A Survey on Evolution of Wireless Generations 0G to 7G

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Abstract: A long way in a remarkably short time has been achieved in the history of wireless. Evolution of wireless access technologies is about to reach its fifth generation (5G).Over the past decade, wireless technology has undergone enormous growth. Surveys have shown that a new wireless subscriber signs up every 2.5 seconds. However, wireless is not a recent technology. Several wireless technologies are available with their own advantages and disadvantages. In this paper we present the study of several generations which are being used 0G, 1G, 2G, 3G, 4G and 5G and try to find some future generations which are under research like 6G, and 7G. We also throw light on the evolution and development of various generations of mobile wireless technology along with their significance and advantages of one over the other.

Keywords: Wireless Communication generations, 0G,1G, 2G, 3G, 4G,5G,6G,7G,CDMA,TDMA,FDMA,GSM

I. INTRODUCTION

Wireless communication is the transfer of information over a distance without the use of enhanced electrical conductors or "wires". The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications). When the context is clear, the term is often shortened to "wireless". It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, Personal Digital Assistants (PDAs), and wireless networking. In the past few decades, the mobile wireless technologies have experience of various generations of technology revolution & evolution, namely from 0G to 4G. An advance implementation of 5G technology which are being made on the development of World Wide Web (WWW). Each generation have some standards, capacities, techniques and new features which differentiate it from previous generations. Due to these new features, the number of mobile phone subscribers is increasing day by day. Evolution of wireless communication was a result for the development of highly reliable, miniature , solid state RF hardware in 1960-70 in Bell's laboratory which is cellular system. Key benefits for developing cellular system are:

a. Operate in minimal bandwidth and provide high usage and consumer's satisfaction using **spectrum efficiency** property.
b. Relative to 'wired', wireless networks are, in most cases, cheaper to install and maintain for its reducing cost feature.
c. Capacity system for mobile telephone will be high because a large number of subscribers cannot create blocking probability due to large coverage area.
d. Most desirable feature is Duplexing ,allows user to send & receive information simultaneously using a single radio link.
e. After Duplexing, the sharing of spectrum is achieved high capacity by simultaneously allocating tha available bandwidth to multiple user, known as multiple access technique.

II. ZERO GENERATION TECHNOLOGY (0G – 0.5G)

In those pre-cell days, a mobile operator set up the calls and there were only a handful of channels available. Mobile radio telephone systems preceded modern cellular mobile telephony technology. Since they were the predecessors of the first generation of cellular telephones, these systems are sometimes referred to as 0G (zero generation) systems. Technologies used in 0G systems included PTT (Push to Talk), MTS (Mobile Telephone System), IMTS (Improved Mobile Telephone Service), AMTS (Advanced Mobile Telephone System), OLT (Norwegian for Offentlig Landmobil Telefoni, Public Land Mobile Telephony) and MTD (Swedish abbreviation for Mobile telephony system D).

- PTT also known as "Press to transmit", a method of conversing on half duplex communication lines including two way radio without needing an existing connection. PTT can be complemented with fixed PC applications acting as PTT clients connected to mobile operator via secured internet links
- MTS system was operator assisted in both directions that is if one was called from public switch telephone network(PSTN). In the case os outbound call one had to go through the mobile operator who would ask for ones mobile number and the number being called and then place the respective calls.

- 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 operates on 900 MHz band and it overcome all the difficulties occurred from IMTS.
- OLT was first land mobile telephone network in Norwegh. It operate on 160 MHz VHF band using frequency modulation on 160 -162 MHz for the mobile unit and 168-170MHz for base stations.
- MTD featured fixed wireless service with high speed internet connection without need of telephone line. It offers "always on" internet access.

0.5G is a group of technologies with improved feature than the basic 0G technologies.

III. 1ST GENERATION TECHNOLOGY OR 1G

1G (or 1-G) is the first-generation wireless telephone technology, cellphones. These are the analog cellphone standards that were 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 (Nordisk Mobile Telephony), AMPS(Advance Mobile Phone Service) and CDPD(Cellular Digital Packet Data).

