

# Comparative Study of 2G, 3G and 4G

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## ABSTRACT

1<sup>st</sup> generation wireless cellular network was introduced in 1980s, till then different advancement has been made in this direction and different generations were introduced like 2G, 3G, and 4G networks after 1G. Here in this paper, a brief comparison is made between 2G, 3G and 4G networks, how they evolved and its advantages and disadvantages, channel-coding scheme used and the frequency band used in each generation have been discussed in this paper.

**Keywords:** GSM, EDGE, HSPA, HSPA+, LTE

## I. INTRODUCTION

As the need arise, first generation was developed around 1980s by Nippon Telegraph and Telephone (NTT) in Tokyo. So, Japan was the first country to commercialize 1G. 1G is based on analog signals based on AMPS (Advance Mobile Phone Service). FDMA (Frequency Division Multiple Access) scheme of multiplexing was used in 1G.

Due to disadvantages like very less capacity and analog technology, 2G was introduced in 1990s based on GSM in Finland. 2G had many advantages like radio signals in 2G are digital, offered better security compared to 1G, made better and efficient use of spectrum available and also had an added facility of text services. Its improved version also included GPRS (General Packet Radio Service) which allowed internet access.

With more number of users using mobile phones to access internet, a faster and robust internet connectivity was needed and 3G was introduced. The concept of CDMA (Code Division Multiple Access) and WCDMA (Wideband Code division multiple access) was introduced in 3G. NTT DoCoMo first commercially launched it in Japan in early 2000s.[1]

3G also had an advantage that it was backward compatible with present 2G systems.

4G communication system was first introduced in Finland in 2010. The concept of OFDM (Orthogonal Frequency division multiplexing) is used in 4G. The internet speed in 4G can reach upto 100 Mbps due to which applications that requires very high speed like online gaming, high definition video streaming and interactive TV can be enjoyed.

## II. 2G

2G is based on GSM (Global System for Mobile Communication) technology. 2G system used combination of TDMA (Time Division Multiple Access) and FDMA (Frequency Division Multiple Access). Due to this more users were able to connect at a time in a given frequency band.

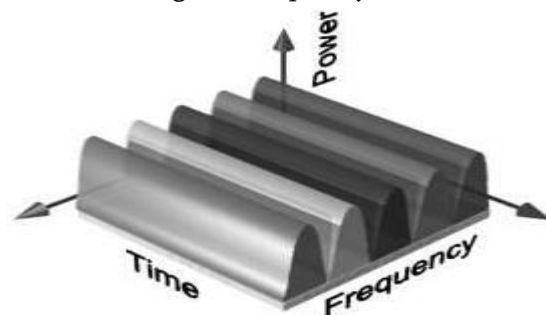


Figure 1. Multiple Access

As shown in the figure, a specific frequency slot is divided into time slots, so multiple user can use a specific frequency slot. The GSM system uses 25 Mhz frequency spectrum in a 900Mhz band. A speed of around 14.4 Kbps is obtained in basic 2G network. The core network used in 2G is PSTN (Public Switched Telephone Network). Circuit switching is used in GSM.

As the need to send data on air interface increased, GPRS (General Packet Radio Service) was clubbed with existing GSM network. Due to this optimal speed upto 150Kbps can be reached. Still, as the need arise to increase the data rate, EDGE (Enhanced Data GSM Environment) was introduced, which increased the amount of data rata four fold times.[2] It was also feasible to make an upgrade on current GPRS system. EDGE can also be considered 2.5G.

### III. 3G

3G system uses CDMA (Code Division Multiple Access) and WCDMA (Wide Band Code Division Multiple Access). CDMA is a technique in which a unique code is assigned to each user using the channel at that time. After assigning a unique code, completely available bandwidth is utilized efficiently in it. Due to this very large number of users can use the channel at the same time compared to TDMA and FDMA.

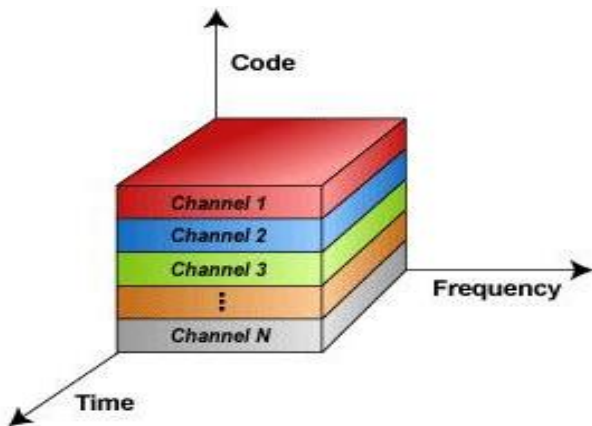


Figure 2 . CDMA Technique

As shown in figure, a unique code is assigned to each user due to which N number of channels can be

formed at a time. 3G uses 15 Mhz to 20 Mhz frequency spectrum and the frequency band for 3G is from 1800 Mhz to 2500 Mhz. A maximum speed of around 2 Mbps is achieved in basic 3G system. WCDMA also known as UMTS (Universal Mobile Telecommunication System) uses much larger carrier frequency due to which more amount of users can be accommodated at compared to CDMA.[3] The core network used in 3G systems is combination of Circuit switching and Packet switching.

