provided an opportunity to develop applications using HTML, CSS and JavaScript which paved way for potential and exponential growth in the mobile platform market place.

The introduction of Sun Microsystems' (J2ME) Java 2 Micro Edition which was an open standard and lightweight virtual machine threw the development market into an orgy of developments. The introduction of J2ME allowed the development of an application in one place and running it anywhere concept which seriously provided the necessary development

environment. This was closely followed by BREW (Binary Runtime Environment for Wireless) by Qualcomm and these two operating platforms worked side by side. Unfortunately the growth of these two platforms were not exponential when compared to mobile device and application market.

The long time desire of mobile enthusiasts to have better input devices, better display, virtual keyboards, low power consumption, GPS technologies all came together into the mobile handsets and that allowed developers to visualize a more serious mobile technology platform. As a consequence major players in the mobile platform industry, Apple's iOS, Google's Android and Microsoft's Windows phone platforms emerged as the forerunners in the mobile platform industry.

2.5.2 iOS

iOS is the operating system from Apple Inc. which runs all its mobile devices such as mobile phones, iPods, iPad tablets and apple TV set top boxes. iOS was originally released in 2007 for the first series of iPhones which provided a touch capable user interface and kick started a frenzy to produce touch only mobile phones. One of the major hallmarks of iOS platform is its ability to allow users to use multi-touch to its device interaction using intuitive touch gestures.

> "Multi-touch based interaction is a form of direct manipulation where users directly manipulate digital objects in a physically natural manner and receive continuous feedback on the effect of their input actions. One of the most popular multi-touch gestures on iOS is the "pinch-to-zoom"gesture which can be used to zoom in and zoom out of pictures" (Helel et. al. 2012, p. 10)

iOS consists of 4 distinct layers called Core OS layer, Core service layer, Media layer and Cocoa layer which are associated with several frameworks that are the core of programing which are called Application Programing Interfaces (APIs). These frameworks are very simple to manipulate while writing program interfaces by simply linking them to the project.

2.5.2.1 iOS app development tools

The iOS Software Development Kit (SDK) was released in 2008 to allow third-party developers to develop applications for iOS devices. The application developers are required to register and create a developer account which requires an annual registration fee and the development environment is Mac OS X Snow Leopard or later. The programing language used for creating iOS apps are Objective C. Xcode which is an Integrated Developer Environment (IDE) is used for writing applications for iOS. Xcode is suite which has a debugger and allows the simulator to compile programs into the ARM based processors which are primarily used in iOS devices.

2.5.3 Android

The Open Handset Alliance (OHA) which is headed by Google developed and keeps maintaining the Android platform which is used by a number of mobile phone manufacturers like Samsung, Motorola, HTC and host of others. This alliance was formed on November 5, 2007 with 37 members and currently there are 84 members (Open Handset Alliance, 2016). The OHA is committed to openness with its mission statement reads as:

> A group of 84 technology and mobile companies who have come together to accelerate innovation in mobile and offer consumers a richer, less expensive

and better mobile experience. Together we have developed Android TM, the

first complete, open and free mobile platform (Open Handset Alliance, 2016)

Before the alliance, Android was originally founded by Andy Rubin, Chris White, Nick Sears and Rich Miner in 1999 as a location aware mobile platform. It was acquired by Google in 2005 and today it is estimated that close to 250 million mobile devices run using this mobile platform. Android kernel is based on Linux kernel with several patches to make it portable in mobile environment.

2.5.3.1. Android app development tools

Android Applications are written in Java and executed by the Dalvik Virtual Machine (VM). There are four layers to the application namely, the Activity, Service, Content and Broadcast Receiver layers. The Android Software Development Kit is available from the android developer site (http://developer.android/com/sdk) and it supports Microsoft windows, Mac OSX and Linux. The Integrated Development Environment for this SDK is Eclipse which is available from http://www.eclipse.org. Though debugging the Android applications can be done through Java Debug Wire Protocol (JDWP) the Eclipse already come with a debugger.