- **NMT** is the first full automatic cellular phone system. It came in service in 1981 as a response to the increasing congestion and heavy requirements of the manual mobile phone network. The two variants of NMT exists-NMT-450 and NMT-900.The numbers indicates the frequency band use respectively.NMT-900 had more channels than NMT-450.The cell size ranges from 2-30 KM. NMT phones used full duplex transmission allowing for simultaneous receiving and transmission of voice. IT had automatic switching and hand over of the call built from the beginning. The main problem here is that the voice was not fully encrypted.
- **AMPS** was an analog mobile phone system standard develops by Bell Labs, introduced in the America in 1983.It was a first generation cellular technology that uses separate channels for each conversation. It was different from older systems by "back-end" call setup functionality which allowed a larger numbers of phones to be supported over a geographical area. In 1983, a total of 40MHz of spectrum in the 800 MHz band was allocated by FCC for AMPS. In 1989, extra 10 MHz has been allocated to AMPS due to increase of cellular system capacity. For AMPS, an uplink frequency is 824-849MHz and downlink frequency is 869-894MHz.Each AMPS frequency is 30 KHz wide.
- **CDPD** is the specification for supporting wireless access to the internet and other public packet switched network. The raw signaling rate is 19.2 kbps, and with Reed-Solomon coding the effective data arte is 14.4 kbps full duplex before control overhead. It employs a technique called RF sniffing to detect an AMPS call is trying to access a frequency channel. CDPD supports connectionless 3 protocols in that sense acts simply as a wireless extension to the internet. CDPD operates with A-interface, E-interface and I-interface service. Hand-off in CDPD occurs when an M-ES moves from one cell to another. CDPD authentication is performed by the mobile network registration protocol management entity(MME).

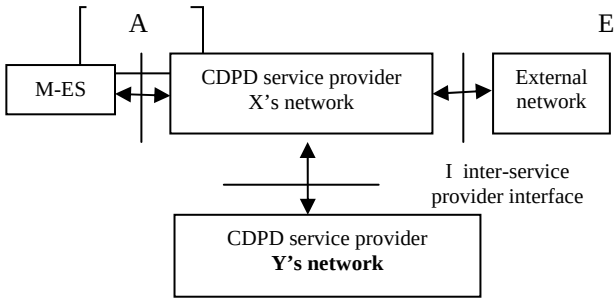

Figure.1 . Reference architecture for CDPD

The unique feature of 1G is the use of cellular technology that is building of hexagonal cells. But 1G has some downfalls regarding overall connection quality. 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. Different 1G standards were used in various countries. 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 reliant on location and proximity.

FEATURES OF 1ST GENERATION

Generations	**1G**
Starts from	1970-84
Frequency	800-900 MHZ
Data capacity	2KBPS
Technology	Analog wireless

Standard	AMPS
Multiplexing	FDMA
switching	Circuit
Service	Voice only
Main network	PSTN
Hand off	Horizontal

IV. 2ND GENERATION TECHNOLOGY OR 2G

Second-generation (2G) mobile systems were first introduced in the end of 1980s. This system was commercially launched in Finland in 1991. This system is still mostly used in different parts of the world. This generation is for data and voice services. Low bit rate data services were supported as well as the traditional speech service. Compared to first-generation systems, second-generation (2G) systems use completely digital multiple access technology, TDMA (time division multiple access) and CDMA (code division multiple access).
The use of digital signals between the handsets and the tower increase the system capacity in two ways:

a. Digital voice data can be compressed and multiplexed very effectively thus allowing more calls to be packed into the same amount of radio bandwidth.
b. 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.

The 2G technology based on two standard – CDMA and TDMA on the basis of multiplexing. In practice, 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 code. 2G cellular telecom networks were commercially launched on the GSM or in other words global system for mobile communication standard in Finland in 1991. The purpose of GSM was twofold: to upgrade transmission technology and to provide a single, unified standard in Europe. 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. SMS is a cheap and easy way to send a message to anyone, other than the voice call. Another use of this technology is the availability of international emergency numbers, which can be used by international users anytime without having to know the local emergency numbers. PDC or personal digital cellular technology was developed in Japan, and is exclusively used in JAPAN as well. PDC uses 25 KHz frequency. Docomo launched its first digital service of PDC in 1993.integrated digital enhanced network (iDEN) was developed by MOTOROLA, as a major mobile technology. It enabled the mobile users to make use of complex trunked radio and mobile phones. iDEN has a frequency of about 25Khz.iDEN allows three or six user per mobile channel.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. If there is no network coverage in any specific area, digital signals would be weak. 2.5G is a group of bridging technologies between 2G and 3G wireless communication. It is a digital communication allowing e-mail and simple Web browsing, in addition to voice. During development over more than 20 years, GSM technology has been continuously improved to offer better services in the market. New technologies have been developed based on the original GSM system, leading to some more advanced systems known as 2.5 Generation (2.5G) systems.

