Overview on Generations of Network: 1G,2G,3G,4G,5G

Vivek Sanghvi Jain, 
BE Student
Computer Department, 
D. J. Sanghvi College of Engineering, 
Vile Parle (West), 
mumbai-400 056
viveksjain6@gmail.com

Sanchit Jain 
BE Student
Computer Department, 
D. J. Sanghvi College of Engineering, 
Vile Parle (West), 
mumbai-400 056
sanchitjain192@gmail.com

Lakshmi Kurup, 
Assistant Professor, 
Computer Department, 
D. J. Sanghvi College of Engineering, 
Vile Parle (West), 
mumbai-400056
lakshmi.kurup@djsce.ac.in

Aruna Gawade 
Assistant Professor, 
Computer Department, D. J. Sanghvi College of Engineering, 
Vile Parle (West), mumbai-400 056
aruna.gawade@djsce.ac.in

Abstract

Evolution is the essence of impact left behind by every being, every technology. We have well seen the advancements in the field of Computer Network i.e. from a simple Telegraph invented in 18th Century to 5G Communication on the verge of being implemented in South Korea. Needs of human beings never ceases to terminate, but they surely do result in invention of new technologies to pacify them. In this paper, we provide an overview on Generations of Networks along with a brief introspection on 5G technology that will provide access to wide range of telecommunication services in accordance with service demands in multiuser environment.

1. Introduction

We can say that wireless phone standards have a life of their own since they are spoken of reverently in terms of generations. The ancient stone-age sounding 1G, or analog cellular, then like 80’s rock came 2G, or digital cellular; 3G wireless, 4G, 5G and so on. The last decade stood witness to remarkable burgeoning in the wireless industry, both in terms of mobile technology and its subscribers. With all the technological advances, and the simultaneous existence of the 2G, 2.5G, 3G and 4G networks, the impact of services on network efficiency have become even more critical. And the latest addition to this group, is the 5G technology, which promises to revolutionaries Internet as we know it with lightening fast speeds.

2. Evolution of mobile technologies

2.1. First Generation (From now on, referenced as 1G)

1G cellular networks were invented in the 1980s. The key idea behind 1G was that the geographical area is divided into cells (typically 10-25km), each served by a “base station.” Cells are small so that frequency reuse can be exploited in nearby (but not adjacent) cells. This allows many more users to be supported in a given area. All 1G systems were analog systems popularly known as early cellular phone technology working in the frequency band of 150 MHz.

The first commercially automated cellular network (the 1G generation) was launched in Japan by NTT (Nippon Telegraph and Telephone) in 1979, initially in the metropolitan area of Tokyo. Within five years,
the NTT network had been expanded to cover the whole population of Japan and became the first nationwide 1G network.

Technologies under 1G:
1G comprised of the following Mobile technologies: Mobile Telephone Systems (MTS), Advance Mobile Telephone Systems (AMTS), Push To Talk (PTT) and Improved Mobile Telephone Service (IMTS).

Issues with 1G:
Analog cellular phones are not very secure. Anyone with an all-band radio receiver connected to a computer can record the 32-bit serial numbers and phone numbers of subscribers when calling can listen in on any conversation. This loophole was exploited in many scandalous ways. There were also reported thefts of airtime. Anyone could collect a large database by driving around and go into business by reprogramming stolen phones and reselling them.

2.2. Second Generation (From now on, referenced as 2G)

2G cellular telecom networks were commercially launched on the GSM standard in Finland by Radiolinja in 1991. [1] 2G used digital signals for voice transmission and had a speed up to 64 kbps. It also provided the facility of Short Message Service (From now on, referenced as SMS) and used the bandwidth range of 30 - 200 KHz.

Technologies under 2G:
2G comprised of the following Mobile technologies: General Packet Radio Service (GPRS), Code Division Multiple Access (CDMA), Global System for Mobile Communication (GSM) and Enhanced Data Rates for GSM Evolution (EDGE).

Some key benefits of 2G Network over its predecessors was that, Digital Encryption was supported by 2G systems which had higher penetration efficiency thereby being more efficient on network spectrum. Moreover, 2G introduced several data services for mobile, the most prominent one being the famous SMS text messages. After 2G was launched, the previous mobile telephone systems were coined as 1G Systems. Although it has been eons since its inception, 2G networks are still used in many parts of the world.

