

# Evolution and Development Towards 4<sup>th</sup> Generation (4G) Mobile Communication Systems

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**Abstract:** It is the need of hour to get ourselves acquainted with the communication technology, its tools and its trends. Mobile communication is an important technology in this regard and mobile phone has become the most common tool of communication over the recent years. As several innovative improvements regarding mobile communication technologies have been made by developing various multiple-access schemes used for wireless communication (such as TDMA, FDMA, CDMA, WCDMA, EDGE etc) but a big challenge is to select the right technology for the applications and systematically identify the factors that influence the overall performance. In this research paper, we present the detail comparison of the different generations of the mobile communication technologies in a tabular form to have a better knowledge and understanding in the advancement of mobile communication systems. The survey presented here will be helpful for designing the new strategies for the development of 4<sup>th</sup> generation mobile communication systems. This research work can steer all those learners who are trying to enhance their acquaintance in the field of mobile communication system, and also for such mentors and researchers who desire to have a foundation for further research and study in this field. [Journal of American Science. 2010;6(12):63-68]. (ISSN: 1545-1003).

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## 1. Introduction

The Internet is the network of large-scale group of connected computers around the world that sends out data using packet switching technique based on the TCP/IP stack. (Wright and Steven, 1995) With a continuous improvement in the field of communication technologies (ITU-R, 2000) and infrastructures by means of enhancing the functionalities of the wired/wireless protocols, the Internet has achieved the massive success and popularity. Over the time with the growing and accelerating progresses in communication patterns (wired and wireless) and wildly demands for spare capacity and connectivity, the Internet in almost every aspect frequently experiences modifications and changes in order to bring up-to-date. Along with the requirements supporting the Internet has been an implausible progress in the field of wire-less and mobile technologies. Since during the last few years, a countless fast improvements have been observed in the area of mobile and wireless technologies, and these two drastically rising user-driven service demands have significantly and intensely revolutionized the spirit and nature of worldwide telecommunications (Freeman and Roger, 2004) in these millenniums and have developed the modern telecom territory.

In this research work, we present the detail survey of the different generations of the mobile communication systems and our purpose is not to

choose a victor because many of the technologies are still in progress. Somewhat, we anticipate to get in detail knowledge of the situations wherein different technologies would work better, and the sources of performance degradation.

The remainder of this paper is structured as follows. In Section 2, we give an overview of the different wireless technologies. In Section 3, we present the comparative analysis of 4<sup>th</sup> generation mobile communications system to the earlier generations (i.e., 1G, 2G and 3G) and progressively analyze their characteristics, and elaborate the various visions for the future utilization of 3G and 4G technologies. Finally in Section 4, we present the conclusions of this work.

## 2. Review of Literature

### 2.1 Introduction to 1G, 2G, 3G and 4G

The list of wire-less air interface protocols which follows signifies the most familiar standards in exercise around the world nowadays. They're structured almost by means of generations (i.e., 1<sup>st</sup> G, 2<sup>nd</sup> G, 3<sup>rd</sup> G and 4<sup>th</sup> G) of development and include various derivations or alternate terms used to describe them.

**1<sup>st</sup> Generation (1G):** 1G of technology was analog (voice-only) i.e., 1G wireless phones exercised analog technology. These devices were weighty and exposure was unreliable, however they effectively

presented the inherent easiness of mobile communications.

**2<sup>nd</sup> Generation (2G):** The 2G of technology is digital – in the United States, mostly devices & services are digital. Digital cellular services are vastly deployed world-wide. They presented a significant development in the quality of voice (since analog information is much subject to distortions as that of digital information) and enhanced capacity as well, as voice calls in a more efficient way can be multiplexed. It provides the different services like some degree of web-access facility, digital voice calling and short message service (SMS). The GSM, TDMA and CDMA are the few cell phone standards of 2G.

