Next Generations of Mobile Networks

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ABSTRACT
Mobile based technologies are most widely used products and shown a huge growth in terms of user base. Every individual around the every corner of the world rely on mobile technology. The thing which makes it more powerful is cellular communication. Cellular communications are not only restricted to voice calls but it has gone way beyond our imagination from generation to generation. There has been seen a number of improvements along with performance. It has a great impact on our daily lifestyle i.e. the way we work, interact, learn, explore etc.

This paper provides an insight about generations of network from 0G to 4G. Also it will throw light on next possible generations - 5G, 6G and 7G. Although 5G is under development and it will be deployed by 2020, there are no such standards has been finalized for it. This paper will also focus on 5G architecture and standards along with the technology that will be used for the development. The next evolutions 6G and 7G are just concepts for now and research works are being carried out, but they are the future of mobile communication networks.

Keywords
0G, 1G, 2G, 3G, 4G, 5G, Architecture, Standards, Technology, Generations of Networks, Comparative Study of Generations, 6G, 7G, Future of Networks.

1. INTRODUCTION
Telecommunication industry showed a potential growth from the last few decades. This had been achieved due to the greater demand for wireless mobile communication technology. Now-a-days mobile phones got much smarter due its capability to record, play, stream, upload, download – audio and video, capture images, share data via Bluetooth and Wi-Fi, browsing internet, voice and video calling, etc. The development of wireless technologies has greatly improved people's ability to communicate and live in both business operations and social functions [1].These developments have evolved from various generations (1G – 5G). Each generation has different and improved standards, capacities, techniques and features as compared to their previous generations. This in turn gave rise to increased number of subscribers.

Wireless communication started in early 1970's and development leads to evolution of different generations in next four decades. Now-a-days different wireless and mobile technologies are present such as third generation mobile networks (UMTS - Universal Mobile Telecommunication System, CDMA2000), LTE (Long Term Evolution), Wi-Fi (IEEE 802.11 wireless networks), WiMAX (IEEE 802.16 wireless and mobile networks), as well as sensor networks, or personal area networks (e.g. Bluetooth, ZigBee) [2]. All-IP based principles are implemented by all wireless and mobile networks i.e. all the data and the signals will be transferred via IP (Internet Protocol) present on network layer.

The huge success of wireless mobile communication is able to be achieved because of rapid technology innovations. From the second generation(2G) mobile communication system to the 3G system, the wireless mobile network has been transformed from a pure telephone based system to a wireless network that is capable to transfer rich multimedia contents. The 4G wireless systems were designed to fulfill the requirements of International Mobile Telecommunications-Advanced (IMT-A) using IP for all services [3]. GSMA Intelligence's definition of 4G includes the following network technologies: LTE, TD-LTE, AXGP, WiMAX, LTE-A, TD-LTE-A, LTE with VoLTE and WiMAX2.5G (5th generation mobile networks or 5th generation wireless systems) is the next major updateto mobile telecommunications standards as compared to the current 4G/IMT-Advanced standards. 5G has speeds which is way better than what 4G offers. The fifth generation (5G) wireless mobile multimedia internet networks can be completely wireless communication without limitation, which makes perfect wireless real world – World Wide Wireless Web (WWWW) [2]. The sixth generation (6G) of wireless mobile communication network must integrate satellites so that it can go fully global and cover more areas. The global coverage systems have been developed by four courtiers. The global position system (GPS) is developed by USA. The COMPASS system is developed by China. The Galileo system is developed by EU, and the GLONASS system is developed by Russia [4].The next generation could be 7G which is the most advance and may unite other generations. It will also set core standards for 6G development that will make use of satellites.

2. EVOLUTION OF GENERATIONS
Mobile communications are widely preferred and become popular due to rapid revolution in mobile technology. The numbers of users are also increased over few decades. However, this is achieved from generations to generations. The revolution begins with Zero Generation (0G) followed by 1G, 2G, 3G, 4G , 5G .

2.1 Zero Generation (0G)
Mobile Radio Telephones are predecessors of modern cellular mobile telephony technology of first generation. Such systems are referred as pre-cellular systems or Zero generation (0G). It is backed up with technologies like Push to Talk (PTT), Mobile Telephone System (MTS), Improved Mobile Telephone Service (IMTS), and Advanced Mobile Telephone System (AMTS).