Issues with 2G:
In less populated areas, the weaker digital signal deployed on higher frequencies may not be sufficient to reach a cell tower. Analog Signals have a smooth decay curve while digital has a steppy one. This was seen as both an advantage as well as a disadvantage. Under good conditions, digital sounded better. Under slightly bad conditions, analog experienced static, while digital has occasional dropouts. As conditions worsened, digital signals started to completely fail, while analog got worse gradually, generally holding a call longer and allowing at least a few words to get through. While digital calls tend to be free of static and background noise, the lossy compression used by the codecs takes a toll; the range of sound that is conveyed is reduced. You hear less of the tonality of someone's voice talking on a digital cell phone, but you will hear it more clearly.[2]

2.3. Third Generation (From now on, referenced as 3G)

International Mobile Telecommunications-2000 (IMT-- 2000), better known as 3G or 3rd Generation, is a generation of standards for mobile phones and mobile telecommunications services fulfilling the International Telecommunication Union. [3] It uses Wide Band Wireless Network with which clarity is increased. The data are sent through the technology called Packet Switching. Voice calls are interpreted through Circuit Switching. Along with verbal communication it includes data services, access to television/video, new services like Global Roaming. It operates at a range of 2100MHz and has a bandwidth of 15-20MHz used for High-speed internet service, video chatting. 3G uses Wide Band Voice Channel that is by this the world has been contracted to a little village because a person can contact with other person located in any part of the world and can even send messages too[3].

Technologies under 3G:
2G comprised of the following Mobile technologies: 3G Technology comprises of Wideband CDMA, WLAN, Bluetooth, Universal Mobile telecommunication Systems (UMTS), High Speed Downlink Packet Access (HSDPA). Data are sent through packet switching. Voice calls are interpreted using circuit switching. It also provides facilities such as Global Roaming Clarity in voice calls, Fast Communication, Internet, Mobile T.V, Video Conferencing, Video Calls, Multi Media Messaging Service (MMS), 3D gaming and Multiplayer-Gaming.

Issues with 3G:
Although the usage price of 3G technology has greatly reduced since its inception due to wider adoption, it still is very costly as compared to 2G technologies. Due to high bandwidth transmission of 3G technologies, power consumption greatly increases which results in reduced device battery life. The data consumption of 3G at times becomes so heavy due to the high transmission rates that it puts a
big load on the network; to alleviate which, many cellular operators implemented data usage caps which were disadvantageous to customers.

2.4. Fourth Generation (From now on, referenced as 4G)

In March 2008, the International Telecommunications Union-Radio communications sector (ITU-R) specified a set of requirements for 4G standards, named the International Mobile Telecommunications Advanced (IMT-Advanced) specification, setting peak speed requirements for 4G service at 100 megabits per second (Mbit/s) for high mobility communication (such as from trains and cars) and 1 gigabit per second (Gbit/s) for low mobility communication (such as pedestrians and stationary users).[4] A 4G system not only provides voice and other 3G services but also provides ultra-broadband network access to mobile devices. Applications vary from IP telephony, HD Mobile Television, video conferencing to gaming services and cloud computing. One of the initial devices to access 4G network was USB wireless modem which was later followed by cellular phones with WiMax and LTE technology.

Technologies under 4G:
4G comprised of the following Mobile technologies:
Long Term Evolution (LTE) Standard based on the GSM/EDGE and UMTS/HSPA, 3rd Generation Partnership Project (3GPP), Multiple In Multiple Output (MIMO) smart antenna technology, Orthogonal Frequency Digital Multiplexing (OFDM), 802.16e - Worldwide Interoperability for Microwave Access (WiMAX), 802.20 - Mobile Broadband Wireless Access (MBWA).

Issues with 4G:
3G and 4G components made for one continent is not always compatible with another continent sue to carrying frequency bands. Another prominent issue in 4G systems is to make higher bit rates available in larger portion of the cell, especially to users in an exposed position in between several base stations. In current research, this issue is addressed by macro-diversity techniques, also known as group cooperative relay, and also by Beam-Division Multiple Access (BDMA).[5] Pervasive networks are a hypothetical amorphous concept where the user can be simultaneously connected to several wireless access technologies and can seamlessly move between them. This technology has not yet been efficiently implemented.