2.5.4 Windows Phone

The introduction of the pocket PC in 2000 by Microsoft saw a new operating system emerge namely Window CE Kernel. In 2003 Microsoft mobile was launched for mobile phones. In 2010 Microsoft released its Windows Phone which is recognized as a true competitor to Android and iOS mobile platforms. Windows Phone provides a holistic programing model which is very easy

to integrate. Windows Phone offers a web based three tire Push notification service namely Toast, Tile and Raw which makes it entirely different from that other mobile platforms.

2.5.4.1. Windows Phone app development tools

To develop applications for Windows Phone either C++ or Visual Basic .NET (VB.NET) are used. Silverlight and XNA are two frameworks which are provided for application development. XNA framework is basically to manage the runtime environment for the applications related to game in the .NET framework and it provides a complete set of APIs for game developers. Several development tools such as Visual Studio, Expression Blend, and Windows phone Emulator are used to integrate and simulate windows phone applications.

2.6 Mobile Web and Development tools

The Open Mobile Alliance (OMA) created the first Wireless Application Protocol (WAP) in the year 1998. This was mainly done to enhance the mobile web and mobile browsing environment. This saw the advent of a number of mobile browsers and mobile programing languages and techniques. Wireless Markup Language (WML) and WML Script started appearing which made use of the WAP standards.

Basically both the mobile web as well as the desktop web make use of the same technologies such as HTML (Hyper Text Markup Language), CSS (Cascading Style Sheet) and JavaScript.When the WAP was first derived it was derived to view the content. Over the years, the evolution of further protocols and the need to have applications itself having the capability to view the application development resulted in a number of changes appearing in the development of mobile web.

2.6.1. Mobile web application development

Writing mobile applications especially making use of mobile web is nothing different from the desktop programing. The only difference in this instance is the scaling down to the requirements of the mobile device, its size, its limitations, its network power, battery power and its mobile friendly features. The following sections highlight the features and limitations of mobile application development environment

2.6.1.1 Device Detection

One of the important aspect of mobile application development is the ability to detect the mobile device so that the specific features available in that device can be optimally utilized. The device detection can be done through the user-agent parameter which normally gets transmitted from the HTTP header of the browser. The simple and most reliable system of device detection is to use a small JavaScript function to determine the device whether it is mobile or non-mobile. Similarly the same HTTP header transmission can also provide the browser information which can be used to optimize the mobile web accordingly.

2.6.1.2 CSS Media Queries

With the use of CSS Media queries, the developers are given the freedom to enhance the programing environment by checking certain mobile conditions such as the resolution of the screen, width of the screen, its height its orientation – portrait or landscape etc.

2.6.1.3 Touch and Gesture Events

There are three types of touch events which are possible in mobile devices, which are touchstart, touchmove and touchend. These events are very important in adhering to while writing programs. Apple introduced its touch event API (Application Programming Interface) starting from its iOS2 onwards. Four objects are important in a touch and gesture event detection, they are the identifier, the target, the screen coordinates and the radius. The APIs will normally gather these objects for effective programming.

2.6.1.4 Data Optimization

Optimizing data for mobile computing is an important aspect for variety of reasons. The important reason being that the wireless data services have very limited bandwidth which needs to be harnessed. If an application has to be developed from the standard HTML the good practice is to make sure that unnecessary empty spaces margins and indentations are removed. Since browsers send separate requests for every external file it is prudent to combine items and the number of style sheets for better optimization of data.

2.6.1.5 Location Based Services (LBS)

One of the main attractions of mobile programing is to use the Location Based Services. Location based services refer to the identification of the location from which the mobile has been used. The early LBS services centered on the mobile operator to know the precise location of the user. Modern mobile programs use the interactive digital maps which are the user interface for LBS. In iOS the *mapkit framework* is used to access and manipulate the maps.The *Maps* application is used to interact with the manipulated data using set APIs. For Android the LBS is

achieved through a Location Manager service using Geocoding services, Google Map view and Google MAP application for accessing and manipulating the Location based queries.

2.7 Types of Mobile Applications

There are three kinds of applications which are possible in mobile environment they are:

- Web Applications
- Native Applications
- Hybrid Applications

2.7.1. Web Applications

Web Applications are applications which are built to serve multi platforms irrespective of the operating platforms. Since all the smart mobile phones have a browser which support mobile technology standards web applications are easy to develop as it follows standard HTML coding. Though it cannot be 100% portable to all the different screens and operating environments, it is more reliable and easy to deploy. The need to download them from app stores are minimized and only a link is need to deploy and activate it on the mobiles. JQuery Mobile and Sencha Touch are two most popular mobile web development frameworks which are commonly used in mobile web application development.

