International Journal of Engineering, Applied and Management Sciences Paradigms, Vol. 22, Issue 01
Publishing Month: March 2015
An Indexed and Referred Journal
ISSN (Online): 2320-6608
www.ijeam.com

Comparison between Cellular Generations

Ahmed Suliman Mohammed Ahmed[1], Dr. Khalid Hamid Bilal[2] and Dr. Amin Babiker A/Nabi Mustafa[3]

[1,2,3]Department of communication, Faculty of engineering Al-Neelain University Khartoum, Sudan

Abstract

This paper investigates different methods of mobile technology. As a result of the wide use of mobile and rapid deployment of wireless networks, we made a comparison between all cellular generations such as 1G, 2G, 3G, 4G and 5G. And we got on the differences between each generation from the other. This rapid progress in wireless networks it grew from the challenges, Nowadays, a rapid growth in mobile technology has satisfied the customer needs to determine the best and highest quality of services provided by the wireless networks.

Keywords: *Cellular Generations, 1G, 2G, 3G, 4G and 5G.*

1. Introduction

Today's market of wireless communications is developed at a very rapid growth. This development causes due to the increasing number of subscribers. In today's life the mobile phone is very essential tool for everyone. Since the mid 1990's the cellular communication industry has a growth. Wireless communication networks have become much more deployment. When the cellular concept was first developed in the 1960's and 1970's. Increasing demand in wireless communication should be the rapid growth of cellular network for achieve the customers need and also for other service providers.

The wireless communication is a strong, viable voice and data transport mechanism. The cellular systems should be able to support the higher data traffic as well as higher spectrum efficiency.

In section 2 the first generation systems are discussed. Section 3 gives a detailed overview of second generation mobile technology. In section 4 third generation systems and its types are discussed. Section 5 gives information about the possible fourth generation technologies. Section 6 5th generations a Technology vision and Conclusion is contained in section 7.

2. First Generation

The first generation mobile systems are based on analog technology. The first technology uses frequency modulation (FM) and frequency division duplexing (FDD), frequency division multiple access (FDMA). The common signaling channels were used in first generation cellular systems. Due to the use of analog technology the analog speech signals are provided by the first generation wireless systems. The data transmission between base station and mobile user not enough and the low data rate necessitates the next generation cellular systems. in the first generation the transmission is not secure due to systems are depend on analog systems ,whereas the second generation systems uses digital modulation so, provides secure transmission of data.

A. AMPS

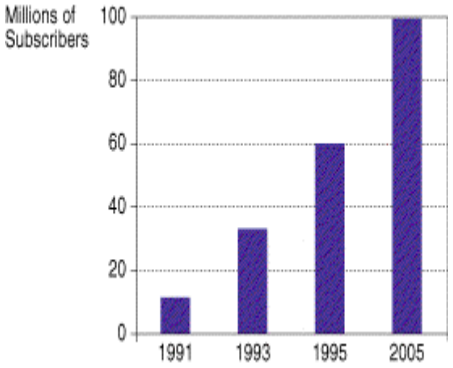
AMPS are the first U.S. cellular telephone system called advanced mobile phone system. The AMPS system uses 7-cell reuse pattern with provisions for sectoring and cell splitting to increase capacity when needed.

AMPS uses frequency modulation (FM) and frequency division duplex (FDD) for radio transmission. It uses FDMA multiple access, Channel bandwidth is 30 KHz. In the United States transmissions from mobile to base stations (reverse link) use frequency between 824-849MHz, while base station transmits to mobile (Forward link) using frequencies between 869MHz and 894MHz. Data rate of AMPS on control channel is 10 kbps

B. ETACS

European Total Access Communication systems (ETACS) was developed in Mid-1980's and is virtually identical to AMPS except it is scaled to fit in 25 KHz channels used throughout Europe. Another difference between AMPS and ETAC is how the telephone number of each subscriber (called the mobile identification number or MIN) is formatted, due to the need to accommodate different country codes throughout Europe as opposed to area codes in U.S.

