International Journal of Applied Engineering Research
ISSN 0973-4562 Volume 10, Number 6 (2015) pp. 14765-14777

http://www.ripublication.com

Evolution of Mobile Wireless Communication Networks (0G-8G)

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Abstract

Recent innovations in Mobile Networks have made the world an encyclopedic digital village. According to present fast lane working environment scenario, Consumers are demanding more advanced and practical applications as fast as possible without a single constraint. To fulfill these demands, there is a need of improving present wireless communication systems for a better understanding of fundamental issues in communication theory and electromagnetic applications. The size of the communication devices is reduced due to increase in processing power. This paper provides an overview of the latest developments in wireless communications, including cellular, fixed wireless, and wireless local area networks according to generations. It focuses a lot on the different standard technologies and the migration paths from 1st generation systems to 4th generation systems and tries to find some future generations which are under research like 5G, 6G, 7G and 8G. The main purpose of this study is to find out future picture of mobile wireless communication.

Keywords: Mobile wireless communication, GSM, GPRS, 1G, 2G, 3G, 4G, 5G, 6G, 7G and 8G.

Introduction

Wireless Communication is the process of transmitting electromagnetic waves over a distance between the two points without any physical connection. Some examples of these types of devices are Bluetooth, remote control, walkie-talkies, PDA, wireless computer mouse, Mobile phones etc. [11, 12].

In today's fast-paced world, people want more applications and own demands of communicating, connecting with people as quick as possible. In the past few decades, the mobile wireless technologies have introduced various generations of technology namely from 0G to 4G. Advance achievements of 5G technology are being processed

on the development of World Wide Web (WWW) [2]. Each generation have some standards, capacities, techniques and new applications which differentiate it from previous generations. The new applications/features attract new mobile phone subscribers. Evolution of wireless communication was a result for the development of highly reliable, miniature, solid state RF hardware in Bell's laboratory during the year 1960-70. Benefits of developing Cellular systems are [30]:

- Bandwidth requirement is minimum and high customer satisfaction using spectrum efficiency property.
- Comparative to 'wired', wireless networks provide flexible communication. Some wireless networks are cost effective than wired networks.
- Capacity of the mobile communication system will be high because a large number of consumers/ customers cannot create blocking probability due to large coverage area.
- Duplexing is the one of the most desirable feature, which allows consumer to transmit & receive data simultaneously using a single radio link.
- The sharing of spectrum is achieved high capacity by simultaneously allocating the available bandwidth to multiple users, known as multiple access technique.

Zero Generation Technology

Mobile radio telephone systems connected to the modern cellular mobile telephony technology. Since they were the precursor of the first generation of cellular telephones, these systems are referred as 0G (zero generation) systems. The technologies involved in 0G systems incorporated PTT (Push to Talk), MTS (Mobile Telephone System), IMTS (Improved Mobile Telephone Service), AMTS (Advanced Mobile Telephone System) and MTD (Mobile telephony system D) [1].

- PTT also known as "Push to talk or press to transmit", a method of discussing on half duplex communication lines including two way radio without needing an existing connection.
- MTS system is totally depended on operator at transmitter as well as receiver side.
- IMTS units produced a dial tone when the receiver was lifted from the cradle and this way seemed more like a landline telephone than a cellular handset. IMTS covered an area of 40-60 miles in diameter had 11-12-13 radio channel in larger cities while rural stations had as few as one or two channels.
- AMTS is also operate on 900 MHz band. the difficulties occurred from IMTS rectified in AMTS [13]
- OLT land mobile system is introduced in Norwegh. It operates on 160 MHz VHF band.
- MTD provided always on internet access with relatively high speed internet connection without need of telephone line.

The primary users were loggers, construction foremen, realtors, and celebrities, for basic voice Communication.

First Generation Technology

1G is the first-generation wireless telephone technology and introduced in the 1980s. A voice call gets modulated to a higher frequency of about 150MHz and is transmitted between radio towers with the help of 1G The 1G first generation mobile wireless communication system was analog frequency modulation system, which was based on three technologies known as NMT (Nordik Mobile Telephony), AMPS (Advance Mobile Phone Service) and CDPD (Cellular Digital Packet Data) [4, 9] as discussed in table 1 .

CDPD is the specification for supporting wireless access to the internet and other public packet switched network as shown in figure 1. The channel coding used in CDPD is Reed-Solomon with 14.4 kbps full duplex data rate. It uses RF sniffing technique to detect an AMPS call is trying to access a frequency channel. CDPD operates with 3 interface services those are A-interface service, E-interface service and I-interface service. Hand-off in CDPD occurs when an M-ES moves from one cell to another. CDPD authentication is done by the mobile management entity (MME).

