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REVIEW ARTICLE

# A Framework of (4G) Wireless Networks-Overview and Challenges

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## ABSTRACT

In digital systems there is an exponential increase in the mobile user demand. Customers demand more facilities from the technology which they use be it a television, computer, phone or any device which accompany them in their day to day life. The internet helps in gaining faster and better access to information from these devices. In modern systems, wireless and mobile communication technologies are improving day by day. The rising demand of mobile internet and multimedia applications resulted in the growth of broadband wireless access technologies. With the growing demands of users, the third generation (3G) network faces diverse limitations with respect to its data rate, bandwidth, etc. as it cannot accommodate the upcoming multimedia environment. The limitations in the current technologies have led the researchers to formulate new methods. One such technology is 4G. 3G will be replaced by 4G in the upcoming years. 4G has the advantage of mobility, high data rates, high capacity and preservation of full backward compatibility. This paper is an attempt to study the 4G wireless system, its aspects and technologies. The main objective is to recognize and explore the problems and challenges connected to the management of mobility in 4G heterogeneous networks. The secondary purpose is to provide information on different features of 4G that include aspects, future architecture and main technological enablers. The work explains the 4G network in detail along with its scope in the communication industry. Finally, an outline on 5G, 6G & 7G technologies has been given.

**Keywords:** Wireless communication, Mobile communication systems, Heterogeneous networks, 4G network, Telecommunications.

## 1. INTRODUCTION

In the modern world, wireless communication is enjoying its fastest development period due to enabling technologies which allow wide deployment. Wireless telecommunication system can be defined as the information transfer between two or more points that are not attached by an electrical connector. The wireless telecommunication system has been classified into different network generations. 3G is not at all meeting the satisfactory constraints of the users and hence some countries have decided to go straight to 4G. Core IP based network layer is used by these new networks and this is called as 4th generation communication perception.

Fourth generation wireless system will be an IP-based integrated system. 4G will have the ability to provide speeds between 100 Mbit/s and 1 Gbit/s. Quality and security add to the importance of 4G. 4G will provide a complete solution of IP where information can be given to users at "Anytime, Anywhere" [1]. 4G wireless communication network is proposed to support performance of broadband and implement applications for voice/video multimedia. The implemented features and 4G standards allow remarkable rises in data rates over 2G, 3G and 3.5G wireless technologies. As of now, worldwide interoperability for microwave access and long term evolution are considered as the candidates to arrive at the 4G wireless performance objectives [2]. In the

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current technologically-driven society, the presence of 4G networks is an important indicator of transition and advancement. 4G also help in network speed, wireless capabilities and visual technologies. Several versions of 4G arise such as that which provides a 1000 Mbps bandwidth in mobile equipment and ordinary 1Gbps. It can also be dealt as heterogeneous networks enabled by radio access technology [3]. The interconnected 4G enabling technologies use Orthogonal Frequency Division multiplexing (OFDM) which include multiple input and output cognitive radio networks. In the process of transition from 3G to 4G enterprise, American multinational telecommunications corporation has decided to pay attention to the different drawbacks brought on by 3G networks. As the rollout process is initiated by AT&T, several factors need to be considered to confirm the success of transition and to ensure that the current networks are not interrupted in the 4G developing process. It is estimated that as a response to new network challenges service providers such as AT&T will develop new pricing approaches for most of their popular products including iPhone.

4G networks require a unique approach to develop effective models for strategic purposes. 4G networks are mostly used to access websites such as gmail, you tube and facebook, which need higher bandwidth for their successful usage [4, 5]. These websites are very popular among the public. Hence service providers think of chances to incorporate the customer needs. Consumers rely on multiple data sources for convenience and entertainment. The 4G systems that is, cellular broadband systems of wireless access have been drawing much interest in mobile communication. [6, 7] 4G systems not only will support the mobile service of network generation, but also support the fixed wireless networks. Figure B1 illustrates various networks and their seamless connectivity [8].