Figure1 Cellular Subscriber Growth Worldwide



3. Second Generation

The second generation mobile technology is a based on of first generation mobile technology. Due to the analog speech signals, low data rate and insufficient data communication there is an emerging demand of the next generation wireless system that provides high speed data communication as well as voice transmission. Thus, the analog technology in first generation is replaced by digital technology in 2G wireless systems. Instead of analog frequency modulation (FM) technique the digital modulation techniques are used in second generation. The access techniques used in second generation are TDMA (time division multiple access) and CDMA (code division multiple access) along with the frequency division duplexing (FDD) technique. By using the second generation technologies the system capacity is three times greater than the first generation analog systems. Due to the increase in spectrum efficiency is three times compared to the first generation analog systems.

The standards in 2G technologies are categorized by following types:

i) GSM (global system for mobile)

It is very popular and widely used 2G technologies by most of the subscribers. The GSM supports 8 times slotted users for every 200 KHz radio channels. The popular features of GSM are short messaging service (SMS). SMS allows the users to send a data in alphanumerical format to the other user by simply dialing the user's mobile phone number. The uplink frequency (from base station to mobile station) is 890-915 MHz and downlink frequency (from mobile station to base station) is 935-960 MHz. The carrier separation for GSM is 200 KHz and bandwidth of GSM is 25MHz. It uses time division multiple access technique along with the frequency division duplexing. In GSM the 0.3 Gaussian minimum shift key (GMSK) modulation is used at the

data rate of 270.833kbps. The voice channels per carrier are 8 and the frame period is 4.615ms.Allows multiple users on a single channel.
GSM includes various types of Tele services and data services. The tele services include emergency calling, fax, videotext, and teletext. The data services also called as bearer services which include computer to computer communication and packet switched traffic. One of the most popular features of GSM is subscriber identity module (SIM) which gives a unique identity to each subscriber.

ii) Interim Standard 136(IS-136)

This standard also known as North American digital cellular (NADC). The IS-136 supports 3 times slotted users for each 30 KHz. This technique also uses time division multiple access (TDMA) with frequency division duplexing (FDD). The forward channel frequency is 1850-1910 MHz and reverse channel frequency is 1930-1990 MHz. the channel bandwidth is 60MHz. The 45 DQPSK (differential quadrature phase shift keying) type modulation techniques are used. The channel data rate is 46.6kbps.

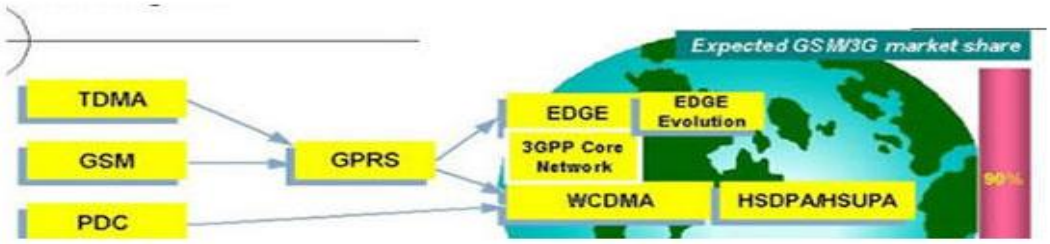
iii) Pacific digital cellular (PDC)

The forward and reverse link frequencies are similar to that of IS-136. Multiple access technique is time division multiple access (TDMA) with frequency division duplexing (FDD). The channel data rate is somewhat different compared to IS-136 and is 42 kbps and carrier separation is 25 KHz.

iv) Interim standard 95(IS-95)