2.5G – GPRS (General Packet Radio Service)- 2.5G, which stands for "second and a half generation," 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. Packet switching is a technique whereby the information (voice or data) to be sent is broken up into packets, of at most a few Kbytes each, which are then routed by the network between different destinations based on addressing data within each packet. GPRS supports flexible data transmission rates as well as continuous connection to the network. GPRS is the most significant 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. 2.5G networks may support services such as WAP, MMS, SMS mobile games, and search an directory.

2.75 – EDGE (Enhanced Data rates for GSM Evolution or Enhanced GPRS): It is a digital mobile phone technology which acts as a bolt-on enhancement to 2G and 2.5G General Packet Radio Service (GPRS) networks. EDGE technology was invented and introduced by Cingular, which is now known as AT& T. EDGE is radio technology and is a part of third generation technologies. EDGE technology is an extended version of GSM. It allows the clear and fast transmission of data and information. It is also termed as IMT-SC or single carrier. EDGE technology is preferred over GSM 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 biggest advantage of using EDGE technology is one does not need to install any additional hardware and software in order to make use of EDGE Technology. There are no additional charges for exploiting this technology.

FEATURES OF 2G, 2.5G AND 2.75G

Generations	**2G**	**2.5**	**2.75**
Starts from	1990	2000	2003
Frequency	850-1900 MHz(GSM) 825-849MHz(CDMA)	850-1900 MHz	850-1900 MHz
Data capacity	10KBPS	200 KBPS	473 KBPS
Technology	Digital wireless	GPRS	EDGE
Standard	CDMA TDMA GSM	Supported TDMA/ GSM	GSM CDMA
Multiplexing	TDMA CDMA	TDMA CDMA	TDMA CDMA
switching	Circuit Packet	Packet	Packet
Service	Voice data	MMS internet	
Main network	PSTN	GSM TDMA	WCDMA
Hand off	Horizontal		

V. THIRD GENERATION TECHNOLOGY (3G – 3.75G)

3G is the third generation of mobile phone standards and technology, superseding 2G, and preceding 4G.It is a CDMA based generation. It is based on the International Telecommunication Union (ITU) family of standards under the International Mobile Telecommunications program, IMT-2000. The 3G activities were initiated 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 IMT0-2000and 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. The basic feature of 3G Technology is fast data transfer rates. 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 is able to 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:

i) General Packet Radio Service (GPRS) offered speeds up to 114 Kbps.
ii) Enhanced Data Rates for Global Evolution (EDGE) reached up to 384 Kbps.
iii) UMTS Wideband CDMA (WCDMA) offered downlink speeds up to 1.92 Mbps.
iv) High Speed Downlink Packet Access (HSDPA) boosted the downlink to 14Mbps.
v) LTE Evolved UMTS Terrestrial Radio Access (E-UTRA) is aiming for 100 Mbps.
For augmented bandwidth, multiple mobile applications and clarity of digital signals, **3G** (**Third Generation Technology**) is the gateway. **GSM technology** was able to transfer circuit switched data over the network. The use of **3G technology** is also able to transmit packet switch data efficiently at better and increased bandwidth. 3G mobile technologies proffers 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**.

3.5G – HSDPA (High-Speed Downlink Packet Access): High-Speed Downlink Packet Access(HSDPA) is a packet-based 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.

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.

FEATURES OF 3G. 3.5G AND 3.75G

Generations	**3G**	**3.5**	**3.75**
Starts from	2001	2003	2003
Frequency	1.6-2.5GHz	1.6-2.5GHz	1.6-2.5GHz
Data capacity	384Kbps	2Mbps	30Mbps
Technology	Broad band /IP technology FDD TDD	GSM/ 3GPP	

Standard	CDMA/WCDMA/ UMTS/CDMA2000	HSDPA/HSUPA	1xEVDO
Multiplexing	CDMA	CDMA	CDMA
switching	Circuit ,packet	packet	packet
Service	High speed voice/data/video	High speed voice/data/video	High speed internet/multimedia
Main network	Packet network	GSM TDMA	
Hand off	Horizontal	Horizontal	Horizontal

VI. FOURTH GENERATION TECHNOLOGY (4G)

It is a successor to 3G and 2G families of standards. The Wireless World Research Forum(WWRF) defines 4G as a network that operates on internet technology combines it with other application such as Wi-Fi and WiMax. I n contrast to 3G, the new 4G framework to accomplish new levels of user experienced and multi service capacity by also integrating all the mobile technologies that exist(e.g. GSM, GPRS,IMT-2000, Wi-Fi, Bluetooth).the fundamental reason for the transition to the ALL-IP is to have a common platform for all the technologies that have been developed so far, and to harmonize with user expectations of the many services to be provided.4G will make sure –" the user has freedom and flexibility to select any desired service with reasonable QoS and affordable price, anytime, anywhere". 4G services started in 2012 but will become mass market in about 2014-2015. The word "MAGIC" also refers to 4G wireless technology which stands for **M**obile multimedia, **A**ny-where, **Gl**obal mobility solutions over, **I**ntegrated wireless and **C**ustomized services.