2.2 First Generation (1G)
First generation of wireless mobile communication systems were implemented in the 1980's. They were analogue system, based on technology called Advance Mobile Phone Service (AMPS) developed by AT&T in North America. The AMPS system was based on frequency modulation radio system which uses Frequency Division Multiple Access (FDMA)

with channel capacity of around 30 KHz and frequency band was 824-894 MHz [5].In 1988, 10MHz additional bandwidth was allocated to AMPS which was developed in Chicago, which had the coverage area of 2100 square miles [6]. Other technologies were Nordic Mobile Telephone (NMT), Total Access Communication System (TACS), C-nets etc.1G was developed to provide only voice communication facility. Paging networks were also considered as 1G technology that provide only messaging facility. 1G had a poor voice quality and no security.

Table 1. First Generation Features

Generation	1G (1970 - 1984)
Technology	Analogue Cellular Technology
Standard	AMPS
Switching	Circuit - switched
Frequency	824-894 MHz
Data Speed	2.4 Kbps
Multiplexing	FDMA
Core Network	PSTN
Service	Only voice or Only message
Hand-off	Horizontal

2.3 Second Generation (2G)

1G had a lot of limitations and issues and to overcome some of these problems 2G has been developed. However, 2G networks where began to emerge around 1980's, but the actual implementations started by early 1990's.Second generation (2G) of wireless mobile communication systems are digital systems. It has seen three types of development, IS-54 (TDMA) in 1991, IS-95 (CDMA) in 1993, and IS-136 in 1996 [6]. It also include Global System for Mobile Communications (GSM) technology which is most consistent 2G standard. 2.5G and 2.75G are the upgrade versions of 2G. They are also referred as GPRS and EDGE respectively. 2G family provides services as voice transmission, web, e-mail, browsing, etc.Although 2G was huge improvement and increased the number of subscribers, the standards were poor. It also unable to handle complex data and inefficiently uses bandwidth. Specifications of 2G family are shown below

Table 2. Second Generation Features

Generation	2G (1990)	2.5G (2000)	2.75G(2003)
Technology	Digital Cellular Technology	GPRS	EDGE
Standard	CDMA, TDMA, & GSM	TDMA / GSM	GSM/CDMA
Switching	Circuit/Packet - switched	Packet-switched	Packet-switched
Frequency	850-1900 MHz (GSM) 825-849 MHz (CDMA)	850-1900 MHz	850-1900 MHz
Data Speed	9.6 kbps	100 kbps	300 kbps
Multiplexing	CDMA, TDMA	CDMA, TDMA	CDMA, TDMA
Core Network	PSTN	GSM, TDMA	WCDMA
Service	Voice data & SMS facility	MMS, Internet, etc.	Higher capacity packetized data
Hand-off	Horizontal	Horizontal	Horizontal

2.4 Third Generation (3G)

Third generation of wireless mobile communication systems had been developed to meet International Mobile Telecommunication – 2000 (IMT-2000), specifications defined by International Telecommunication Union (ITU). Need for High speed, fast data transmit, and Quality of Service (QOS), lead to the evolution of 3G.It was launched in 2001 and provided a network that is capable of transporting rich multimedia contents. For voice calls / SMS facility -- circuit switching are used whereas for data services -- packet switching are used. The technologies include W-CDMA, CDMA-2000 and TD-SCDMA. It is also compatible with other cellular standards like CDMA, GSM, and TDMA. It operates at a range of 2100MHz and has a bandwidth of 15-20MHz used for High-speed internet service, video chatting [2].3G also turned global roaming for subscribers into reality. Universal Mobile Telecommunications System (UMTS) was adopted by Europe which chose W-CDMA as the standard 3G technology. UMTS is based on GSM infrastructure therefore made it easier for GSM operators to upgrade to it. It became the most popular 3G technology. UMTS added High Speed Packet Access (HSPA) and Evolved High Speed Packet Access (HSPA+) which are also referred as 3.5G and 3.75G. 3G also has some limitations such costly, patchy coverage, etc.