This 2G standard is very popular and also known as cdmaone. This standard uses code division multiple access (CDMA) with frequency division duplexing. It supports 64 voice channels per carrier that are orthogonally coded. The upload channel frequency for IS-95 is 824-849 MHz and the download channel frequency is 869-894 MHz. The carriers are separated by 1.25MHz frequency. The signal is modulated by binary phase shift keying (BPSK) modulation with quadrature spreading at the data rate of 1.2288 Mchips /sec.
Although, the 2G standard mobile technologies provides efficient voice data transmission but the internet browsing applications are at very lower speeds. . So, for providing higher data rate transmission for internet browsing applications, e-mail services the 2G standards are modified and a new standard called 2.5 G standard is developed with backward compatibility with 2G standard. The 2.5G technologies uses wireless application protocols (WAP) by which the web pages are viewed by the users in a compressed form. . The 2.5G technology is evolved from the standards (GSM, PDC, IS-95and IS-136) in 2G technologies. Figure shows various upgrade paths

Fig No (2) Evolution of Mobile system to 3G:



For 2G technologies and also for 3G. In, 2.5G IS-95B standard is evolved from the cdma-one standard in 2G which uses channel bandwidth od 1.25 MHz. The high speed circuit switched data (HSCSD) is evolved from GSM standard which allows individual user to use consecutive time slots to obtain the higher speed data access on the GSM networks. It uses 200 KHz channel bandwidth and provides transmission rate up to 57.6 kbps. The general packet radio service (GPRS) includes features of both GSM, IS-136 and PDC. It provides a packet data access which is suited for non- real time internet usage, fax, e-mail, web browsing where the downloading speed is greater than uploading speed. The enhanced data rate for GSM evolution is more advanced GSM standard which is designed from the common features of GSM and IS-136. It is also referred as enhanced GPRS.

Table no (1)2nd Generation Cellular and Cordless Systems

System country	***IS-54 USA***	***GSM Europe***	***IS-95 USA***	***CT-2 ,Asia Europe***	***CT-3 DCT-90 Sweden***	***DECT Europe***
Access technology	TDMA/ FDMA	TDMA/ FDMA	CDMA/FDMA (DS)	FDMA	TDMA/ FDMA	TDMA/ FDMA
Frequency Band						
BS(MHZ)	869-894	935-960	869-894	864-868	862-866	1800-1900
MS(MHZ)	824-849	890-915	824-849			
duplexing	FDD	FDD	FDD	TDD	TDD	TDD
Modulation	Pi/4 DQPSK	GMSK	BPSK/QPSK	GFSK	GFSK	GFSK
Frequency assignment	fixed	fixed	fixed	Dynamic	Dynamic	Dynamic
Power control						
MS	Y	Y	Y	N	N	N

BS	Y	Y	Y	N	N	N
Speech coding	VSELP	RPE-LTP	Q CELP	ADPCM	ADPCM	ADPCM
Speech rate(kbps	7-95	13	8(Variable rate)	32	32	32
Channel Bit rate (kbps)	48.6	270.833	1228.8	72	640	1152
Channel coding	½ rate convolution	½ rate convolution	½ rate forward 1/3 rate reverse CRC	None	CRC	CRC

4. Third Generation

The third generation (3G) wireless systems provide backward compatibility for 2G and 2.5G. The 3G technology is originally designed for higher speed internet access and various types of web browsing applications. The 3G standard provides various attractive services one of it is video conferencing which enables multiple called parties that can communicate face to face though they are at a long distance. This service is very useful in case of business industries where various conferences are performed by video conferencing. The 3G also provides multimedia services, video calling, gaming services and internet access at a very high data rate.

The 3G standard is categorized in two types which are as follows:

A. 3GPP (3G partnership project for wideband CDMA standard)

This standard is based on backward compatibility with GSM and IS-136/ PDC. The 3 GPP standards involves wideband code division multiple access (W-CDMA), time division synchronous code division multiple access (TD-SCDMA) and enhanced data for GSM evolution (EDGE). The W-CDMA is also called as universal mobile telecommunication system (UMTS). The W-CDMA uses both frequency division duplexing (FDD) and time division duplexing (TDD). This technique is backward compatible with GSM and forward channel bandwidth is 5 GHz. The data rate is up to 2 Mbps. Its spectral efficiency is six times greater than GSM system. The TD-SCDMA is a popular GSM compatible standard. It has 1.6 MHz bandwidth and uses TDD duplexing technique. The channel bit rate is up to 2.227 Mbps.

