

## Evolution of Mobile Communication Network: from 1G to 4G

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### Abstract

The demand of mobile and internet is increasing day by day, they are becoming the preferred means of personal and professional communication, giving a new dimension to the telecom industry. To meet up the users demand more and more advancement is being done in the field of communication. This paper gives an overview of the evolution of wireless network technologies from 1G to 4G commonly known as first generation (1G), second generation (2G), third generation (3G) and the fourth generation (4G). The first generation mobile communication provided the basic voice communication facility, whereas the second generation supports both the voice and data services. Then the third generation came into existence which gave a boom to the telecommunication industry as it offers subscribers a wide range of data services, such as mobile Internet access, video conferencing and multimedia applications. But as the demand increased the communication industry moved towards a new generation known as fourth generation with much more advanced features in addition to the usual voice and other services of 3G. The 4G provides mobile ultra-broadband Internet access and provides users with much faster data transmission rates. Priorities for this standard include better reception, with less dropped data, IP interoperability for seamless mobile internet, faster information exchanges and much more.

**Keywords:** 2<sup>nd</sup> Generation (2G), 3<sup>rd</sup> generation (3G), 4<sup>th</sup> generation (4G), Long Term Evolution (LTE), Universal Mobile Telecommunications System (UMTS).

### 1. Introduction

The past few decades has shown a great advancement in the field of mobile communication. With the increase in the demand of communication and with increased number of mobile subscribers telecommunication companies are working to bring new technologies into existence with better features so as to meet up the user requirement. Cellular technology has revolutionized our lives; in early days there were fixed land line phones and there was no way to connect to the world without fixed line telephones. Mobile wireless communication has filled this gap and now we can contact anyone, anywhere, anytime; it provides a new set of services which not only focuses on voice communication but also tries to give the user access to a new global communication reality.

Cellular technologies have come a long way and are mostly know as 1st generation, 2nd Generation, 3rd generation, and now 4th generation system is being introduced, where each new generation brings a new technology and more high data rates than the previous one. The 1st generation system commonly known as 1G technology was introduced in the early 1980s. It was basically analog-based communication technology which only provides analog voice services and no data services;

moreover it supports data bandwidth of up to 2.4kbps. The 2<sup>nd</sup> Generation (2G) mobile telephone networks were the next stage in the development of wireless systems after 1G, which introduced a mobile phone system that was completely digital. The 2G system provides data bandwidth of up to 64kbps which is better than 1G, it supports both voice and data transmission i.e. the facility of message sending was available moreover it also provides enhanced calling features like caller ID.

Then the 3<sup>rd</sup> generation came into existence with significant features as they support much higher data transmission rates of upto 2Mbps and offer increased capacity, which makes them suitable for high-speed data applications as well as for the traditional voice calls which also supports global roaming. The benefits of higher data rates and greater bandwidth mean that 3G mobile phones can offer subscribers a wide range of data services, such as mobile Internet access and multimedia applications.

Compared to earlier mobile phones a 3G handset provides many new features such as TV streaming, multimedia, videoconferencing, Web browsing, e-mail, paging and navigational maps. The 4G/LTE (Fourth Generation / Long Term Evolution) is the next stage in mobile network development. In addition to the usual

voice and other services of 3G, provides mobile ultra-broadband Internet access and also provides users with much faster data speed of about 100 Mbps while a user moves at high speeds and 1Gbps data rate in a fixed position. Priorities for this standard include better reception, with less dropped data, IP interoperability for seamless mobile internet and faster information exchanges. The 4G enhancement promises to bring the wireless experience to an entirely new level with impressive user applications, such as sophisticated graphical user interfaces, high-end gaming, high-definition video and high-performance imaging.

