

An Overview on Evolution of Mobile Wireless Communication Networks: 1G-6G

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Abstract- There has been a huge advancement in mobile wireless communication since the last few decades. This advancement consist of several generations and is still going on. The journey of mobile wireless communication began with 1G followed by 2G,3G,4G,and under research future generations 5G,6G,7G. In this paper an attempt has been made to provide an overview of evolution of mobile generations by comparing the challenges and features that have evolved from each generation and explaining how improvements have been made from earlier generation to the next one.

Keywords-1G, 2G, 3G, 4G, 5G, 6G, CDMA, GSM, UMTS.

I. INTRODUCTION

In the last few decades, Mobile Wireless Communication networks have experienced a tremendous change. The cellular wireless Generation(G) generally refers to a change in the nature of the system, speed, technology and frequency. Each generation have some standards, capacities, techniques and new features which differentiate it from the previous one. The first handheld mobile cell phone was demonstrated by Motorola in1973.The 1st commercial automated cellular network was launched by NTT in Japan in 1979, followed by the launch of Nordic Mobile Telephone(NMT) system in Denmark, Finland, Norway and Sweden, in 1981.After this begins the development in generations for mobile wireless communication. The first generation(1G) mobile wireless communication network was analog used for voice calls only. The second generation(2G) is a digital technology and supports text messaging. After this was 3G which provided multimedia support along with higher data transmission rates and increased capacity. The fourth generation(4G) integrates 3G with fixed internet to support wireless mobile internet, which is an evolution to overcome the limitations of 3G and also raises the QoS, increases the bandwidth and reduces the cost of resources. The 5G brings forward a real wireless world-Wireless World Wide Web(WWWW) while 6G is proposed to integrate 5G with satellite networks for global coverage. 7G deals with space roaming.

II. 1G OR FIRST GENERATION TECHNOLOGY (ANALOG)

The first generation wireless mobile communication system is an analog technology developed in 1980s.It was used for voice services and was based on technology called as Advanced Mobile Phone System(AMPS).The AMPS system was frequency modulated and used frequency division multiple access(FDMA) with a channel capacity of 30KHz and frequency band of 824-894MHz.It supports a speed up to 2.4kbps.In 1988,AMPS was allocated with additional 10MHz bandwidth called as Expanded Spectrum, which was first deployed in Chicago, with a service area of 2100 square miles. AMPS was first launched by US in 1982.

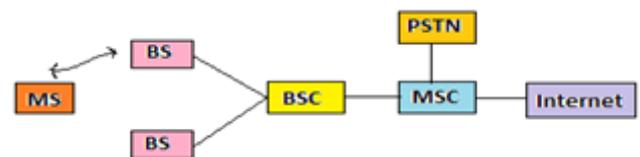


Figure 1. Architecture of AMPS

III. 2G OR SECOND GENERATION TECHNOLOGY (DIGITAL)

The second generation wireless mobile communication system is a digital technology introduced in late 1980s.It uses digital signals for voice transmission and has a speed of 64kbps.The bandwidth of 2G is 30-200KHz.2G provides services such as short message services(SMS),picture messages and multimedia message services(MMS).It uses digital modulation schemes such as Time Division Multiple Access(TDMA) and Code Division Multiple Access(CDMA).TDMA allows division of signals into time slots. CDMA provides each user with a special code to communicate over a multiplex physical channel.TDMA technologies like GSM, PDC, iDEN, IS-136 and CDMA technology like IS-95 are used.

GSM(Global System for Mobile Communication) is the most widely used 2G mobile standard.2G was commercially launched on GSM standard in Finland, in 1991.GSM technology was the first one to support international roaming. This enabled the mobile subscribers to use their mobile phone connections in different countries of the world with better quality and capacity.