## 2. HISTORY OF WIRELESS TELECOMMUNICATION SYSTEM

This section summarizes the mobile wireless technology evolution from 1G to 4G. It is expected that 4G systems, offer high data rates to a number of users at the same time. The evolution of cellular mobile networks has been indicated in figure B2 [9].

In 1980, telecommunication started with 1G where analog radio signal was used and voice was the main traffic. [10] The first generation wireless networks (1G) was fundamentally analog cellular systems with a circuit switched network architecture. These networks faced the challenges in basic voice telephony such as limited local and regional coverage and capacity. The increased demand for high frequency ranges in the telecommunication sector resulted in the development of new techniques of analog to digital transmission. [11] In 1990s, second generation (2G) was launched. It was implemented to meet the growing demands of voice telephony, messaging and data services. The digital system enables signal compression in an efficient manner compared to analog systems. It also facilitates the transmission of more packets with the same bandwidth as in 1G.

[12] In third generation (3G) systems different 2G systems were combined into a single system. They included both spatial and terrestrial components. 3G has the capability to unify CDMA, TDMA and GSM for facilitating the services. Figure B3 shows the 3G network architecture [13]. This result is achieved by the following three modes viz wideband CDMA, CDMA2000 and the Universal Wireless Communication (UWC- 136) interfaces. 3G also integrate voice and data applications. The disadvantages of 3G networks include high bandwidth, large capital and high spectrum licensing fees.

Finally, vendors and operators started to seek new ways of determining next generation wireless technology. It resulted in the so called fourth generation (4G). This review briefly explains the opportunities and requirements of 4G systems. An analysis of the technologies implemented in 4G networks has also been done. [14] Figure B4 shows the multi-access technologies of 1G, 2G and 3G networks.

## 3. TECHNOLOGIES USED IN 4G

Owing to QOS and coverage range constraints, Wi-Fi do not fulfill the entire wireless criteria [15]. Compared to wireless fidelity (Wi-Fi), the 4G technologies such as long term evolution and microwave access are efficient. Unlike 3G, 4G possess good QOS and wide coverage range. LTE and WiMAX have similarities in licensed spectrum bands,

QOS support and wider coverage range [16]. Both WiMAX and LTE telecommunication technology provide broadband wireless service. WiMAX and LTE support both Frequency-Division Duplex (FDD) and Time-Division Duplex (TDD) systems. All the proposals of 4G wireless networks has been implemented in OFDM [17]. In WiMAX, OFDMA used both uplink (UL) and the downlink (DL) simultaneously. OFDM enable data exchange at speeds above 100mbps. It can also remove interference that affects high speed signals [18].

## 4. 4G AND ITS APPLICATIONS

4G promises many improvements in the network industry. Some of them include small latency, downlink data rate over 100 megabits per second, efficient spectrum use and low implementation cost [19]. 4G also provide extraordinary applications viz video streaming, graphical user interfaces, gaming and ad hoc, multihop high performance networks. [20] 4G services are parallel to 3G services but it offer high data rates and enable applications which require speed to have it linked through 1 carrier. 4G technology applications include [21, 22]:

- Ultra high speed internet access to general web browsing.
- Online satellite mapping.
- Highspeed
- 4G Location-based services - a provider can help in accessing location of particular places through the available equipments.
- 4G could access X-rays and provide video conferencing facility even from remote areas.
- 4G HDTV - 4G help in transmitting High Definition Television (HDTV) channels that can be watched anywhere from the world.
- 4G provides facilities for lifetime education at low costs.
- 4G enabled video games can facilitate their execution in real time.

## 5. CHALLENGES

### 5.1. Security and privacy

In 4G Networks, security measures are at the core and data transmission should be made as safe as possible. “The 4G addresses core security, mobility and QoS through existing mechanisms reuse whereas still trying to work on certain handover issues and mobility” [23]. Effective tools series should be grown which are vital for maximum security as threats from hackers and security violations are on the rise. Owing to the 4G network nature, the systems are more prone to security attacks and hence, multiple security levels, including authentication steps are to be implemented [24].