Table 3. Third Generation Features

Generation	3G (2001)	3.5G(2003)	3.75G(203)
Technology	Broadband/IP technology, FDD,TDD	GSM/3GPP	GSM/3GPP
Standard	CDMA, WCDMA, UMTS, CDMA 2000	HSPA	HSPA+
Switching	Circuit/Packet - switched	Packet-switched	Packet-switched
Frequency	1.6 GHz – 2.5 GHz	1.6 GHz – 2.5 GHz	1.6 GHz – 2.5 GHz
Data Speed	2 mbps	14 mbps	21 mbps
Multiplexing	CDMA	CDMA	CDMA
Core Network	Packet network	GSM TDMA	GSM TDMA
Service	High speed data, voice, video	High speed broadband data, voice, video	High speed internet, multimedia
Hand-off	Horizontal	Horizontal	Horizontal

2.5 Fourth Generation (4G)

The 4G wireless systems were designed to fulfil the requirements of International Mobile Telecommunications-Advanced (IMT-A) using IP for all services [3]. 4G is being developed to accommodate the QOS and rate requirements set by forthcoming applications like wireless broadband access, Multimedia Messaging Service (MMS), video chat, mobile TV, HDTV content, Digital Video Broadcasting (DVB), minimal services like voice and data, and other services that utilize bandwidth [7].In 4G systems, an advanced radio interface is used with orthogonal frequency-division multiplexing (OFDM), multiple-input multiple-output (MIMO), and link adaptation technologies [1]. 4G standards

include Long Term Evolution (LTE) and IEEE 802.16 (WiMax). It provides increased data rates as compared to 3G. The major issue with 4G is security because of its IP-Address system.

Table 4. Fourth Generation Features

Generation	4G (2010)
Technology	IP-broadband,Wi-Fi, MIMO
Standard	WiMAX and LTE
Switching	Packet - switched
Frequency	2 GHz - 8 GHz
Data Speed	50mbps
Multiplexing	MC-CDMA and OFDM
Core Network	Internet
Service	Dynamic Information access
Hand-off	Vertical

3. NEXT POSSIBLE GENERATIONS

3.1 Fifth Generation (5G)

4G technology has been started to deploy, on the other side, the research for next generation named as 5G also started. It is considered to be next major phase of mobile telecommunication standard after 4G. Research and development work for 5G will continue to meet the commercial goal of 5G for all by 2020.5G is considered to be waybeyond than just faster data speeds on mobile devices.It is

ubiquitous access to high & low data rate services.5G will involve combination of existing and evolving systems [8].

According to GSMA Intelligence, there exists two views of 5G technology:

View 1 – The hyper-connected vision: In this view of 5G, mobile operators would create a blend of pre-existing technologies covering 2G, 3G, 4G, Wi-Fi and others to allow higher coverage and availability, and higher network density in terms of cells and devices, with the key differentiator being greater connectivity as an enabler for Machine-to-Machine (M2M) services and the Internet of Things (IoT). This vision may include a new radio technology to enable low power, low throughput field devices with long duty cycles of ten years or more.

View 2 –Next-generation radio access technology:This is more of the traditional 'generation-defining' view, with specific targets for data rates and latency being identified, suchthat new radio interfaces can be assessed against such criteria. This in turn makes for a clear demarcation between a technology that meets the criteria for 5G, and another which does not.

The Next Generation Mobile Networks Alliance defines the following requirements for 5G networks:

Data rates of several tens of megabits per second should be supported for tens of thousands of users

1 gigabit per second to be offered simultaneously to tens of workers on the same office floor

Several hundreds of thousands of simultaneous connections to be supported for massive sensor deployments

Spectral efficiency should be significantly enhanced compared to 4G

Coverage should be improved

Signalling efficiency should be enhanced

Latency should be reduced significantly compared to LTE

5G networks is said to be real wireless world that may be supported by technologies like LAS - CDMA (Large Area Synchronized Code - Division Multiple Access), OFDM (Orthogonal frequency - division multiplexing), MCCDMA