The unique feature of first Generation mobile is the use of hexagonal cells. Overall connection quality is somewhat poor in 1G. It has low capacity unreliable handoff, poor voice links, and no security since voice calls were played back in radio towers, making these calls susceptible to unwanted dropping or interference by third party. First generation mobile standards were different in different country. AMPS 1G standard was used in the United States. NMT was used in Nordic countries (Denmark, Finland, Iceland, Norway and Sweden), as well as in its neighboring countries Switzerland and Netherlands, Eastern Europe, and Russia. Italy used a telecommunications system called RTMI. In the United Kingdom, Total Access Communication System (TACS) was used. France used Radiocom 2000. In West Germany, Portugal, and South Africa, a telecommunications system known as C-450 was used. In comparison to 1G's analog signals, 2G's digital signals are very contingent on location and proximity.

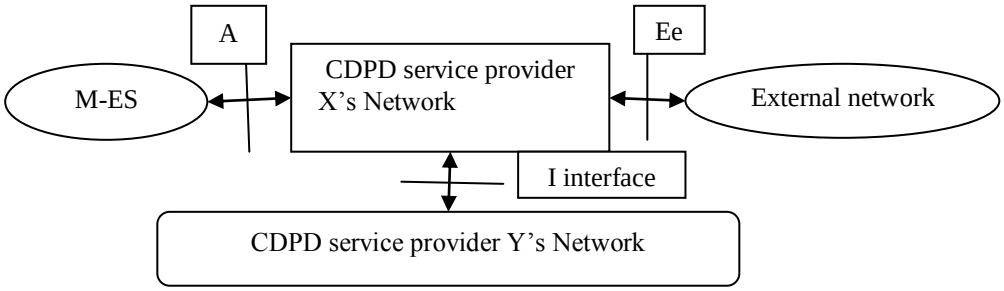

Figure 1: Reference architecture for CDPD [2]

Table 1: Features of first generation

Technology (Analog wireless)	NMT	AMPS	CDPD
Established year	1981	1983 by Bell Labs	1983
Features	First fully automatic cellular phone system	In 1G Cellular technology each conversation uses separate channels.	Low speed, high latency data service Primarily intended for paging and email. Provide broadcast and multiple-access service.
	NMT-450 NMT-900		
Cell size range	2-30Km		
Transmission	Full duplex		
Uplink frequency		824- 849MHz	
Downlink frequency		869-894MHz	
Problem	Voice encryption is the main problem.	AMPS is unsuited for packet data	• Limited bandwidth • Security IP network attacks
Switching	Circuit	Circuit	Circuit
Multiplexing	FDMA	FDMA	FDMA
Handoff	Horizontal	Horizontal	Horizontal

Second Generation Technology

In the same vein Second-generation (2G) mobile systems were introduced in the end of 1980s. Commercial launch of this system was took place in Finland in the year 1991[7,16]. This generation is introduced for both data and voice services. These systems are completely digital and digital multiple access technology, TDMA and CDMA. In this technology the use of digital signals in between the mobile equipments and the base station increases the system capacity in two ways. One way is the Digital voice data can be compressed and multiplexed very effectively thus allowing more calls to be packed into the same amount of radio bandwidth. The second way is the digital systems were designed to emit less radio power from the handsets. Thus making the cells smaller and adjusting greater number of cells in the same amount of space [32].

The 2G technology entirely depends on two types of mobile standards on the basis of multiplexing those are CDMA and TDMA. In practical applications, the TDMA

and CDMA schemes are combined with FDMA. Thus the term "TDMA" is used to describe systems that first divide the channel into frequency slots and then divide each frequency slot into multiple time slots. Similarly, CDMA is actually a hybrid of CDMA and FDMA where the channel is first divided into frequency slots. Each slot is shared by multiple users who each use a different. The features of the GSM standard makes international roaming very common between mobile phone operators, enabling subscribers to use their phones in many parts of the world. GSM has enabled the users to make use of the short message services (SMS) to any mobile network at any time.

Personal digital cellular (PDC) technology was developed in Japan, and is solely used in JAPAN. it uses 25 KHz frequency. In the year 1993 Docomo launched first digital service of PDC. Motorola developed a major mobile technology integrated digital enhanced network (iDEN). It also uses a frequency of about 25 KHz. IS- 136 is a second generation cellular phone system. It is also known as digital AMPS. The use of 2G technology requires strong digital signals to help mobile phones work. 2.5G is a group of bridging technology between 2G and 3G wireless communication. It is a digital communication allowing E-mail and simple Web browsing, in addition to voice. New technologies have been developed on the basis of GSM system, leading to some more advanced systems known as 2.5 Generation (2.5G) systems as summarized in table 2.