2.7.2. Native Applications

Native Applications on the other hand makes use of the inbuilt mobile specific features and the specific resolutions and screen sizes which are native to particular mobiles. Since it is native to the operating environment as well as to the device more specific APIs are being used from the

native environment to accelerate the application process. Normally a native application can be downloaded only from the specific application store which gives more control over the in-house monetary processes and also the proper execution of services like push notifications and other mobile specific activities.

2.7.3. Hybrid Applications

Hybrid applications are developed using Native application method and within which the web application links are imbedded so that a parallel cross platform actions are controlled. Hybrid applications are built with a combination of web technologies like HTML, JavaScript, CSS and they are hosted inside the native applications so that it can use the mobile browsing environment. Adobe PhoneGap is one of the manyopen source hybrid application development environments which is used for creating hybrid applications.

2.8 Definitions of Terms and Concepts

Accelerometer is a built-in piece of electronic equipment which is used to measure the tilt and motion movement of a device. It also detects the rotation, gestures, swinging and shaking. This is commonly used in the mobile devices to activate auto screen rotation when the users change the orientation of the device.

AMPS (Advanced Mobile Phone System) is a 1st Generation analog cellular radio standard developed by Motorola and AT&T which operated on 50 MHz spectrum band.

Android is an operating system created and maintained by Google for smart phones which is based on the Linux kernel. Since it is born out of Open Handset Alliance the majority of the code is open source.

API (Application Program Interface) is s simplified set of instructions or routines which are designed for any particular application program (software) or for any system which can call or do specific instructions on specified programs or services of a computer operating system (OS) or network operating system (NOS).

Bandwidth refers to the capacity of a circuit in bits per second (bps). In other words, the total signaling capacity rate of the circuit.

Baseband A single-channel transmission system, i.e., a transmission system that supports a single transmission at any given time. All contemporary wired local area networks (LANs) are baseband.

Blog(Web log) is a publicly accessible journal maintained on the Web by an individual or group.

Broadband is transmission rate which is faster than the primary ISDN rate which is 1.544 Mbps in North America and 2.048 Mbps in most of the rest of the world. In the Wide Area Network (WAN) domain, broadband is an imprecise term referring to a circuit or channel providing a relatively large amount of bandwidth.

Browser is the inter-mediatory program between the operating system and the internet which allows users to locate and retrieve information from networked information services especially through URL addresses.

C++ is an object-oriented programming language developed by Bjarne Stroustrup at Bell Laboratories during mid-1980s. This can be called as the development of C programing language.

CDMA (Code Division Multiple Access) is multiplexing technique used in radio networks, CDMA is rooted in spread spectrum (SS) technology developed in the 1940s. Spread spectrum is a wideband radio transmission technology that spreads of the transmitted signal over a spectrum of radio frequencies that is much wider than that required to support the native narrowband transmission.

CSS Cascading Style Sheet is a set of HTML rules which is used to define the appearance of web pages in a website. Whenever there are more than two sets of rules for the same element CSS use the precedence rules to decide which commands should be used.

DSL (Digital Subscriber Line) - any group of broadband digital access technologies which operate over embedded unshielded twisted pair (UTP) telecommunication local loop.

EDGE (Enhanced Data rates for GSM Evolution) This is a 2.5Generation standard developed by the European Telecommunications Standards Institute (ETSI) as the final stage in the evolution of data communications within the GSM standards in the year 1999.

ENIAC (**E**lectronic **N**umerical **I**ntegrator **A**nd **C**alculator) is the first electronic computers which was built at the University of Pennsylvania in mid-1940s. Around 18,000 vacuum tubes were used to construct this computer which occupied an entire floor space. ENIAC was programmed by plugging cables into circuit boards.

Flash memory is a type of Erasable and Programmable Read Only Memory which can only be erased in blocks and cannot be erased one byte at a time. Flash memory is usually used for storing larger amounts of data.