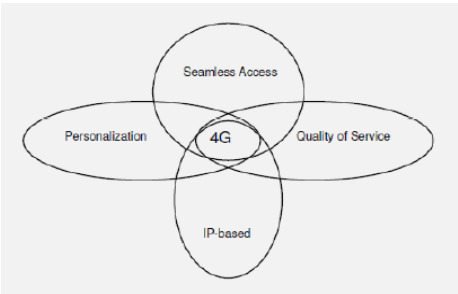

Fig.5.Features of 4G (next generation mobile communication)

The few objectives defined for 4G wireless communication standard are:

a. Spectral efficient system & high network capacity
b. Nominal data rate of 100 Mbps at high speeds.
c. Smooth handoff across heterogeneous network.
d. Seamless connectivity & global roaming across multiple networks.
e. 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.
f. UMB- It stands for Ultra Mobile Band. It is intended to be called as 4G technology because of its various features as:

   i) It employs OFDMA technology along with advanced antenna techniques to provide peak rates of up to 280Mbps.
   ii) Goals for UMB include significantly improving system capacity, greatly increasing user data rate throughout the cell, lowering costs, enhancing existing services etc.

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

   i) 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.
   ii) 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.

FEATURES OF 4G

Generations	4G
Starts from	2010
Frequency	2-8GHz
Data capacity	200Mbps-to- 1Gbps
Technology	LTE, Wi MAX
Standard	IP-broadband LAN/WAN/PAN
Multiplexing	MC-CDMA, OFAM
switching	Packet
Main network	Internet
Hand off	Horizontal &Vertical

VII. FIFTH GENERATION TECHNOLOGY (5G)

The major difference, between current generations & expected 5G techniques must be something else than increased maximum throughput; other requirements include:

a. Lower battery consumption.
b. Better Coverage & high data rates available at cell edge.
c. Around ! Gbps data rate in mobility.
d. More Secure; better cognitive radio security.
e. Cheaper traffic fees due to low 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.

FEATURES OF 5G

Generations	5G
Starts from	2015
Data capacity	Higher then 1Gbps
Technology	IP v6
Standard	IP-broadband LAN/WAN/PAN&WWW
Multiplexing	CDMA
switching	All packet
Service	Dynamic Information access, wearable devices with AI capabilities
Main network	Internet
Hand off	Horizontal & Vertical

VIII. SIXTH GENERATION TECHNOLOGY (6G)

The 6G mobile system for the global coverage will integrate 5G wireless mobile system and satellite network. The telecommunication satellite is used for voice, data, internet, and video broadcasting; the earth imaging satellite networks is 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.

IX. SEVENTH GENERATION TECHNOLOGY (7G)

The 7G will be the most advance generation in mobile communication network. It is like the 6G for global coverage but it will also define the satellite functions for mobile communication. But in 7G, there will be some research 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 dream of 7G can only be true when all standards and protocols are defined. May be this is possible in next generation after 7G and can be named as 7.5G.There is another way,is direct HD video broadcasting for news gathering purpose likewise. This can be the best solution of cost on lower level user.

X. CONCLUSION

The world of wireless telecommunications is rapidly evolving. The last few years have witnessed a phenomenal growth in the wireless industry. Their current development is the outcome of various generations. In this paper we review the various generations of mobile wireless technology, their portals, performance, advantages and disadvantages of one generation over other. The first generation (1G) has fulfilled the basic mobile voice, while the second generation (2G) has introduced capacity and coverage. This is followed by the third generation (3G), which has quest for data at higher speeds to open the gates for truly “mobile broadband” experience, which will be further realized by the fourth generation (4G). 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 .Satellite network will be used from 6G mobile communication systems and onwards. In 6G the cost of mobile call will be relatively high but in 7G this problem will be improved and the cost of call will be reduced and lower level user will benefit from it.

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