2.5. Fifth Generation (From now on, referenced as 5G)

The evolution of LTE does not end with LTE advanced (release 10) rather continues to evolve into further releases. Each new release further enhances system performance and adds new capabilities with new application areas. Some of the additional applications, benefiting from mobile connectivity, are home automation, smart transportation, security, etc. [6]

Need for 5G:
From user point of view, apart from throughput, other factors that differentiate 5G from its predecessors and makes its implementation essential are:

• Battery Consumption Alleviation
• Improved coverage range and higher data rate availability at cell edge.
• Multiple concurrent paths for data transmission and hand over.
• 5G provides support for interactive multimedia, voice, video, Internet, and other broadband...
services which are more effective and more attractive and have Bidirectional accurate traffic statistics

• An estimated mobility data rate of over 1Gbps with a large broadcast capacity to 65,000 connections at a time.
• Improved security features; better cognitive radio/Software Development Radio (SDR).
• Higher system level spectral efficiency.
• Worldwide wireless web (WWWW), wireless-based web applications that include full multimedia capability beyond 4G speeds. [6]
• Several Artificial Intelligence aided applications at high bandwidth with multiple sensors enabled mobile devices.
• 5G technology offer high resolution for crazy cell phone user and bi-directional large bandwidth shaping [7].
• 5G technology offer transporter class gateway with unparalleled consistency [7].

5G Network Model is an All-IP based model for mobile and wireless network interoperability.[7] The All-IP Network (from now on referenced as AIPN) has the capacity to satisfy the ever increasing mammoth demands of the burgeoning cellular market. It also is a general platform for all radio access technologies and standards. All-IP Network uses packet switching as compared to circuit switching used its predecessors, and its continual evolution provides performance and cost optimization. In 5G, Network Architecture consists of a user terminal (which has a crucial role in the new architecture) and a number of independent, autonomous radio access technologies (from now on referenced as RAT) [8]. AIPN based mobile applications and services such as Mobile Portals, Mobile Commerce, Mobile Health-Care, Mobile Government, Mobile Banking and several others are offered via Cloud Computing Resources (from now on referenced as CCR). [7] The best feature about cloud computing is that a user can access any data uploaded on the cloud ubiquitously from anywhere, from any terminal with an internet connection or a secure connection to the storage cloud without the need to install any third party application or softwares.

5G technology offer high speed bandwidth for crazy cell phone users. The advanced billing interfaces of 5G technology makes it more attractive and effective. 5G technology also providing subscriber supervision tools for fast action. The high quality services of 5G technology based on Policy to avoid error.

The 5G core is to be a Re-configurable, Multi-Technology Core. The core could be a convergence of new technologies such as nanotechnology, cloud Computing and cognitive Radio, and based on All IP Platform.[6] CCR links the Reconfigurable Multi Technology Core (from now on referenced as RMTC) with remote reconfiguration data from RRD attached to Reconfiguration Data models(from now on referenced as RDM). The main challenge for a RMTC is to deal with an increasing number of numerous radio access technologies. The core is a convergence of the nanotechnology, cloud computing and radio, and based on All IP Platform. Core changes its communication functions depending on status of the network and/or user

<table>
<thead>
<tr>
<th>APPLICATION LAYER</th>
<th>APPLICATION(SERVICE)</th>
</tr>
</thead>
<tbody>
<tr>
<td>PRESENTATION LAYER</td>
<td></td>
</tr>
<tr>
<td>SESSION LAYER</td>
<td>OPEN TRANSPORT PROTOCOL</td>
</tr>
<tr>
<td>TRANSPORT LAYER</td>
<td>UPPER NETWORK LAYER</td>
</tr>
<tr>
<td>NETWORK LAYER</td>
<td>LOWER NETWORK LAYER</td>
</tr>
<tr>
<td>DATA LINK LAYER</td>
<td>OPEN WIRELESS ARCHITECTURE</td>
</tr>
<tr>
<td>PHYSICAL LAYER</td>
<td></td>
</tr>
</tbody>
</table>