GPRS (General Packet Radio Service) is a data service developed after the 2nd Generation of mobile services before the 3rd Generation services were developed and often called as 2.5Generation data service enhancement for GSM networks. It uses a packet-switched service that takes advantage of available GSM time slots for data communications and supports both X.25 and TCP/IP packet protocols.

GPS (Global Positioning System) is a satellite-based navigation system which comprises of a constellation of 24 satellites which were launched by the United States Department of Defense. The satellites are positioned in such a way that the signals from six of these satellites can be received by any GPS terminal at virtually any point on the Earth's surface at any time. The main purpose of the satellites are to constantly broadcast two different types of timing signals namely LI for civilian and L2 for military based on atomic clocks that are accurate. These signals are manipulated to accurately determine the positioning of the reception at the GPS terminal.

GSM (Global System for Mobile Communications née Groupe Spéciale Mobile) GSM is a pan-European digital cellular radio standard developed in 1982 by Speciel Mobile Group which was formed by the Confederation of European Posts and Telecommunications. It was adopted in the year 1987.

Gyroscope sensors, which is sometimes known as Gyro-sensor is used in mobile devices to measure the angular rate and angular velocity of the divices which translates to detecting the change in rotational anger per unit of time. It is often measured in terms of degrees.

HAWHAW is derived from **H**TML **A**nd **W**ML **H**ybrid **A**dapted **W**ebserver. This is a webserver with a dynamic toolkit to create mobile web applications.

HSDPA (High Speed Downlink Packet Access) is the precursor of 4th Generation Network standards know to be 3.5Generation cellular radio technology proposed a downlink data rates to 14.4 Mbps.

HTML (Hypertext Markup Language) is a tag-based scripting language used to format documents for the web environment through a web browser. The main feature of HTML is its use of hyperlinks to connect and relate to another page. The development of HTML is overseen by the World Wide Web Consortium (W3C).

HTTP (**H**ypertext **T**ransfer **P**rotocol) -- a standard protocol / method of publishing information as hypertext in HTML format on the Internet or in a web enabled environment.

iOS is an operating system developed by Apple and released in 2007 for its mobile devices (*iPod, *iPhone, and *iPad). iOS makes use of multi-touch user interface with clear large icons for controlling the devices. At the stage of compilation of this thesis the current version is iOS 9.3.4.

IP(Internet Protocol)is the basic communications protocol in TCP/IP (Transmission Control Protocol / Internet Protocol) based networks for relaying data across network boundaries.

iPad / iPod and iPhone are mobile devices with touchscreen operating on iOS operating system which is marketed by Apple.

Javais a powerful language developed by Sun Microsystems in 1990 for OOPs (object-oriented programming). In 2006–07Java was made open source software which can be compiled as bytecode which can be interpreted by any computer which uses Java Run Time.

JavaScript is asimple scripting language designed by Netscape and Sun Microsystem to aide more color and ability to web pages. JavaScript code can embedded in the HTML codes and executed and interpreted by the web browsers.

LCD (**L**iquid **C**rystal **D**isplay) is a type of display which uses liquid crystals which are chemicals in nature and responds to polarized light and controlled by electric field. This is commonly used in digital watches, calculators, laptops, tablets, flat-panel computer displays and mobile display units.

Local Area Network (LAN) -- a networked connection generally operated in a smaller area often within a single organization.

MapKit framework is an API framework which is available for iOS device programing. Mapkit makes it easy to provide references to map utilities in mobile programing by allowing to display maps, shift from one coordinate to another, fix locations, and derive routes and other shapes on top of the map.

MBps (MegaByte per second)is a bandwidth measurement used in the transmission which equals to million times of 106 bytes per second.

Middleware is a software that occupies a middle position between Application software and the Operating system which makes the middleware compatible to run under a number of different operating systems. Examples are web browsers, scripting languages like Java, HTML etc.

Mobitex (Mobile text) is low-speed, packet-switched wireless data networks deployed in Europe and the United States alongside cellular radio networks.

MyMobileWeb is an open source development environment which helps in the development of mobile web applications including portals. It provides a content management platform to help in the development of mobile websites. It uses the open standards as its main backbone.

NMT (Nordic Mobile Telephone) is referred to the mobile radio technology developed in 1980s when the first generation of mobile services existed.

Node is an individual computer or a connection point in a network.