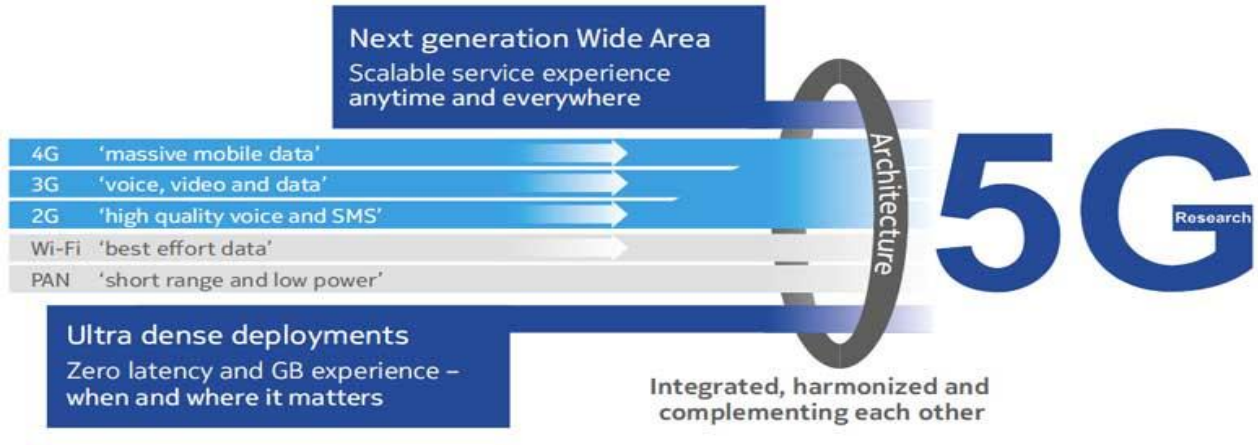

Fig. 1:5G - Symbiotic integration of existing and new technologies [8]

(Multi - Carrier Code Division Multiple Access), UWB (Ultra - wideband), Network - LMDS (Local Multipoint Distribution Service) and IPv6.5G will be developed on the basis of two key design principles: Flexibility and Reliability. 5G may incorporate several potential concepts that has been researched. They are Millimetre-Wave technologies, Future PHY / MAC, Massive MIMO, Dense networks, Pervasive networks, Group cooperative relay, Cognitive radio technology, Wireless Mesh Networking, Dynamic Ad-hoc Networking, Smart Antennas,Network Function Virtualisation (NFV), Software Defined Networks (SDN), Heterogeneous Networks (HetNets), World Wide Wireless Web (WWWW) and many more.

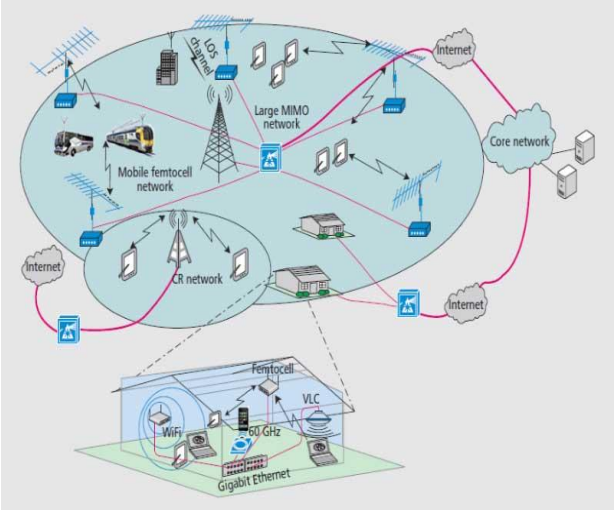

Fig. 2: Expected Architecture of 5G [1]

5G will provide services like interactive multimedia, voice over IP (VoIP), HD videos, Internet and other high quality services. It may provide support for immersive services like use of sensors, Internet of Things (IoT), Virtual Reality (VR) and Augmented Reality (AR). 5G may also provide security assurance for privacy and identity.

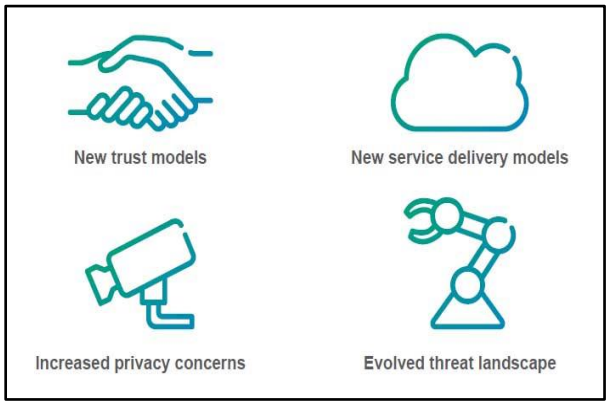

Fig. 3:The defining characteristics of 5G security [9]

Table 5. Fifth Generation Features

Generation	5G (2020)
Technology	WWWW, IPv6
Standard	Yet to be finalized
Switching	Packet - switched
Frequency	15 GHz
Data Speed	> 1 GBPS (expected)
Multiplexing	MC-CDMA, LAS-CDMA and OFDM
Core Network	Internet
Service	Interactive multimedia, voice over IP, augmented reality, virtual reality, IoT, etc.
Hand-off	Horizontal and Vertical