B. 3 GPP-2(3G partnership project for CDMA-2000 standard)

This 3G technology is backward compatible to 2G CDMA technique i.e. IS-95 and 2.5G technique i.e.IS-95 B. The CDMA -2000 standard uses both FDD and TDD duplexing methods. The downlink frequency can be implemented using either direct spreading or multi carrier and uplink frequencies supports the simultaneous combination of multicarrier and direct

spreading. The 3G – CDMA 2000 1xRTT (radio transmission technology) implies a single 1.25 MHz radio channel. The data rate is up to 2 Mbps.

5. Fourth Generation

The fourth generation mobile communication system is developed after the third generation (3G) mobile phone standards. A fourth generation system (4G) provides various features which are not involved in Third generation standards or any other generation before 3G

Long Term Evolution (LTE) was Start in 2009/2010 with major operators in Asi (NTTDoCoMo) and North America Western European will follow very closely

Initial deployments will focus on "Hot Zone" areas to maximize access to high data users

The Hot zone coverage will be driven by distributed BTS solutions for high density, high Data speed areas

Compelling LTE Performance:

Peak LTE throughput (high spectral efficiency)

-DL: 100Mb/s SISO; 173Mb/s 2x2 MIMO; 326Mb/s 4x4 MIMO for 20 MHz

-UL: 58Mb/s 16QAM / 86Mb/s 64QAM (based on 1 Tx UE)

Spectrum efficiency

_DL: 3-4 times HSDPA for MIMO (2,2)

_UL: 2-3 times E-DCH for MIMO(1,2)

Ultra low Latency

_Reduced call setup times (50-100ms) & RTT (10ms from UE to server)

Capacity

_200 users for 5 MHz, 400 users in larger spectrum allocations

Flexible spectrum use maximizes flexibility

_ 1.4, 3/3.2, 5, 10, 15, 20 MHz

_ All frequencies of IMT-2000: x4 450 MHz to 2.5 GHz

Key Principles:

The OFDM technology is similar technology as FDM (Frequency division multiplexing) technology but a technological difference is that in OFDM the sub carriers are orthogonally spaced to each other to reduce the interference. It also reduces the Frequency selective fading which affects severely the transmitted signal at a channel. Due to the orthogonal arrangement of subcarriers the cross-talk between sub channels is eliminated. One advantages of OFDM is that inter carriers guard bands are not necessary.

OFDM also improves the spectral efficiency. The OFDM technology uses a fast Fourier transform (FFT) to convert the time domain signal in to frequency domain signal

OFDMA (DL) / SC-FDMA (UL): Robust modulation in dense environments

Increased spectral efficiency, Simplified Rx design _ cheaper UE, Scalable - go beyond 5 MHz limitation

MIMO: Increased link capacity

_Multiple-input, multiple-output UL& DL

_ Collaborative MIMO (UL)

_ Overcome multi-path interference

IP Core: flat, scalable

_ Short TTI: 1 ms (2 ms for HSPA)

International Journal of Engineering, Applied and Management Sciences Paradigms, Vol. 22, Issue 01
Publishing Month: March 2015
An Indexed and Referred Journal
ISSN (Online): 2320-6608
www.ijeam.com