(a) 2.5G – GPRS (General Packet Radio Service)-

2.5G, is a cellular wireless technology developed in between its predecessor, 2G, and its successor, 3G. The move into the 2.5G world began with General Packet Radio Service (GPRS). GPRS is a radio technology for GSM networks that adds packet switching protocols, shorter setup time for ISP connections, and the possibility to charge by the amount of data sent, rather than connection time. GPRS is famous because of its flexible data transmission rates as well as unbreakable connection to the network. GPRS is a powerful step towards 3G. CDMA-2000 is a hybrid of 2.5G/3G protocol of mobile telecommunication standard that uses CDMA. It is considered as 2.5G protocol in IxRTT and 3G protocol in EVDO [3].

(b) 2.75 – EDGE (Enhanced Data rates for GSM Evolution or Enhanced GPRS):

EDGE technology was introduced by AT& T. It is a part of 3G technology. It is an extended version of GSM. It allows the fast data & information transmission. EDGE technology is popular due to its flexibility to carry packet switch data and circuit switch data. The use of EDGE technology has augmented the use of black berry, N97 and N95 mobile phones. The principal advantage of EDGE technology is one does not required to install any additional hardware and software to use this Technology. There are no additional charges for exploiting this technology [3].

Table 2: Features of second generation along with some intermediate generations

Generation	2 G	2.5 G	2.75 G
Year	1991	2000	2003
Frequency band	850-1900 MHz	850-1900 MHz	850-1900 MHz
Capacity in terms of Data	10Kbps	200 Kbps	473 Kbps
Multiplexing used	TDMA and CDMA	TDMA and CDMA	TDMA and CDMA
Switching	Circuit as well as Packet	Packet	Packet
Service	Voice and Data	MMS and internet along with Voice and Data	MMS and internet along with Voice and Data
Network	PSTN	GSM TDMA	WCDMA
Handoff	Horizontal	Horizontal	Horizontal

Third Generation Technology

In today's world most of the persons are using this generation technology and standards. 3G is the third generation of mobile phone standard, superseding 2G, and preceding 4G. It is a CDMA based generation [15]. It is based on the International Telecommunication Union (ITU) family of standards under the International Mobile Telecommunications program, IMT-2000. The 3G actions were started in Europe and North America under the respective names IMT0-2000 and CDMA-2000. These were based on wideband direct CDMA (WCDMA) and multi carrier CDMA. Both IMT0-2000 and CDMA-2000 used FDD to support two way transmissions with frequency isolation. There are many 3G technologies as W-CDMA, GSM EDGE, UMTS, DECT, WiMax and CDMA 2000.WCDMA and cdma2000 have many similar features. However, a major difference is that WCDMA is backward compatible with GSM networks, while CDMA 2000 is backward compatible with IS-95 networks. 3G technologies use TDMA and CDMA for the use of value added services like mobile television, GPS (global positioning system) and video conferencing. 3G technology is much flexible, because it can support the 5 major radio technologies. These radio technologies operate under CDMA, TDMA and FDMA. The new mobile broadband networks established two distinct 3G families: 3GPP and 3GPP2.The 3rd Generation Partnership Project (3GPP) was formed in 1998 to foster deployment of 3G networks that descended from GSM. 3GPP technologies evolved as follows [25, 31]:

- General Packet Radio Service (GPRS) offered speeds up to 114 Kbps.
- Enhanced Data Rates for Global Evolution (EDGE) reached up to 384 Kbps.
- UMTS Wideband CDMA (WCDMA) offered downlink speeds up to 1.92 Mbps.
- High Speed Downlink Packet Access (HSDPA) boosted the downlink to 14Mbps.

- ❖ LTE Evolved UMTS Terrestrial Radio Access (EUTRA) is aiming for 100 Mbps [17-18].

3G is the significant step towards improved bandwidth, multiple mobile applications and clarity of digital signals. 3G technology is able to transmit packet switch data efficiently at better and increased bandwidth. 3G mobile technologies offers more advanced services to mobile users. It can help many multimedia services to function. The spectral efficiency of 3G technology is better than 2G technologies [4, 9].

(a) **3.5G – HSDPA (High-Speed Downlink Packet Access):**
High-Speed Downlink Packet Access(HSDPA) is a packetbased data service in W-CDMA downlink with data transmission up to 8-10 Mbit/s (and 20 Mbit/s for MIMO systems) over a 5MHz bandwidth in WCDMA downlink. Its implementations includes Adaptive Modulation and Coding (AMC), Multiple-Input Multiple-Output (MIMO), Hybrid Automatic Request (HARQ), fast cell search, and advanced receiver design.