**3<sup>rd</sup> Generation (3G):** The 3G (Smith et al., 2000) of wireless technology is committed to provide reasonably speedy wireless communication to support more useful services such as data, video and multimedia as well as voice. The wire-less mobile communication technology in it's present form is often known as 2.5 G (Gozalvez et al., 2001) (called EDGE technology) but simply existing right networks of 3G in the United States are EVDO & UMTS (with HSPDA) offered by (Sprint/Verizon) and Cingular carriers, respectively. The 3G offers next to future advances into the business/private wire-less technology, particularly in a field of mobile communications and some expected capabilities and features of 3G systems are:

- Enhanced features for multimedia communications (i.e., digital data & voice, video & remote controls system)
- Supporting to utilize onto all advanced modes (i.e., electronic-mail, fax, paging, cellular-telephones, web-surfing, video-conferencing etc)
- Extensive bandwidth & high-speed capability (upwards of 2 Mbps)
- Providing flexibility for Routing (repeaters, satellites, LANs etc)

**4<sup>th</sup> Generation (4G):** The 4G (Woerner, 2001) of wireless technology is still underway and stands to be the upcoming wireless devices standard. The key difference between 4G and 3G technologies is the improved data transfer rates and security, like it is for 3G over 2.5G or 2G. The 4G is looked forward to offer more enhanced versions of the same advancements promised by 3G (e.g., improved-multimedia, video-streaming, global-access and worldwide-portability through all kinds of devices).

Normally, a generation is defined by the result of technology grows over a time-frame of ten-

to-fifteen year, hence, 4G would turn to whatever is deployed in the 2010 period onward, supposing 3G exploitation covers the 2000-2010 period.

Somewhat, 4G would provide customers with on demand first-class video and audio by utilizing OFDM (Robertson, 1999) (Orthogonal Frequency Division Multiplexing) technique and would able to better allocate network resources to multiple clients by making use of multiple channels simultaneously. Unlike the 3G networks which are a mixture of packet-switching and circuit-switching networks, 4G (Hui et al., 2003) will be based on packet switching only and might actually connects the whole world and be operable from any place above or on the surface of the globe.

## 2.2 Code Division Multiple Access (CDMA)

CDMA (Gharavi et al., 2001) is a type of multiplexing which doesn't share the channels by frequency or time (like FDMA or TDMA), however it en-codes information by some unique codes related to each channel and exploits dynamic interferences effects of a particular code to do multiplexing. In addition, it refers to a digital cellular telephony system which utilizes these multiple access schemes. CDMA has since been applied in a number of communication systems (i.e., Omni-TRACS satellite system (Freeman et al., 2004) and Global Positioning System (GPS) (Hatch et al., 2002)). Figure 1 presents a general architecture of a CDMA system.

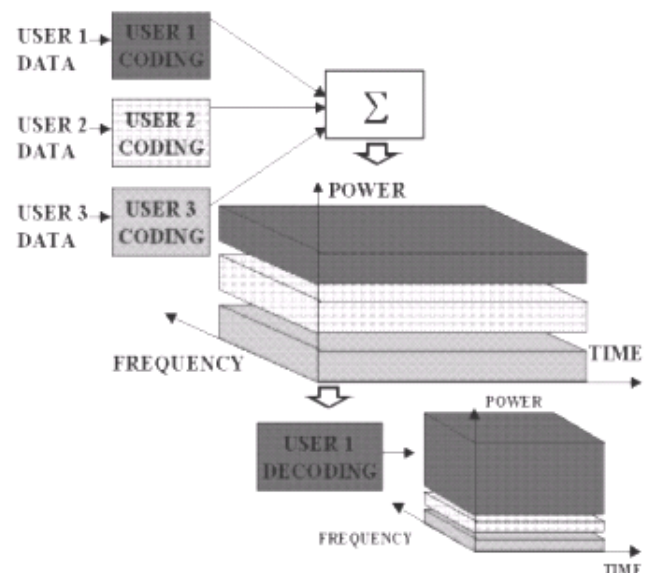


Figure 1. Working of CDMA system

### 2.3 Wideband Code Division Multiple Access (WCDMA)

WCDMA (Bidaud, 2001) is a type of wideband digital radio-access technology. In 1998, the European Telecommunications Standard Institute (ETSI) used it to support 3G multimedia applications for wideband digital radio-access. WCDMA offers an innovative service capability, improved network speed and low-cost for services (data and voice) compared to 2G technologies. It is the foremost worldwide 3G-standard preferred by eight of the world's ten largest service-providers. Operators can softly progress from GSM on the way to WCDMA, hence saving investments via reutilizing the GSM setups and services (Gozalvez et al., 2001).