One of the major goals of 4G networks is to cover a wider geographical area with seamless service. Apparently, small local area networks run these operating systems. These wireless networks heterogeneity leads to complications in security and privacy. Moreover, the methods of encryption and decryption used for 3G networks are not applicable for 4G networks. In order to get rid of these issues two methods can be considered. The first step is to transform the present methods so that they will be applicable to heterogeneous 4G networks. The second step is to develop new mechanisms in the case where modifications are not possible [25].

### 5.2. Quality of service

Non IP based and IP based are the two categories of wireless systems. With the advent of 4G systems, the networks will converge to a single network. Wireless systems possess diverse characteristics such as bit rates, channel, bandwidth allocation and hand off support. Hence Qos maintenance is an important issue. Resource allocation is an important part of QoS assurance. Since 4G systems will have to accommodate different user types and applications with dissimilar QoS, resource allocation will be challenging. A possible solution is the presence of network resource manager that monitor the network utilization on a link by link basis and allocate the bandwidth as needed [26].

### 5.3. Hand off delay

In 4G wireless networks, handoff delay is another important issue. During the handoff process [27], the user may experience QoS drop that will affect the performance of upper-layer protocols and applications. Both QoS variability and handoff delay can be reduced by deploying a priority-based algorithm. Deployment of a receiver-specific filter close to the source can significantly reduce the traffic and processing amount.

### 5.4. Less battery backup shown by 4G supportive devices

Due to presence of large number of sending and receiving devices available in 4G, supporting devices runs off quickly. With technological developments the devices shrink in size due to large scale integration and micro architecture. Therefore in 4G devices if we need to improve the battery life by designing a more powerful battery of Li-ion, the device size would increase proportional to the back-up size which is not desired [28].

### 5.5. Spectrum

The allocation of frequency spectrum is another one challenge in 4G. The GSM and PCS systems are used in the frequency bands in the range of 806-960 MHz and 1710-1885MHz. The 3G network services initial frequency contains the 1990- 2005 MHz and 2010-2200 MHz bands. At present, 3G is very popular and the number of subscribers is on the rise. The 4G networks will also support a large number of users. Research and studies show that 4G will operate in high or less congested frequency bands like 5GHz and 60GHz [29].

### 5.6. Networks access

In 4G systems, mobile devices will be used to access cellular networks, WLAN, satellite networks and fixed wireless networks. This should be done with the help of several universal access points. The access point performs a number of functions that include conversion of protocols and frequencies, QoS negotiation for connections and seamless handoffs. Figure B5 shows a 4G network with horizontal and vertical handoffs. Network access methods involve usage of common protocols such as wireless ATM [30]. The first choice of the access network will be determined by several factors such as accessibility, services capabilities, QoS and cost. Since, the operator will deploy networks with multiple standards and protocols, 4G systems permit interconnection with dissimilar networks and provide universal mobility. An architecture for all-IP will be used for systems of 4G [31].

## 6. ADVANTAGES AND DISADVANTAGES

### 6.1. Advantages of 4G

[32] Pure Data Network: 4G-network is an "All-IP" based data network. A totally data based network will permit more bandwidth which means further data can be passed through the network.

Further Devices and Applications: 4G network devices can take advantage of the higher bandwidth and speeds to deliver more applications for robust data.

Speed: 4G theoretical speed has recommended the data rates up to 100 Mbps for extraordinary mobility and 1Gbps for small mobility should be the target value.

Hand off: The improved 4G network standards will permit smooth hand off from single coverage area to another without interruption to any on-going transfers of data. This will result in smooth streaming data.