Operating system is a program that allows users to control and operate a computer or a microprocessor based unit. A typical Operating System allows user input and provides response by manipulating the input through its central processing unit.

Packet Switching is a technique used for dynamically segmenting messages with a fixed maximum size to store and transmit them.

Palmtop computer is a very small computer with an LCD screen and compressed keyboard that can be hand-held or kept in the palm top and carried in the pocket. Some models are mere personal assistants with address list, calculator and personal organizer while some advanced versions are programmable.

PSTN (Public Switched Telephone Network) also known as *PSTS* (Public Switched Telephone System) is a generic term for General domestic public telephone network which operates under the circuit switched network optimized voice communication.

PTT -- Push-To-Talk or Press- To-Talk. is referred to the system of sending or transmitting message through a half-duplex radio system. A full duplex system uses push to talk and release to listen mechanism.

RF (Radio Frequency) -- Radio wave frequencies of the electromagnetic spectrum. This doesn't involve electricity, light or any other rays.

ROM (**R**ead-**O**nly **M**emory) a computer memory that contains instructions that are specifically meant only for read only and not intended to be changed. Mostly Operating System instructions such as boot instructions are written in this memory.

SDK Software **D**evelopment **K**it is a utility found on any of several products to develop software using that application software or system.

SIM (Subscriber Identification Module) is a smart card which is normally used in a GSM mobile network to serve the security measure. When used in the mobile phone it can store user data such as profile, privileges, identification and personal directory of telephone numbers. The SIM can be used with any GSM mobile to provide mobility across any GSM carriers.

TCP/IP (Transmission Control Protocol/Internet Protocol) is the combination of two protocols developed by DARPAnet for optimizing the performance of networks. This is the mandatory standard to be used by any system connecting to the internet.

TDMA (Time Division Multiple Access) is a multiplexing technique used in digital wireless systems that divides each frequency channel into multiple time slots, each of which supports an individual conversation. The total available bandwidth, the bandwidth of the individual channels,

and the number of time slots per channel vary according to the particular standard, as well as the specific coding technique employed.

UMTS (Universal Mobile Telecommunications System) which is also known as Wideband CDMA (W-CDMA) which is a 3rd Generation digital cellular radio technology that is an upgrade to GSM.

Visual Basic was introduced in 1991 by Microsoft as one of the development environment for programming in windows. The layout of programs can be done visually and basic coding can be done by scripting in visual basic. The current version is called *Visual Basic .NET* or *VB.NET* and uses the .NET Framework for fully object-oriented programming.

WALL (**Wireless Abstraction Library**) was developed by Luca Passani is a library consists of tags that allow developers to use it for creating mobile pages similar to plain HTML. The advantage of using these tags are that device capabilities are queried dynamically using the inbuilt query API.

WAP (Wireless Access Protocol) is a carrier-independent but device-independent, protocol employed in Web-enabled cellular networks to support audio, video, text and graphics. The disadvantage is that it is optimal when it access websites which were written using WML (Wireless Markup Language), which is similar to HTML.

Web 2.0 is a name given to a number of new ways of using the World Wide Web, especially the interactive web, which involves Social Networking and user participation.

Wide Area Network(WAN) is anetwork with communications on a wider and often over large distances.

WiFi. is aIEEE 802.11b specified wireless Ethernet link operating in the 2.4 GHz band with a range of up to 100 meters.

WiMAX (Worldwide Interoperability for Microwave Access) is a broadband wireless access solution expected to provide upto 15 Mbps of bandwidth within a radius of 3 kilometers. This specification is based on the standards recommendations from the IEEE 802.16 Working Group and the European Telecommunications Standards Institute (ETSI). WiMAX can support a maximum signaling of 70 Mbps.

WML (**w**ireless **m**arkup **l**anguage) is an extension of XML specifically aimed at writing codes for wireless Devices.

Xcode is developed by Apple as an integrated development environment (IDE) which consists of a suite of tools meant for software development especially for macOS, iOS, WatchOS and tvOS.

XML (**E**xtensible **M**arkup **L**anguage) is a language similar to HTML, but designed for transmitting complex data structures of any type, with rich features not just web pages. Unlike HTML, XML does not have a defined set of tags instead, it is extensible as the users can create their own set of tags.