### 2.4 Global System for Mobile Communications (GSM)

For mobile communications the most well-liked standard in the world is GSM (Bach, 2000). More than 2-billion people across the world (over 250 countries/territories) use the services offered by the GSM. It distinguishes much from its ancestors given that collectively speech and signaling channels are digital, indicating that it is assumed as the 2G mobile communication system. GSM now becomes an open standard that is presently proposed by the 3GPP. According to the consumer judgment, the GSM system's main advantage has been high-quality digital-voice channels and reduced price alternative to make calls (like SMS) and from a network operator prospective, it has been the potential to employ equipments as of various providers as the open standards accepts simple inter-compatibility. In addition, these standards permitted networks providers to allow roaming facilities that means the customers can utilize their phones whole across the world. Figure 2 illustrates the general architecture of a GSM system.

### 2.5 General Packet Radio Service (GPRS)

The GSM mobile phones users get benefit from a new mobile data service called GPRS (Bratton et al., 2001). The GPRS is an imperative step in the evolution of 2G mobile systems towards 3G systems. It offers a reasonable data transfer speed, via utilizing unoccupied TDMA channels in the GSM networks. It provides friendly billing system, high capacity channel and reduced call setup time. The GPRS system is optimized for the packet switched data networks and is transition totally from the cellular network of circuit switched to packet switched. Figure 3 describes the general architecture of a GPRS system. GPRS improves GSM data services providing:

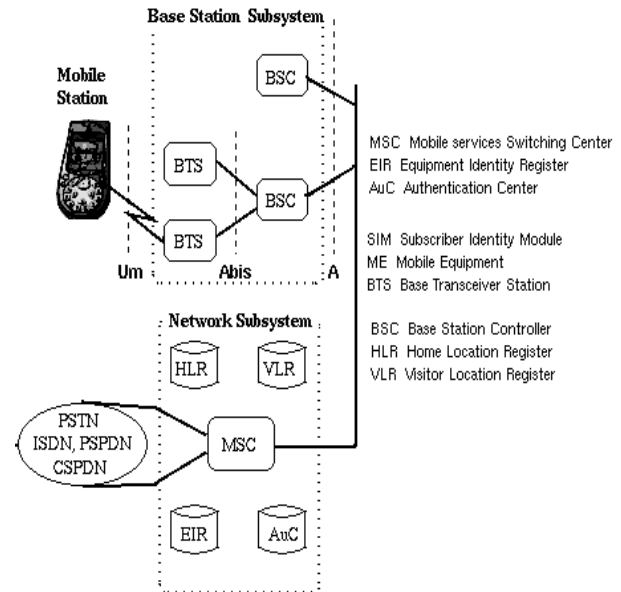


Figure 2. GSM system's architecture

- offer variety of services at reasonably low-cost to support flexible co-existence using GSM voice
- provide bursty traffic support
- possible support for connectivity to the Internet
- providing fast-access time
- utilize network and radio resources efficiently

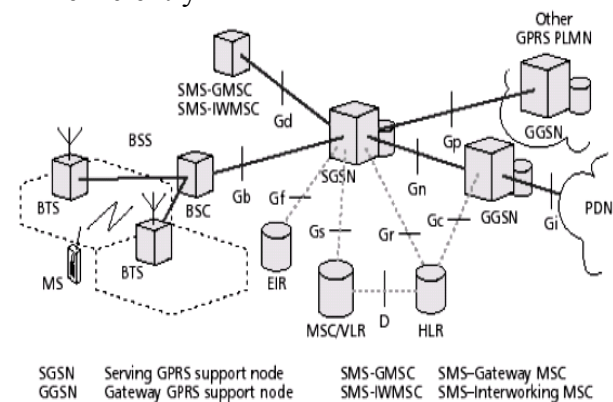


Figure 3. GPRS system's architecture

## 3. Comparison of Technologies

### 3.1 Tabular Comparison of 1G, 2G and 3G Technologies

Table 1 shows the comparison of the three technologies (i.e., 1G, 2G and 3G) in terms of data services currently offered by the different carriers.