Faster response time: Faster response time or lower latency is one of the benefits of 4G technology. 4G technology decreases latency to 1/100th of a second (about 10ms).

### 6.2. Disadvantages

Despite all the above stated advantages, there are still limitations that must be addressed. Operating area is one major disadvantage. [33] Rural areas and many buildings in metropolitan areas are not being served well by current wireless networks. This network limitation will carry over to future wireless system generations. Furthermore new frequencies in cell towers are essential. Some other limitations are battery usage, implementation difficulties and requirement of complex hardware. Another disadvantage of 4G is that the consumer will be enforced to purchase a new device to support the 4G since it is impossible to make current equipment compatible with the 4G network.

## 7. BEYOND 4G

### 7.1. 5G technology

Table A1 shows 4G and 5G networks comparison. [35] 5G mobile network technology enables the usage of mobile phones with a very high bandwidth. Users have never experienced such a large value technology. Awareness has increased to the maximum possible extent. The 5G networks contain many advanced features. Users can connect their 5G technology mobile phone to their laptop or computer to get broadband. 5G

technology comes with the combinations of high clarity camera, MP3 recording, video player, big phone memory, dialing speed, audio player and much more. [36] 5th wireless mobile multimedia internet networks can be regarded as a complete wireless communication network without any drawback [37].

### 7.2. Wireless network technology for 6G & 7G

6G network technology will combine all wireless mobile networks with satellites to get global coverage. This will be the under advanced concept for cellular network of "Sixth Generation". It is assumed that 6G will offer 1GB data transfer speed. Networks of 6G mobile communication can mix 5G and networks of satellite communication. The satellite communication networks consist of earth imaging satellite networks and navigation satellite networks. [38] The navigation satellite networks are used for global positioning. The satellite telecommunication networks are used for global telephony, multimedia, video and high speed network connectivity. The earth imaging networks are used for resource monitoring and weather information. The 7G system can be supported by the system of global navigation satellite, the earth image satellite system, the satellite telecommunication system and the cellular system of 6G. Compared to the cellular base stations, satellites are much inexpensive and steady [39].

## 8. CONCLUSION

4G wireless networks not only allow scalable, efficient and dependable services of wireless network but also provide wide range of services. However a rethinking on the technologies of security, privacy, architect and billing is required. It is believed that future research will provide a way to overcome these challenges and mix newly developed services to 4G networks. It is also expected that worldwide wireless web will be widespread across the globe and voice and data communication may take place exclusively with respect to interaction of satellite. Finally it is concluded that it will be beneficial to invest in 4G network technologies. Current users of mobile gadgets possess great awareness of the mobile network technology. The technologies of 5G, 6G &7G contain all advanced features which makes them most powerful to meet the global coverage.