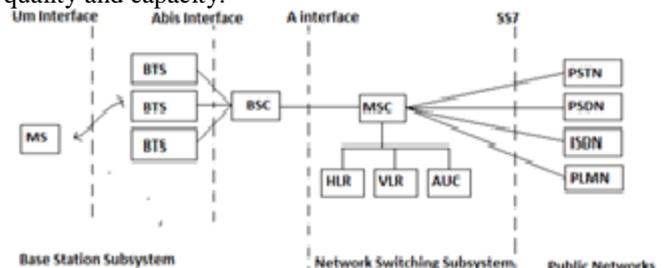


Figure 2. GSM System Architecture

IV. 2.5G TECHNOLOGY

The GSM technology was continuously improved to provide better services which led to development of advanced

systems called as 2.5 Generation(2.5G) systems.2.5G lies between 2G and 3G technologies. In addition with circuit switched domain of 2G system, 2.5G implements a packet switched domain, and provides a data rate of 144kbps.2G used technologies such as General Packet Radio Service(GPRS) and EDGE(Enhanced Data rates in GSM Environment).GPRS provides packet switching protocols, short setup time for ISP connections and the possibility to charge the subscriber according to the amount of data sent rather than connection time. GPRS supports flexible data transmission rates and provides continuous connection with the network. GPRS is the significant step towards 3G.

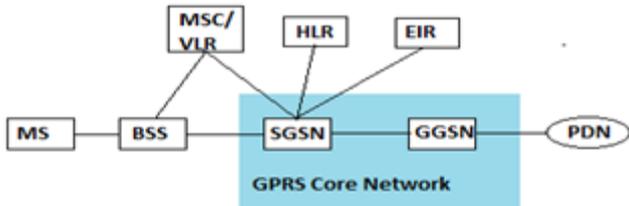


Figure 3. Architecture of GPRS

V. 3G OR THIRD GENERATION TECHNOLOGY

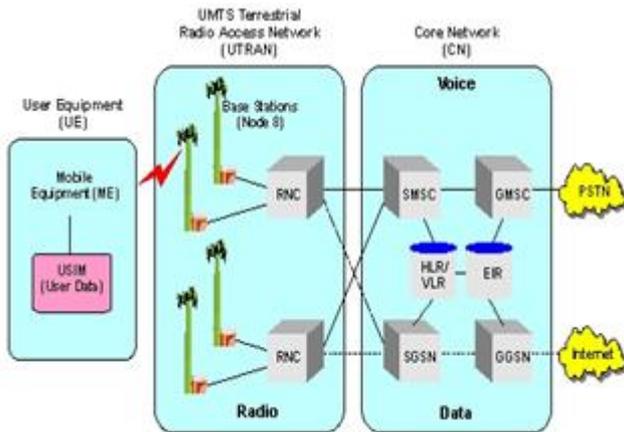


Figure 4. WCDMA Network Diagram

The third generation wireless mobile communication system was introduced in 2000. The goal of 3G systems was to offer increased data rates from 144kbps to 384kbps in wide coverage areas and 2Mbps in local coverage areas. 3G offers advanced services to the users as compared to 1G and 2G. Along with voice communication it includes data services, access to TV/videos, Web browsing, e-mail, video conferencing, paging, fax and navigational maps. It has a bandwidth of 15-20MHz used for high speed internet, video chatting, etc. A 3G mobile system was defined by an organization called 3rd Generation Partnership Project(3GPP) which fulfils the IMT-2000 standards. It was called as UMTS(Universal Mobile Telecommunication System) in Europe, which is TSI driven. IMT2000 is the ITU-T name for the third generation system, while CDMA2000 is the name of American 3G variant. Also the IMT2000 has accepted a new 3G standard from China, i.e TD-SCDMA. WCDMA is the air-interface technology for UMTS. The first commercial 3G network was launched by NTT Do co mo in Japan, in 2001.

VI. 4G OR FOURTH GENERATION TECHNOLOGY

The fourth Generation mobile system was introduced in the late 2000s and was all IP based network system. The main goal of 4G technology is to provide high speed, high quality, high capacity, security and low cost services for voice and data services, multimedia and internet over IP. The reason for the transition to all IP is to have a common platform to all the technologies developed so far. It has the capability 100Mbps and 1Gbps of .To use 4G mobile network, multimode user terminals should be able to select the target wireless system. To provide wireless services anytime and anywhere, terminal mobility is a key factor in 4G. Terminal mobility implies automatic roaming between different wireless networks. The 4G technology integrate different existing and future wireless technologies(e.g. OFDM, MC-CDMA, LAS-CDMA and Network-LMDS) to provide freedom of movement and uninterrupted roaming from one technology to another. LTE(Long Term Evolution) and WiMAX(Wireless Interoperability for Microwave Access) are considered as 4G technologies. The first successful field trial for 4G was conducted in Japan, in 2005.