(b) **3.75G – HSUPA** (**High-Speed Uplink Packet Access):**
High Speed Uplink Packet Access (HSUPA) is a UMTS / WCDMA uplink evolution technology, directly related to HSDPA and the two are complimentary to one another. HSUPA will enhance advanced person-to-person data applications with higher and symmetric data rates. It will initially boost the UMTS / WCDMA uplink up to 1.4Mbps and in later releases up to 5.8Mbps.

Table 3: Features of third generation along with some intermediate generations

Generation	3 G	3.5 G	3.75 G
Year	2001	2003	2003
Frequency band	1.6-2.5GHz	1.6-2.5GHz	1.6-2.5GHz
Capacity in terms of Data	384 Kbps	2Mbps	30Mbps
Multiplexing used	CDMA	CDMA	CDMA
Switching	Circuit as well as Packet	Packet	Packet
Service	High speed Voice, Data and video	High speed Voice, Data and video	High speed internet/ multimedia
Network	Packet network	GSM TDMA	
Handoff	Horizontal	Horizontal	Horizontal

Fourth Generation Technology

4G is next in line to 3G and 2G families of standards. The World wireless Research Forum (WWRF) defines 4G as a network that works upon internet technology and

includes various applications such as Wi-Fi and WiMax. The 4G network gives a new experience to users by its multi service capability and it integrates all the mobile technologies that exists (e.g. GSM, GPRS,IMT-2000, Wi-Fi, Bluetooth). In simple words 4G is a common platform for all the technologies that have been developed so far, and to harmonize with customer expectations of the many services to be provided. 4G gives freedom and flexibility to select any desired service with reasonable QoS and affordable price, anytime, anywhere to its users. 4G services are already started in 2012 but it is not in mass market. It will become mass market in about 2016-2017 [10, 26]. The word "MAGIC" also refers to 4G wireless technology which stands for **M**obile multimedia, **A**ny-where, **Gl**obal mobility solutions over, Integrated wireless and **C**ustomized services [19]. The features of 4G is shown in figure 2.

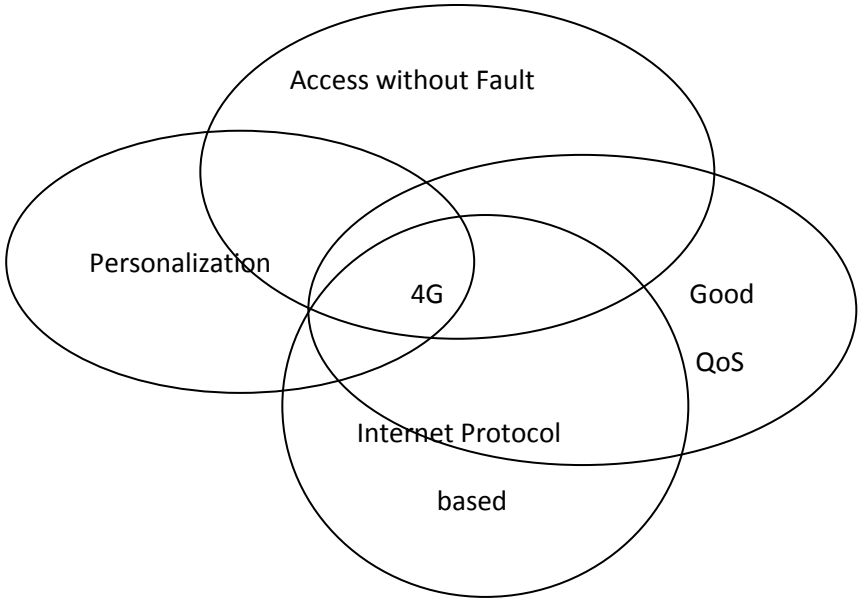

Figure 2: Features of 4G

The objectives defined for 4G wireless generation are: [5, 29]

- Spectral efficient system & high network capacity
- Nominal data rate of 100 Mbps at high speeds.
- Smooth handoff across heterogeneous network.
- Seamless connectivity & global roaming across multiple networks.
- IPv6- The 4G networks will be based on packet switching only. It requires low latency data transmission.4G wireless network should support a great number of wireless devices that are addressable & routable.
- UMB- It stands for Ultra Mobile Band. It is planned to be called as 4G technology because of its features:
  - It utilizes OFDMA technology along with sophisticated antenna techniques to provide peak rates of up to 280Mbps.

- Its improved system capacity, user data rate throughout the cell, lowering costs, enhancing existing services etc.