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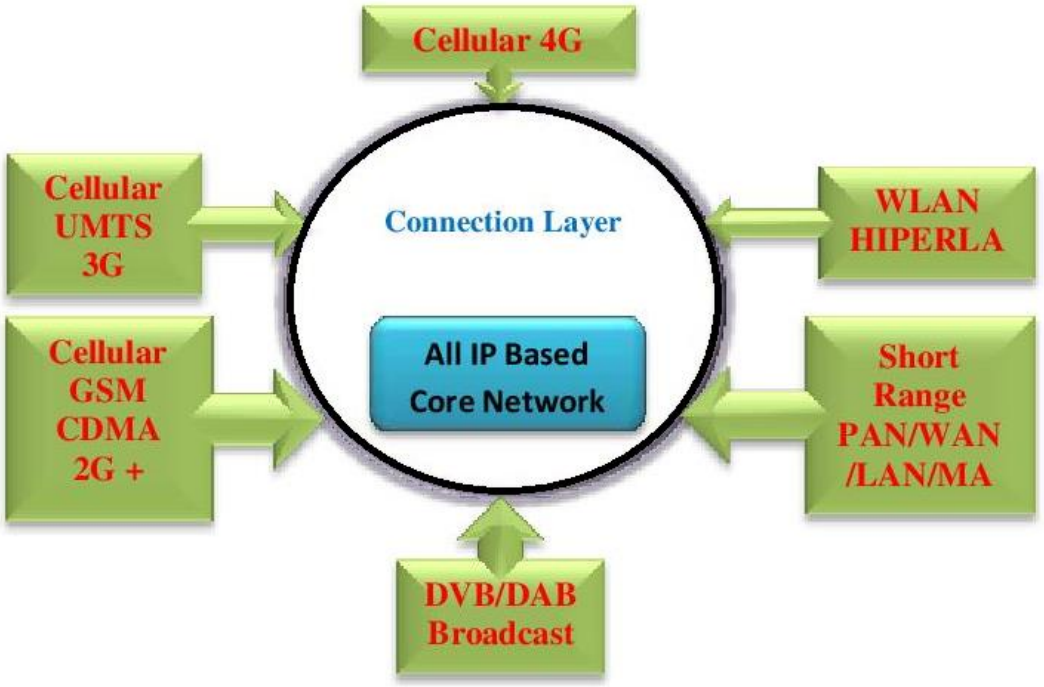
## APPENDIX A

Adapted from [34]

Table A1.Contrast between 4G and 5G

| Technologies | Data Capacity | Technology | Standards | Technologies | Service | Multiple Access | Core Networks |
|---|---|---|---|---|---|---|---|
| 4G | 2Mbps to 1Gbps | LTE, Wi MAX | OFDMA, MCCDMA ,network-LMPS | Integration of broadband LAN/WAN/PAN and WLAN | Dynamic information access, wearable devices, HD streaming, global roaming | CDMA | All IP network |
| 5G | 1Gbps and higher as per need | IP v6 | CDMA and BDMA | Integration of broadband LAN/WAN/PAN/ WLAN and advanced technologies based on OFDM modulation | Dynamic information access, wearable devices, HD streaming, any demand of users | CDMA, BDMA | Flatter IP network |

## APPENDIX B

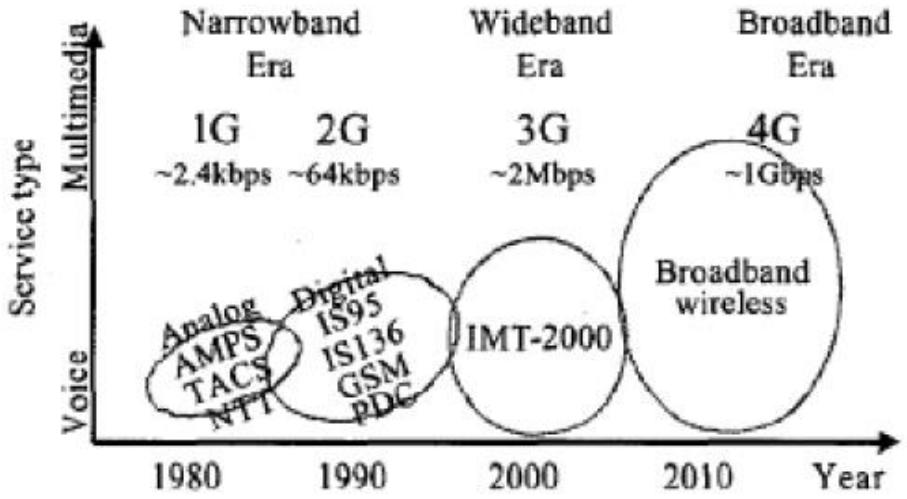



**Legend:**

| | | | | | |
|---|---|---|---|---|---|
| PAN | = | Personal Access Network | DAB | = | Digital Analog Broadcast |
| LAN | = | Local Area Network | MAN | = | Metropolitan Area Network |
| WAN | = | Wide Area Network | UMTS | = | Universal Mobile Telecommunications System |
| DVB | = | Digital Video Broadcast | WLAN | = | Wireless Local Area Network |