3.2 Sixth Generation (6G)

Sixth generation (6G) of wireless mobile communication must cover global area which could be possible by means of satellite technology. This will increase the performance, efficiency and reliability. Also there will be limitless expansion because air waves cannot be over-crowded. 6G will be based on All-IP network and real wireless world. It will be the best candidate to create an infrastructure of World Wide Wireless Web (WWWW). It is required to use air fibre networks that will be able to produce 300 mbps data rates practically and 10 Gbit/s theoretically. 6G won't replace existing mobile phone networks. It will create a blend of existing and emerging generations too. The main goal of 6G network is to create global telephone backbone, provide connections for rural and developing areas and setup a global mobile communication. The satellite networks consist of telecommunication satellite network, Earth imaging satellite network and navigation satellite network [10].It may include technologies such asSpace-Division Multiple Access (SDMA), Polarization-Division Multiple Access (PDMA), Demand Assignment Multiple Access (DAMA),Permanent Assignment Multiple Access (DAMA), Cognitive radio technology and many more technologies will evolve as research will progress. The classical satellite system includes mobile user link (MUK), gateway link (GWL) and inter-satellite link (ISL). 6G being a satellite technology, security could be the major issue. Researched have found that satellite communication systems have vulnerabilities and design flaws. However, this could result in the evolution of 6.5G or 6.75G depending on the implementation.

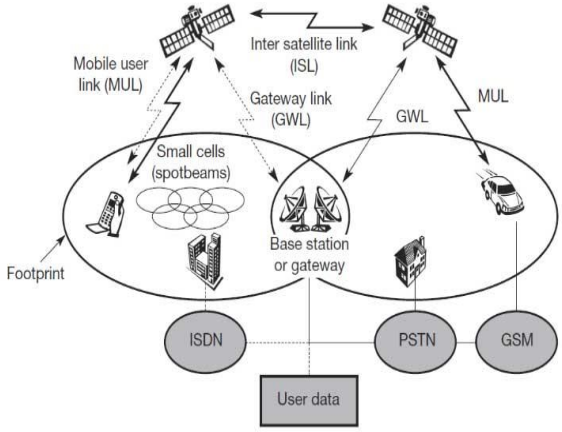

Fig. 4: Typical satellite system for global mobile communications across the world [11]

3.3 Seventh Generation (7G)

Seventh generation (7G) of wireless mobile communication will be the most advance generation as compared to its predecessors. It will set a well-defined standards and protocols for satellite communication as well as improve the security. 7G systems can be supported by global navigational satellite system using techniques such as OFDM methodology and FEC for the speed of communication process. It will provide better Quality of Service (QOS). 7G can be improved by including services like direct HD video broadcasting. It must achieve "Zero Latency" which is not achieved by previous generations. It must be cost-effective technology with no issues related to data capacity coverage and hand-off. It must set a goal to provide network for all and to implement the concept of net neutrality i.e. provide access to all the contents at a constant and equal speed to different users.

4. CONCLUSIONS

This paper discussed evolution of generations from 0G to 4G and various technologies that made every generation better from its predecessors. The paper also highlights the future generations of mobile networksi.e. 5G, 6G, and 7G. 5G is the

vision and mission of providing high quality services with added security by 2020. On the other hand, 6G will target to provide global coverage of networks by means of satellites. 7G must implement the net neutrality concept so that every user get access to all the content on the internet and at same rate without discriminating. The next generation of networks will provide better performance, efficiency, flexibility, reliability and strong security.It will resolve many issues and also create a World Wide Wireless Web using All-IP based networks. The technologies that will contribute to achieve these goals are EDGE, WiMax and LTE-Advance. The world of universally uninterrupted access to information, entertainment and communication will open new horizon to our lives and also change our life style significantly. The faster technology development leads to research for next generation of mobile networks, whereascustomer demands are increasing at constant rate based on the technology they adopt. Internet of Things s and augmented reality are the examples new developments.

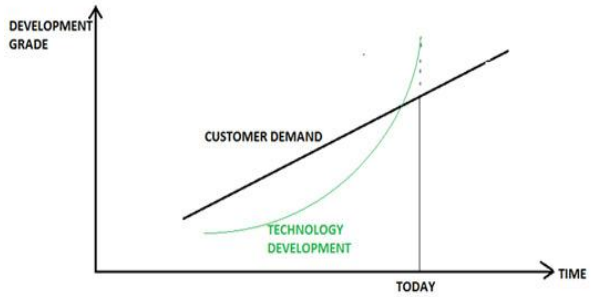

Fig. 5: Technology development v/s Customer demand

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