Figure 3 Modified OSI to support 5G demands. RMTC is connected to different radio access technologies ranging from 2G/GERAN to 3G/UTRANand 4G/EUTRAN in addition to 802.11x WLAN and 802.16xWMAN. Other standards are also enabled such as IS/95, EVDO, CDMA2000, etc. [9]
The two OSI layers i.e., Physical and Medium Access Control layers define the wireless technology. For these two layers the 5G mobile networks is likely to be based on Open Wireless Architecture. The network layer will be support IP (Internet Protocol). Also various drawbacks of IPv4 (version 4) such as limited address space and no real possibility for QoS support per flow will be overcome by IPv6, but packet header size significantly increases. Still, mobility still remains a problem. So each mobile device in 5G will have Mobile IP standard on one side as well as many micro-mobility solutions (e.g., Cellular IP, HAWAII etc.) The mobile and wireless network varies from wired networks with respect to transport layer. In case of wired network segments lost are due to network congestion, while in case of wireless networks losses are because of higher bit error ratio in the radio interface. For 5G mobile terminals will have the possibility to download (e.g., TCP, RTP etc. or new transport protocol) version, which is targeted to a specific wireless technology, installed at the base stations. This is called here Open Transport Protocol - OTP. With respect to application layer, the ultimate request from the 5G mobile terminal is to provide intelligent QoS management over variety of networks. Today, in mobile phones the users manually select the wireless interface for particular Internet service without having the possibility to use QoS history to select the best wireless connection for a given service. In case of 5G mobile phone the QoS parameters such as delay, jitter, losses, bandwidth, reliability, will be stored in a database with aim to be used by intelligent algorithms running in the mobile terminal as system processes, which at the end shall provide the best wireless connection upon required QoS and personal cost constraints.

Currently 5G technology is still in its Research and early development stages and it will be years before a perfect 5G standard is established. But when that does happen, large-scale implementation with device support from multiple vendors will follow. When that foes becomes available lightening fast speeds will be made available to the consumers. Data Transfer speed is predicted to cross the barrier of gigabits per sec. It would also provide efficient use of available bandwidth as has been seen through development of each new technology. 5G services would probably be successfully tested and implemented around the year 2017 and available for general public use by year 2020.


Table 1 Comparison of Generations of Mobile Communication Standards

<table>
<thead>
<tr>
<th>Generation (1G - 5G)</th>
<th>Definition</th>
<th>Throughput</th>
<th>Technology</th>
<th>Time Period</th>
<th>Features</th>
</tr>
</thead>
<tbody>
<tr>
<td>3G</td>
<td>Digital Broadband and Packet Data</td>
<td>3.1 Mbps (peak), 500-700 Kbps</td>
<td>CDMA, WCDMA, WLAN, Bluetooth, UMTS, HSDPA</td>
<td>2004-2005</td>
<td>Universal access to different mobile devices made possible along with Multimedia &amp; streaming services.</td>
</tr>
<tr>
<td>4G</td>
<td>Digital Broadband and Packet Data</td>
<td>100-300 Mbps (peak), 3-5 Mbps, 100 Mbps</td>
<td>802.16e WiMax, LTE, 3GPP, MIMO, OFDM, 802.20</td>
<td>Now (Transitioning to 4G)</td>
<td>High Definition streaming supported. Portability increased further.</td>
</tr>
<tr>
<td>5G</td>
<td>Not Yet Fixed</td>
<td>Higher than 1Gbps</td>
<td>www (coming soon)</td>
<td>Soon (probably 2020)</td>
<td>Dynamic Information access, Wearable devices with AI Capabilities</td>
</tr>
</tbody>
</table>

5G is a completed wireless system with yet no limitation, some people also call it the “REAL wireless world”. Figure 3 shows the modification in OSI model to support 5G technology which is explained below.
3. Conclusion

As mentioned above, the last decade stood witness to an astounding growth in the network communication industry. The ever-increasing demands of users triggered research and led to development of various generations of technologies, which recently lead to a comprehensive manifestation of upcoming 5G system. As the history of mobile communications shows, attempts have been made to reduce numerous technologies to a single global standard. 1G had fulfilled the need for a basic mobile voice, the 2G had introduced capacity and coverage, followed by 3G, which had a quest for data at higher speeds to open the gates for truly a mobile broadband experience, which was further realized by the 4G. 5G promises to bring higher data transfer speeds (reaching up to few gigabits per sec) and various other high quality services. 3G came into India only recently, and the cost for the same is still high. 4G is expected to come to India by the end of 2014, and there is no doubt that it will be embraced by all telecom users, seeing yet another monumental shift in Wireless Connectivity Technology.

4. Acknowledgements

It gives us great pleasure in acknowledging the resources and help received from the Computer Science Department, D. J. Sanghvi College of Engineering. We would also like to thank our parents for their support and encouragement.

5. References

[1] Radiolinja’s History - April 04 - Corporate.elisa.com
[3] 3G Wireless Networks - Clint Smith, Daniel Collins
[5] 5G mobile communication systems based on beam-division multiple access and relays with group cooperation - IT R&D program of MKE/IITA: 2008-F-004-01
[6] Prospective of Fifth Generation Mobile Communications - Dr. Anwar M. Mousa, University of