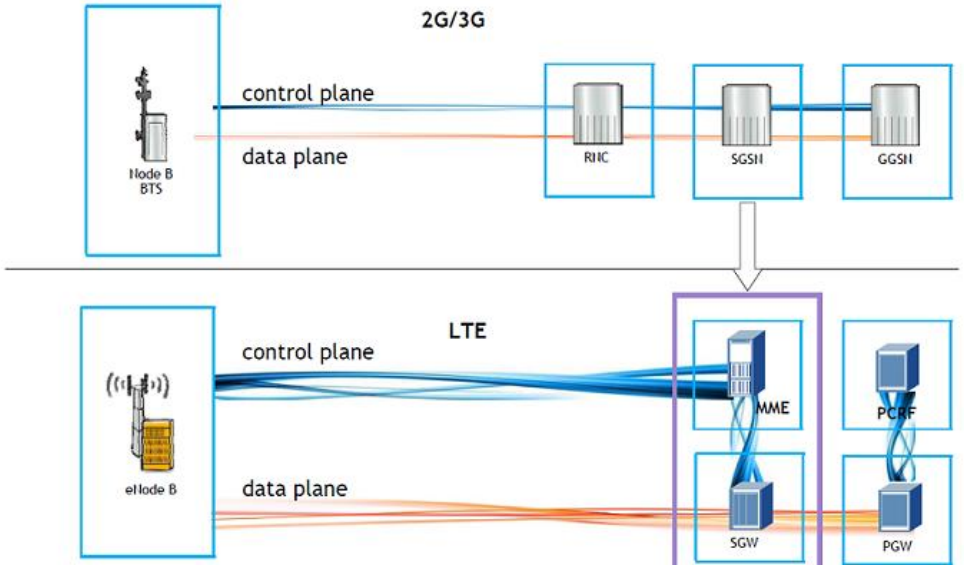
Table No (2) deference between 3G and 4G specification

specification	*3G*	*4G*
Frequency band	1.5-2.8 GHz	2-8 GHz
Band width	5-20MHz	5-20MHz
Date rate	Up to Mbps	20 Mbps or more
Access	Wideband CDMA	Multi-carrier-CDMA or OFDM(TDMA)
FEC	Turbo codes	Concatenated codes
Switching	Circuit / packet	packet
Top speeds	200kmph	200kmph

Table No (3) Applicability and performance of wireless technologies

		2G (GSM/GPRS)	3G (HSPA, HSPA+)	4G LTE
Applicability	Application breadth			
	Degree of mobility			
	Responsiveness			
	Richness / data-intensity			
	Application criticality			
	Device type	Feature phone, smartphone	Tablet, smartphone	PC/laptop, tablet, smartphone
Performance (typical measured)	Download speed (Mbps)	0.01 – 0.13	1 – 5	10 – 40
	Upload speed (Mbps)	0.008 – 0.13	0.2 – 0.5	1 – 15
	Latency (ms)	300– 700 (GPRS)	100 – 200	50 – 150

Fig No (3)2G/3G and LTE Architecture Comparison



In LTE, compared to existing 2G or 3G technologies, there is one network element less for the user plan Between the UE and the external network. When a 2G/3G UE sends a packet in UL, it passes through 4 Network Element before reaching the PDN. In LTE like there is not equivalent to the BSC/RNC, there are only 3 network elements. That means lower latency.

5G: A Technology Vision

5G stands for 5th generation wireless technology it is a name which is used in some of the research paper and going to become a next major phage of mobile telecommunication beyond the current 4G standard. It is a concept which is only theory not real.It changes the way we are using wireless device by providing very high bandwidth. It adds a no of advantages over the present 4g technology.

5G wireless networks will support 1,000-fold gains in capacity connections for at least 100 billion devices, 10 GB/s individual user experience capable of extremely low latency and response times. Deployment of these networks will emerge between 2020 and 2030

5G radio access will be built upon both new radio access technologies (RAT) and evolved existing wireless technologies (LTE, HSPA, GSM and Wi-Fi)

Breakthroughs in wireless network innovation will also drive economic and societal growth in entirely new ways

5G will realize networks capable of providing zero-distance connectivity between people and connected machines.