To further increase the speed of data, HSPA and HSPA+ (High Speed Packet Access) was introduced. Due to HSPA+ networks can be upgraded to run at broadband speeds. The concept of MIMO (Multiple Input Multiple Output) was first introduced in HSPA+. Due to this data rates can reach to as high as 42 Mbps.[4] HSPA and HSPA+ can be considered as 3.5G and 3.75G respectively. The modulation technique used in HSPA+ was 64-bit QAM.

MIMO is a method in which concept of Multipath propagation is used to improve the radio link. Same signal are received multiple times on receiver side. Due to this, the probability of error is decreased and overall performance is improved.

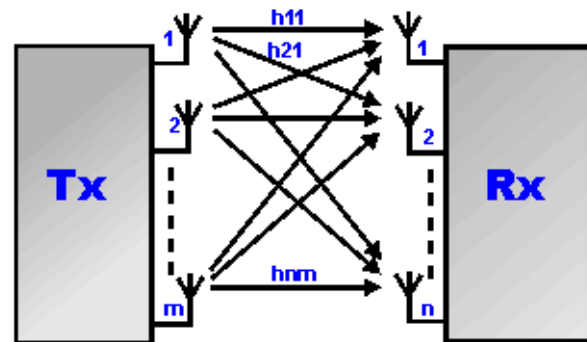


Figure 3. General Outline of MIMO System

Another advantage in 3G system is of Hand-off. In this, user equipment is connected to two towers simultaneously due to which call drop don't take place during hand-off.

#### IV. 4G

LTE (Long Term Evolution) is a 4G mobile communication standard based on GSM/EDGE and UMTS/HSPA technologies. LTE uses Multi carrier CDMA or OFDM (Orthogonal Frequency Division Multiplexing). In OFDM, high data rate modulating stream is divided and then placed onto many slowly modulated narrowband closed-spaced subcarriers.

The frequency band used in 4G is from 2000 Mhz to 8000 Mhz and uses a frequency spectrum of 5Mhz to 20 Mhz. A maximum downlink speed of around 100 Mbps and uplink speed of around 50 Mbps is achieved in LTE systems. Due to such a high data rate, it can support bandwidth hungry applications like online gaming, live streaming of high definition video, voice over IP.

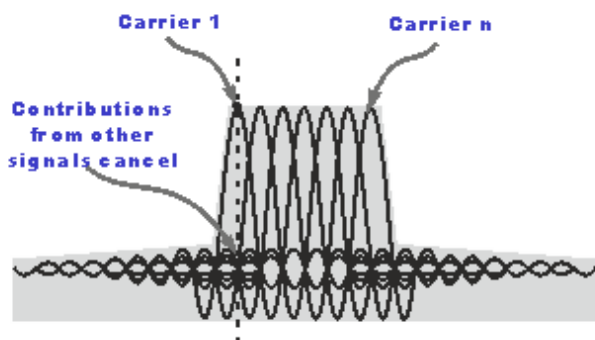


Figure 4 . OFDM Spectrum

The core network type used in 4G is IP based. 4G network has very low latencies, has a wider channel and carrier aggregation upto 100Mhz.

The two common modes of LTE are LTE FDD and LTE TDD.

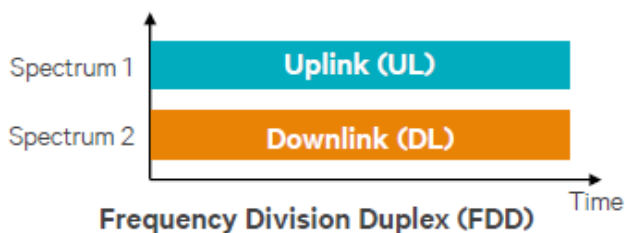


Figure 5. Two common modes of LTE

#### V. CONCLUSION

Last decade saw a huge advancement in field of wireless communication and especially in the field of cellular networks. Though 4G has been deployed in many countries, but still 3G technology is most widespread. Still it will take some years to completely migrate to 4G systems and work has already begun towards 5G technologies and its challenges.

#### VI. REFERENCES

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