### 3.2 Tabular Comparison of 3G and 4G Technologies

The 3G is the next step leaving beyond the 2G standards (for instance CDMA and GSM). The important aspects of 3G consist of the skills to merge the cellular mobile networks with the internet, adding multimedia applications to a wireless

computer/mobile phone by improving the range and QoS of voice and data services. In near future, the 4G is the upcoming technology of wire-less networks which will switch from 3G to 4G networks. To understand both the technologies more clearly their detail comparison are as follows (Table 2):

Table 1: Comparison of 1G, 2G and 3G technologies

Generation	Technology	Features
1 <sup>st</sup> Generation (1G)	AMPS (Advanced Mobile Phone Service)	Support voice service: Analog, data services: No
	CDMA (Code Division Multiple Access)	Analog Cellular (Discontinued) Speed: 9.2-kbits/sec
2 <sup>nd</sup> Generation (2G)	Time Division Multiple Access (TDMA) Personal Digital Cellular (PDC)	PDC & TDMA (only support one-way data transmission) Offers advance calling options as caller ID Not constantly on data connections
	Code Division Multiple Access (CDMA)	CDMA carriers: Sprint, Verizon Technology: 1xRTT Digital voice service Speed: 128-Kbits/sec
	Global System for Mobile Communications (GSM)	GSM carriers: Cingular, Nextel, T-Mobile Technology: GPRS, EDGE, UMTS Speed: 40-160-kbits/sec
3 <sup>rd</sup> Generation (3G)	Wideband Code Division Multiple Access (WCDMA)	Carriers: Cingular Technology: UMTS Excellent voice qualities About 2-Mbits/s Constantly on data connection
	CDMA-2000	CDMA carriers: Sprint, Verizon Technology: EV-DO Speed: 500-700-kbits/sec Based on the Interim Standards (95) CDMA standards
	Time-Division Synchronous Code Division Multiple Access (TD-SCDMA)	Supports broad-band data services (such as multimedia & video), Improved roaming features

Table 2: Comparison of 3G and 4G technologies

Key Parameters	3 <sup>rd</sup> Generation (3G)	4 <sup>th</sup> Generation (4G)
(1) Speed	<b>3G has the ability to utilize circuit/packet data at higher bit rates</b> 144 kb/s or higher in high capacity vehicular-traffic. 384 kb/s for pedestrian traffic. 2 Mb/s or greater for indoor-traffic.	<b>4G can support data rates up to 20 to 100 Mbps in mobile mode</b> A developed wireless corporation NTT-DoCoMo is evaluating 4 G tech over 100 Mb/s (when moving) & 1 Gbit/s (when it is still)
(2) Bandwidth	<b>3G uses 5to20 MHz Bandwidth</b> A radio signal bandwidth is defined as being the difference b/w the upper/lower frequencies of the signal. The bandwidth amount required for 3G service would be as more as 15to20 MHz.	<b>4G has the absolute bandwidth-range of 100MHz or above</b> The bandwidth could be as much as (100MHz) and data could be sent at much highly rates. The data sending cost could be relatively much low and worldwide mobility could be probably 100MHz or above.
(3) Switching Design Basis	<b>3G is relay on packet switching or circuit switching</b> A few 3G aspects also utilize packet switching. Circuit switching leads PSTN-public switched telephone network. Networks	<b>4G utilizes packet-switching</b> Packet-switching dominating the data-networks such as the internet. Through circuit switching, whole packets send directly towards the receiver in an arranged manner, over a single track in sequence. Remaining