Fig No (4) mobile service type for each cellular:

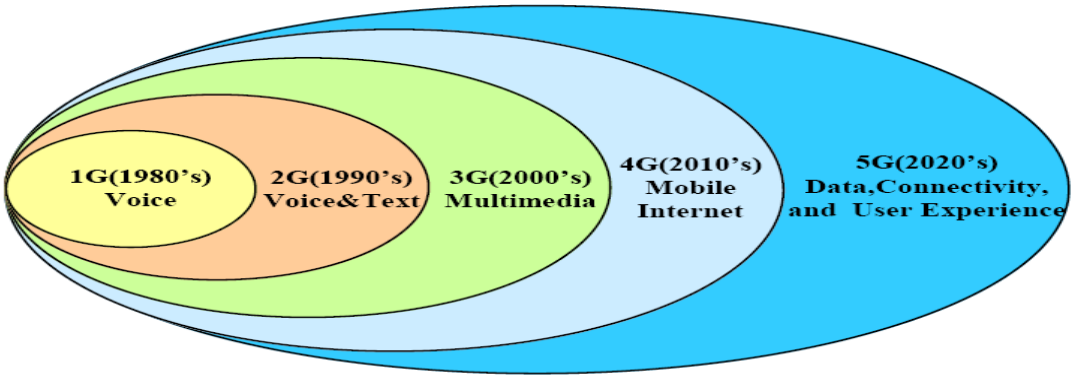


Table No (4) Summarizes the key differences between various mobile technologies and their suitability to meet the needs of each of the use-case characteristics.

Technology	1G	2G	3G	4G	5G
Design Began	1970	1980	1990	2000	
Implementation	1981	1991	2001	2010	2020
Services	Analog voice	Digital voice, short message	Higher capacity, data rates up to 2 Mbps	Higher capacity, completely IP-Oriented, multimedia ,data to hundreds of megabits	Higher capacity, completely IP-Oriented, multimedia,data10 Gb/s
Standards	AMPS, ETACS, NMT etc.	TDMA,CDMA,GSM	WCDMA CDMA-2000	Single standard	
Data Rate	NA	14.4 kbps	2 Mbps	>200 Mbps	10 Gbps
Multiplexing	FDMA	TDMA, CDMA	CDMA	OFDM	
Core Network	PSTN	PSTN	Packet network	Internet	

6. Conclusion

In this study we observed the extent of is a evolution has happened in such a short period of the telecommunications industry has been noticed in the first generation relies on technology analogue and no place to serve the data and in the second generation occurred improve relatively has become digital system plays a role in the technology of communications and in the third generation improvement in the level of voice quality and increased data service clearly For better performance we have to make 3G as IP based which

will allow higher data transmission rate. We have to use only packet switching so that we can achieve higher internet speed avoid circuit switching which makes internet speed slow occurred in the fourth generation a big jump is all IP and the 5G (5th generation mobile networks projects to denote the next major phase of mobile telecommunications standards beyond the current 4

This paper presented a detailed survey of development of mobile technologies and the journey from 1G to 4G. From all above discussion it can be revealed that mobile technologies are developed at very rapid growth. The 1G mobile systems gives a start up to the cellular concept while, 2G systems provides various features to the users. The 3G mobile systems provide various attractive multimedia services. 4G system increases the data rates to a great extent. It also has high spectrum utilization ratio and low transmitting power.

Reference

[1] Alcatel lucent Presentation Title Month 2008
[2] GSM– course The International Engineering Consortium Web ProForum Tutorials http://www.iec.org
[3] The Business Benefits of 4G LTE PCMag.com, LTEworld.org, mobile-phones-uk.org.uk, ISPreview, 3G Americas/RYSAVY Research, Agilent technologies, TeliaSonera, Verizon, AT&T, EE, Arthur D. Little
[4] EXAMS CORNER An Interface for Competitive Exams!! http://tnpsc.wordpress.com/2014/02/09/generations-of-network-0g-1g-2g-3g-4g-and-5g/
[5] 4GWireless– Advances and Challenges Suresh R. Borkar Adjunct Faculty, Dept of ECE, Ill Instt. of Tech. sureshbo@hotmail.com Apr 14, 2006 International Journal of Emerging Technology and Advanced Engineering Website: www.ijetae.com (ISSN 2250-2459, Volume 2, Issue 10, October 2012)