❖ WiMax is defined as Worldwide Interoperability For Microwave Access is based on IEEE 802.16 standards. Its various goals are.-

- It aims to provide wireless data over long distances in a variety of different ways from point to point links to full mobile cellular type access.
- Multimedia WiMax plus CDMA & other technologies can work together to fulfill both long range, low bandwidth and shorter range high bandwidth requirement on the basis of providing user with always but connected [22, 28].

Table 4: Features of Fourth generation

Generation	4G
Year	2010
Frequency band	2-8 GHz
Capacity in terms of Data	200Mbps to 1 Gbps
Multiplexing used	MC-CDMA, OFAM
Switching	Fully packet switching
Service	Hi speed internet
Network	IP
Handoff	Horizontal and vertical

Fifth Generation Technology

In the same vein the 5G mobile system for the global coverage will integrate 4G wireless mobile system and satellite network. The telecommunication satellite network is mainly used for voice, data, internet, and video broadcasting. Development of this generation is done according to fulfill the user requirements [8, 24, 27]. The key difference, between 4G & expected 5G technology will be something else than increased maximum throughput; other requirements include:

- ❖ Minimum battery consumption.
- ❖ Good Coverage & high data rates available at cell edge.
- ❖ Nearly Gbps data rate in mobility.
- ❖ More Security; Good cognitive radio security.
- ❖ Low traffic fees due to minimum infrastructure deployment cause.

5G is to be a new technology that will provide all the possible applications, by using only one universal device and interconnecting most of the already existing communication infrastructures. It will have software defined radio modulation schemes. The 5G mobile networks will focus on the development of the user terminal where the terminals have to access to the different wireless technologies at the same time and will combine different flows from different technologies [20,23].

Table 5: Features of Fifth Generation

Generation	5G
Year of expecting	2017
Capacity in terms of Data	>1 Gbps
Multiplexing used	CDMA
Switching	Fully packet switching
Service	Dynamic information access, wearable devices with AI capabilities
Network	Internet
Handoff	Horizontal and vertical

Sixth Generation Technology

Technology is also growing day to day according to fulfill the requirements of end users. The 6G will be the expecting technology in future which will integrate 5G wireless mobile system and satellite network. It includes all the features of 5G along with some advanced features. The telecommunication satellite is used for voice, data, internet, and video broadcasting; the earth imaging satellite networks is specially used for weather and environmental information collection; and the navigational satellite network is for global positional system (GPS). The 5G mobile networks will focus on the development of the user terminal where the terminals have to access to the different wireless technologies at the same time. In 6G handoff and roaming will be the big issue because these satellite systems are different networks and 6G has four different standards. So the handoff and roaming must take place between these 4 networks but how it will occur is still a question [6, 21].

Seventh & Eighth Generation Technology

The 7G & 8G will be the most advanced generations in mobile communication network. It is like the 6G for global coverage but it will have advance satellite functions for mobile communication and consider the limitations of 6G like handoff difficulty and roaming setback. Research is going in this technology on demanding issues like the use of mobile phone during moving condition from one country to another country, because satellite is also moving in constant speed and in specific orbit, the standards and protocols for cellular to satellite system and for satellite to satellite communication system. The satellite to satellite communications and its related protocols and standards maybe considered as 7.5G or in 8G. The direct HD videos broadcasting for news gathering will also a powerful application of these generations. These generations may be the best solution of cost on lower level customers [14].

Conclusion

The world of wireless communication is rapidly evolving. Mobiles have become very essential part of our daily life. The last few years have witnessed an extraordinary growth in wireless industry. Their current progress is the upshot of various generations. In this paper we take a survey on various generations of mobile wireless technology, their performance, advantages and disadvantages of one generation over another. The first generation (1G) has accomplished the basic requirement of mobile voice, while the second generation (2G) has acquainted capacity and coverage. The 2G is followed by the third generation (3G), it has provided wireless data service with high data rates in wide coverage areas. It will be realized by the fourth generation (4G). 4G can integrate current existing cellular networks and Wireless LAN with fixed internet networks. All these generations from 1G to 4G have comforted the living of a common user but have their own sets of problems. To overcome those end user problems the 5G mobile networks will focus on the improvement of the user terminal where the terminals have to access to the different wireless technologies at the same time. Satellite networks will come into the picture from 6^{th} Generation systems and onwards. Since the navigation satellite networks have being developed by five countries, which will make the space handoff/roaming difficulty. To provide these extra facilities, 6G may be costly. In 7G & 8G the problems of 6G will be enhanced and the cost of call will be reduced to satisfy the end users. In future the research work will be on real wireless world with no more limitations.

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