## 2. Evolution of Mobile Communication Network

The mobile communication technologies are divided into generations, a short overview of these generations is given below:

### 2.1 First generation mobile communication

The first generation mobile communication which was introduced in 1980s was based on the analog system. The most popular analogue 1G systems were advanced mobile phone system (AMPS) which was launched in United States. Nordic mobile telephone (NMT), total access communication system (TACS) and some other analog systems were also introduced in 1980s across the Europe. All of the standards in 1G use frequency modulation techniques for voice signals. The spectrum within cell was divided into number of channels which was not efficient in terms of the available radio spectrum, and this placed a limitation on the number of calls that could be made at any one time. Analog systems were based on circuit switching technology and offers only voice communication and no data communication. After the introduction of 1G technology mobile communications have undergone significant changes and experienced enormous growth and the number of subscriber reached nearly 20 million by 1990.

#### Key features and facilities of 1G

- Based on analog system.
- It supports data speed of up to 2.4kbps.
- cordless telephone.

#### Basic disadvantages of 1G

- Only voice, no data communication.
- Low capacity.
- Poor handoff.
- Less secure.
- Poor voice link.

### 2.2 Second generation mobile communication

An improvement to 1G communication came into existence in the form of 2G technology which was introduced in late 1980's and was based on low-band

digital data signaling. In this analog technology was replaced by Digital Access techniques such as TDMA (Time division multiple access) and CDMA (code division multiple access).

The most popular 2G wireless technology is known as Global Systems for Mobile Communications (GSM). Global System for Mobile Communications, or GSM, uses TDMA technology to support multiple users. The TDMA breaks down data transmission, such as a phone conversation, into fragments and transmits each fragment in a short burst, assigning each fragment a time slot. With a cell phone, the caller does not detect this fragmentation. During development over more than 20 years, GSM technology has been continuously improved to offer better services to its users. GSM supports 450 million cellular subscribers, with international roaming in approximately 140 countries and 400 networks. CDMA uses spread spectrum technology to break up speech into small, digitized segments and encodes them to identify each call. The CDMA distinguishes between multiple transmissions carried simultaneously on a single wireless signal. It carries the transmissions on that signal, freeing network room for the wireless carrier and providing interference-free calls for the user. The CDMA breaks down calls on a signal by codes, whereas TDMA breaks them down by time. The result in both cases is an increased network capacity for the wireless carrier and a lack of interference for the caller.

#### Key features and facilities of 2G

- Enhanced Spectrum efficiency.
- Provides data rate of up to 64kbps.
- Improved system capacity, and network coverage.
- Roaming facility.
- Voice and data services.
- Enhanced security.

#### Basic disadvantages of 2G

- It does not support high data rates.
- Weaker digital signal.
- Unable to handle complex data.

### 2.3 Third generation mobile communication

The 3G brought great transformation in mobile communication world. The 3G fulfils the specifications of International Mobile Telecommunications-2000 (IMT-2000), the official International Telecommunication Union which intended to provide wireless access to global telecommunication system. To meet the IMT-2000 standards, a system is required to provide peak data rates of at least 200 kbit/s. The most important IMT-2000 proposals are the Universal Mobile Telecommunications System (UMTS) as the successor to GSM. The UMTS uses the W-CDMA, TD-CDMA, or TD-SCDMA air interfaces in which WCDMA is the most popular air-interface technology for the UMTS. The main components includes BS (Base Station) or nod B, RNC (Radio Network

Controller), apart from WMSC (Wideband CDMA Mobile Switching Centre) and SGSN/GGSN.

The W-CDMA gives additional advantages of high transfer rate, and increased system capacity and communication quality by statistical multiplexing. The W-CDMA utilizes efficiently the radio spectrum, because the CDMA technique enables all base stations to use the same frequency. In the WCDMA system, the data is split into separate packets, which are then transmitted using packet switching technology, and the packets are reassembled in the correct sequence at the receiver end by using the code that is sent with each packet. The UMTS systems are designed to provide a range of data rates, depending on the user’s circumstances, providing up to 144 kbps for moving vehicles, up to 384 kbps for pedestrians and up to 2 Mbps for indoor or stationary users. The 3G basically focused on multimedia applications such as video calling, videoconferencing for mobile phones, improved capacity, world roaming, low cost, better compatibility, high speed data.