	resources establish calls through the most capable route.	packets from other calls race upon such circuits too, making the mostly use of each path or flow, pretty different the circuit switching calls which engage a single path to the omission of all others.
<b>(4) Access Technologies</b>	<p><b>3G utilizes CDMA-2000 &amp; WCDMA as access technologies</b> WCDMA offers speeds b/w 384kb/s &amp; 2Mb/s. If this protocol is deployed over a WAN, the maximum-speed is 384kb/s. If it is employed in a LAN, the upper-speed is 2Mb/s. It is approved also by the ITU. The others important 3G standards are CDMA2000 that is product of the initial 2G CDMA IS-95 standard. The different transmission technology utilized in CDMA2000 that are 1xRTT, CDMA-2000-1xEV_DV &amp; 1xEV_DO.</p>	<p><b>4G is based on OFDM/OFDMA</b> 4G uses OFDM/OFDMA to better distribute networks resources among the available users. 4G enable equipments permit to utilize available bandwidth and to make utilizing multiple channels parallelly. In OFDM, pulse making task &amp; modulation can be done via an easy IDFT that can be deployed much better as that of IFFT. Thus, in the receiver we require only a FFT for reversing this process.</p>
<b>(5) Frequency Band</b>	<p><b>Country dependent/continent (1800to2400 MHz)</b> In Europe, the satellite services utilize the 1980to2010 MHz for uplink-bands &amp; 2170to2200 MHz for downlink. In United States, 45MHz of capacity in the 1710to1755 MHz band &amp; 45MHz of space in the 2110to2170 band for 3G applications are available.</p>	<p><b>High frequency bands capability (2to8 GHz)</b> Mobile communication 4G systems will have to exploit the frequency band as competently as feasible, with the minimum possible transmission power.</p>
<b>(6) Network Architecture</b>	Cell-Based Wide-Area (WAN)	Wire-less LANs Hybrid Integrations (WiFi/Bluetooth) & Wide Area
<b>(7) Forward Error Correction</b>	Convolutional rate: (1/2), (1/3)	Concatenated Coding Schemes
<b>(8) Component Design</b>	Optimized antenna design, multi-bands adapter	Smart Enabled Antenna, softwares multi-bands & wide-band radio
<b>(9) Major Requirement Driving Architecture</b>	Pre-dominantly voice driven: data was constantly add-on	Converged data & VoIP (Voice Over IP)
<b>(10) Internet Protocol</b>	Numerous air link protocols, plus IP 5.0	Up to (IP 6.0)
<b>(11) Backup Compatibility</b>	3G CDMA-2000 is backward compatible to the 2G IS-95 standards. It supports less compatibility.	4G enhances the 3G capacity/capability by an order of magnitude.
<b>(12) Market Overview</b>	<p><b>(a) Lacks of Demand</b> The 3G services market diffusion has been slow as estimated initially because of fewer demands for developed services lately exploitation by the service providers &amp; challenges relevant to QoS and convergence. <b>(b) Other Challenges</b> Other challenges are operational costs that are considerably greater than in a 2G/2.5G operation and doubt surrounding nearby demand for non-voice qualities</p>	<p><b>(a) High-Speed Multimedia Service Demand</b> <b>(b) Fixed-Mobile Convergence</b> <b>(c) Issues of Spectrum</b> <b>(d) Issues of Standards and Certification</b> <b>(e) Technological Challenges</b> <b>(f) Alternative Services/Applications for 4G</b></p>
<b>(13) Mobile Top Speeds</b>	200 kilometer per hour	200 kilometer per hour
<b>(14) Cost Comparison</b>	It's working costs that are considerably larger than in a 2G-2.5G system and doubt nearby estimate requirement for non-voice qualities.	At this phase, no certified 4G networks devices have been commercialised that's why costs are not determined. Though, it is sensible to guess that unverified latest technologies will initially be a focus for less demand hence, costs will be comparatively large & will only reduce slowly as demand raises. Because of the beginning price of CPEs, 4G vendors are assuming to provide leasing contracts.



#### 4. Conclusions

In this research work, we have surveyed four wireless technologies namely 1G, 2G, 3G and 4G. We conclude that the 4G mobile technologies will stimulate subscriber interest in broadband wireless applications because of its ability and flexibility towards the world of wireless mobile communications. A concentrated effort seems to categorize how wire-less mobile technologies can accompany a more user focused world of wire-less. Finally the report elaborates the different Mobile Communication Technologies that have been developed in the past and their evolution and development towards 4<sup>th</sup> generation communication systems. Their detail comparison with each other has been discussed to have a better knowledge and understanding about the technological advancement made towards the evolution and development of 4<sup>th</sup> generation communication systems. In this research work, we have tried to gather as much information as possible and assemble it in such a manner that the reader can gain maximum knowledge of the topic.

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