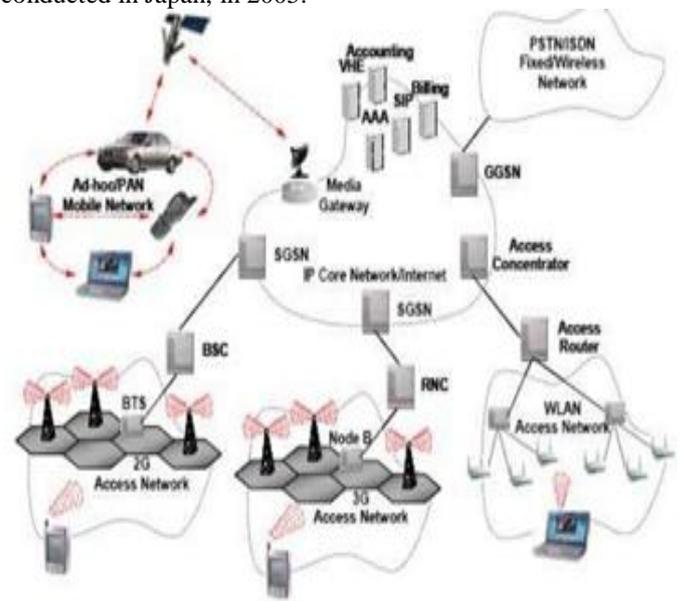


Figure 5. 4G Network Architecture

VII. 5G OR FIFTH GENERATION TECHNOLOGY

The fifth generation mobile and wireless communication network is the real wireless world which would be supported by LAS-CDMA, OFDM, MC-CDMA, UWB, Network-LMDS, IPv6.5G can be called as the perfect real wireless world or World Wide Wireless Web(WWWW) as it has no limitations. The basic protocol for running on both 4G and 5G is IPv6.5G aims to provide unlimited access to information and the ability to share data anywhere, anytime by anyone for the benefit of the world.5G technologies covers all the advanced features which makes 5G mobile technology most powerful and will be in huge demand in future. The 5G mobile is all-IP based for mobile and wireless network interoperability. The standardization activities for 5G have already started this year which may lead to commercial availability around 2020.

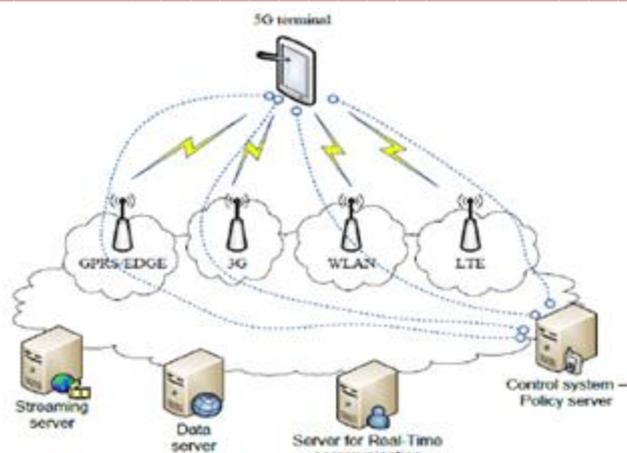


Figure 6. 5G Mobile Network Architecture

TABLE I. OSI layers in the 5G Mobile Terminal Design

Application Layer	Application(Service)
Presentation Layer	
Session Layer	Open Transport Protocol(OTP)
Transport Layer	
Network Layer	Upper Network Layer
	Lower Network Layer
Data Link Layer	Open Wireless Architecture (OWA)
Physical Layer	

In 5G network, the Physical and Data Link layer defines the 5G wireless technology indicating it as an Open Wireless Architecture(OWA).The 5G technology also maintain virtual multi-wireless network. To perform this the Network layer is sub-divided into two layers; upper network layer for mobile terminal and lower network layer for interface. Here all the routing will be based on IP addresses which would be different in each IP network worldwide. In 5G technology the higher bit rate loss is overcome by using Open Transport Protocol(OTP).The OTP is supported by Transport and Session layer. The application layer is for quality of service management over various types of networks.