**Key features and facilities of 3G**

- Faster data rates.
- Supports multimedia applications such as video and photography.
- Value added services like mobile television, GPS (global positioning system), video call and video conferencing.
- High speed mobile internet access.
- Increased capacity.

**Basic disadvantages of 3G**

- Requires 3G compatible handsets.
- The cost of upgrading to 3G devices is expensive.
- Power consumption is high.
- 3G requires closer base stations which is expensive.

**2.4 Fourth generation mobile communication**

The 4G is an emerging technology in the field of communication. As the data requirements increased, efforts were made to improve the downlink and uplink throughput rates by employing higher modulation techniques. Third Generation Partnership Project (3GPP) launched the Long Term Evolution (LTE) project in November 2004 in order to ensure the continued competitiveness of the UMTS in the future. As LTE is considered as the evolution of universal mobile telephone system (UMTS), hence LTE’s equivalent components are thus named evolved UMTS terrestrial radio access (E-UTRA) and evolved UMTS terrestrial radio access network (EUTRAN). The basic architecture of LTE contains a separate IP connectivity layer for all the IP based services and Evolved Packet System (EPS) which handles the overall communication procedure.

LTE is completely an all IP based system. Since there are provisions in LTE for inter-operation with existing systems, there are various paths available to connect to

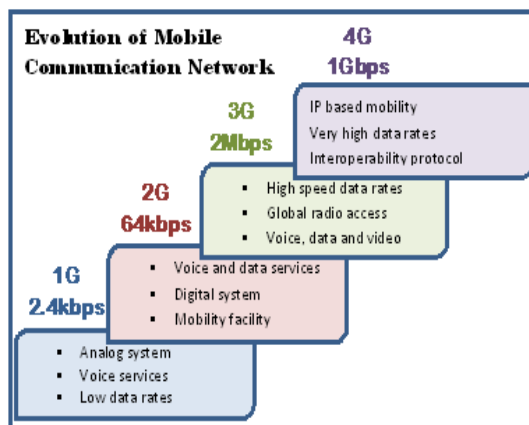
LTE. An operator with a GPRS/EDGE network or a Non-3GPP systems can connect to a LTE network. Due to this increased flexibility, LTE is the choice of majority of operators worldwide. By using Orthogonal Frequency Division Multiple Access (OFDMA), LTE will be able to provide download rates of about 100 Mbps for multi-antenna (2x2), multiple-input multiple output (MIMO) for the highest category terminals. For these terminals upload rate is about 50 Mbps. Moreover, it provides better mobility, efficient radio usage, high level of security, flexible spectrum utilization, reduced delay/latency, cost efficient deployment and various other advantages which makes LTE more reliable and user friendly.

**Key features and facilities of 4G**

- High spectral efficiency.
- High voice quality.
- Easily access internet, streaming media, video calling etc.
- Very low latency.
- Simple protocol architecture.
- Efficient multicast/broadcast.

**Basic disadvantages of 4G**

- Higher data prices for consumers.
- It is very expensive and hard to implement.
- Complex hardware.
- Power usage is more.



**Fig.1** Evolution of mobile communication network

**Conclusion**

The world of communication has shown a great transformation over generations, communication has moved from a simple voice communication system to an IP based system. The increasing demand and increased number of users has forced the communication industry to modify technology from 1G to 4G. The modified facilities given to the users by the mobile communication industry enabled users to expand their business and communicate worldwide. The first generation only

provided voice communication facility, second generation supported both voice and data but third generation along with these facilities also provided multimedia services. Then the fourth generation came into existence which gave an easy platform with more modified communication services. As the use of communication has reached from personal level to the professional level, the evolution of 4G has provided a time saving and easy access technology to the professionals.

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