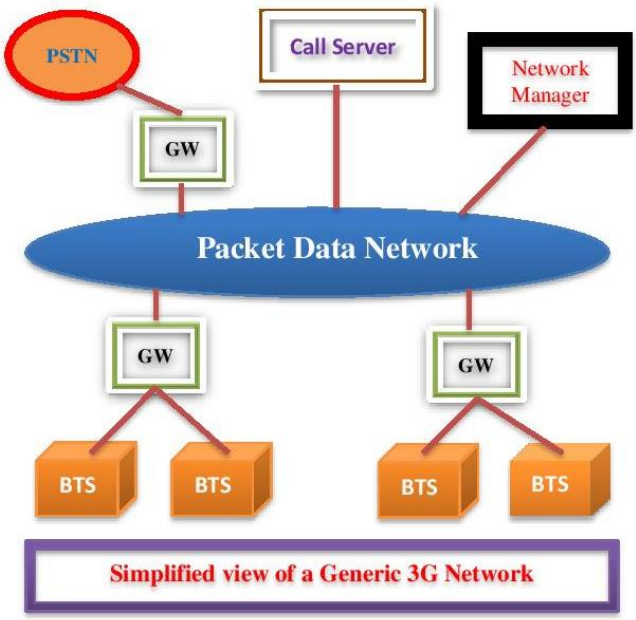
Adapted from [8]

Figure B1.Seamless connections of networks



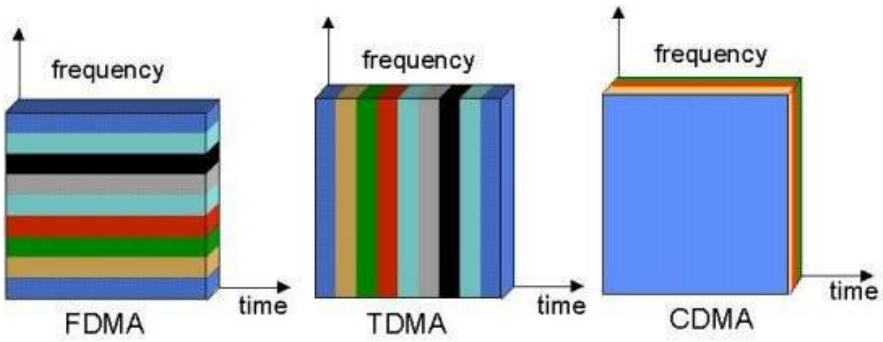

Adapted from [9]

Figure B2.Mobile cellular networks evolution



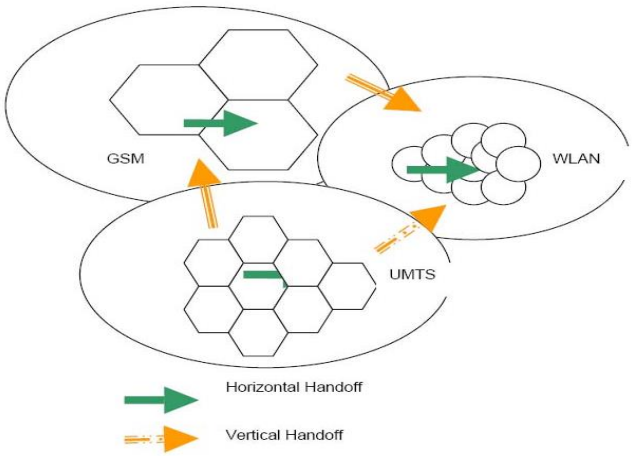

Adapted from [13]

Figure B3.Architecture of 3G network




Adapted from [14]

Figure B4.4G and future wireless systems optimization frequency, time and coding combination [14]




Adapted from [31]

Figure B5.4G network showing horizontal and vertical handoff [31]