Features

- 5G provides large broadcasting of data in Gigabit.
- 5G terminals have software-defined radios.
- 5G uses different modulation techniques and error-control techniques.
- 5G provides hundreds of channels without streaming.
- 5G technology offer transporter class gateway with unparalleled consistency.
- 5G technology supports virtual private network.
- 5G offers bidirectional bandwidth and less traffic
- 5G provides 25Mbps connectivity speed with data bandwidth higher than 1Gb.
- Remote diagnostics is a great feature of 5G.
- The uploading and downloading speed of 5G is very high.

VIII. 6G OR SIXTH GENERATION TECHNOLOGY

The sixth generation mobile and wireless communication network can integrate the satellite communication networks and 5G to provide global coverage. The satellite communication network may consist of telecommunication satellite networks, earth imaging satellite networks and navigation satellite networks. The goal of 6G is to integrate these kinds of satellite networks to provide network position identifier, multimedia and internet connectivity, and weather information services to the mobile users. The four countries which have these satellite systems are: The Global Position System(GPS) by USA, the Galileo by Europe, the COMPASS by China and the GLONASS by Russia. If 6G integrates with 5G with these satellite networks, it would have four different standards. So handoff and roaming will be a big issue in 6G.The radio over fiber system is already in existence, but with the advent of 6G technology, mankind will be more close to any extraterrestrial civilization in the universe.

Features

- Ultra fast Internet access.
- Data rates will be up to 10-11 Gbps.
- Smart Homes, Cities and Villages.
- May be used in the production of Energy from galactic world.
- Home automation, Space technology, Defence applications will be modified with 6G networks.
- Satellite to Satellite Communication
- Natural Calamities will be controlled with 6G networks.
- Sea to Space Communication.
- Mind to Mind Communication may be possible.

IX. CONCLUSION

The world of mobile wireless communication is rapidly developing. The last few years have experienced a remarkable growth in wireless industry. Attempts are being made to reduce the number of technologies to a single global standard resulting in 5G,6G and 7G. 5G aims a real wireless world with no limitations while 6G integrates 5G with satellite networks. Due to variable technologies and standards, with 6G handoff/roaming will be an issue. This drives the 7G of mobile wireless networks which aims to acquire space roaming. Trials have already started on 5G which may lead to its commercial availability around 2020. The world is trying to become completely wireless, demanding uninterrupted access to information anytime and anywhere with better quality, high speed, increased bandwidth and reduction in cost.

TABLE II: Comparison of all Generations

Generation→/Features↓	1G	2G	3G	4G	5G	6G
Year	1970-1980	1980-1990	1990-2000	2000-2010s	2015 onwards	After 5G
Speed	2.4Kbps	64Kbps	2Mbps	200Mbps to 1Gbps	1Gbps and Higher	10 to 11Gbps
Technology	Analog Cellular	Digital Cellular	Broadband CDMA, IP	Unified IP & seamless combination of broadband LAN, WAN, WLAN, PAN	4G+WWWW	5G+satellite
Standard	AMPS	GSM,PDC,IS-95,IS-136,EDGE,GPRS	CDMA 2000, UMTS,TD-SCDMA,WCDMA	LTE, WiMAX	LAS-CDMA, OFDM, MC-CDMA, UWB, Network-LMDS, IPv6	GPS,COMPASS, GLONASS, Galileo systems
Multiplexing	FDMA	TDMA,CDMA	CDMA	CDMA	CDMA	CDMA
Switching	Circuit	Circuit & Packet	Packet except circuit for air interface	Packet	Packet	Packet
Core Network	PSTN	PSTN and Packet network	Packet Network	Internet	Internet	Internet
Handoff	Horizontal	Horizontal	Horizontal & Vertical	Horizontal & Vertical	Horizontal & Vertical	Horizontal & Vertical
Services	Voice only	Digital voice and short messaging, packetized data	Integrated high quality audio, video and data	Dynamic information access, wearable devices	Dynamic information access, wearable devices with AI capabilities	Ultra fast Internet access

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