American Journal of Electrical and Electronic Engineering, 2019, Vol. 7, No. 2, 34-37
Available online at http://pubs.sciepub.com/ajeee/7/2/2
Published by Science and Education Publishing
DOI:10.12691/ajeee-7-2-2

Evolution of Mobile Communication Technology towards 5G Networks and Challenges

Arun Agarwal[1,*], Kabita Agarwal[2], Sumanshu Agarwal[1], Gourav Misra[3]

[1]Department of Electronics and Communication Engineering, Institute of Technical Education & Research, Siksha 'O' Anusandhan Deemed to be University, Khandagiri Square, Bhubaneswar-751030, Odisha, India
[2]Department of Electronics and Telecommunication Engineering, CV Raman College of Engineering, Bhubaneswar-752054, Odisha, India
[3]School of Electronic Engineering, Dublin City University, Glasnevin, Dublin 9, Ireland
*Corresponding author: arunagrawal@soa.ac.in

Received May 19, 2019; Revised June 26, 2019; Accepted July 04, 2019

Abstract Communication on the move has always been sought for its convenience. Today's mobile communication refers to portable devices operated with battery. Wireless communications is the fastest growing segment of the communications industry. Cellular systems have experienced exponential growth over the last two decades. Future mobile communications focus on everything Wireless in one Device along with Ubiquitous Communication among People and Devices. 5G technology stands for fifth generation.5G network will provide high data rate ,low latency, high reliability energy saving, cost reduction, higher system capacity and massive device connectivity.5G wireless systems is built with five technologies Millimeter waves, small cell, Massive MIMO, Beam forming and Full duplex. Like previous generation 2G, 3G and 4G mobile networks 5G are the digital cellular networks.5G are using the millimeter wave (mm Wave) which provide the higher bandwidth (3-300 GHz).

Keywords: *5G, Massive MIMO, OFDM, beam forming, full duplex, mm wave*

Cite This Article: Arun Agarwal, Kabita Agarwal, Sumanshu Agarwal, and Gourav Misra, "Evolution of Mobile Communication Technology towards 5G Networks and Challenges." *American Journal of Electrical and Electronic Engineering*, vol. 7, no. 2 (2019): 34-37. doi: 10.12691/ajeee-7-2-2.

1. Introduction

Many mobile users want faster data speeds and more reliable service. The 5G promises to deliver that and much more [1]. Millimeter wave communications plays a most important role to achieve the 5G vision [2,3]. The major problem faced by mm Wave is that they cannot penetrate buildings and walls. Like 4G, 5G will be a global standard dominated by LTE-Advanced. It has a bright future because it can handle best technology and it takes over the world market in coming days. Technologies like switch and router used in 5G network provides high connectivity. 5G consist of 4G base stations, mm Wave base stations and mobile devices. The main bottleneck in any wireless networks is effect of multipath fading as depicted in figure below.

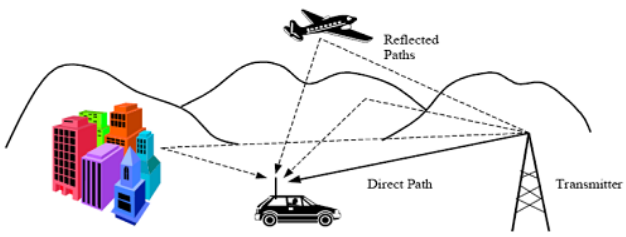

Figure 1. Effect of multipath on mobile receiver

2. Evolution of Mobile Technology

2.1. 1G

First generation. This term refers to the first generation cellular systems that were analog telecommunications standards introduced in the 1980s. The voice channel typically used frequency modulation, and they used FDMA techniques. Examples: NMT (Nordic Mobile Telephone), used in Nordic countries, Switzerland, Netherlands, Eastern Europe and Russia, AMPS (Advanced Mobile Phone System) used in the United States and Australia, TACS (Total Access Communications System) in the United Kingdom, C-450 in West Germany, Portugal and South Africa.

1G types of phones was introduced in 1982 for the use of voice services and was based on technology known as Advanced Mobile Phone System (AMPS). The AMPS system was frequency modulated

Features

1. It is based on analog system
2. Poor voice quality and battery life
3. Limited capacity

2.2. 2G

Second Generation. This term refers to the second forms of cellular telecommunications systems that were introduced. The systems were digital and were oriented to voice with only low speed data services. Systems such as GSM and US-TDMA used a mixture of TDMA and FDMA techniques. IS-95 /cdmaOne was the first CDMA system. 2G services are frequently referred as Personal Communications Services, or PCS, in the United States.

2G refers to the second generation and based on GSM. It was developed in late 1980s. It mainly focused of on digital signals. It provides services to deliver text and picture message at slow speed (in kbps).

Features

1. It uses digital signals
2. It supports or provides services such as text messages etc.

2.3. 2.5G

This systems enable high-speed data transfer over upgraded existing 2G networks. Examples: EDGE, GPRS, CDMA2000 etc.

2.4. 3G

Third generation. The designation for systems following the 2G systems and they offer high speed data services in addition to the basic voice capability. Typically they use CDMA techniques and include UMTS (W-CDMA), CDMA2000 1xEV-DV, CDMA2000 1xEV-DO, and TD-SCDMA.

3G refers to the third generation and is based on WCDMA It provides various services like data services access to television/video

Features

1. It provides faster communication
2. It has large capacities and broadband capabilities
3. It send/receive large email messages

3GPP - Third Generation Partnership Project. The group that was set up to produce globally applicable Technical Specifications and Technical Reports for a 3rd Generation Mobile System based on evolved GSM core networks. It produced the standards for W-CDMA (UMTS). Later the scope of the organisation was widened to include the maintenance and development of the GSM Technical Specifications and Reports.

3GPP2 - Third Generation Partnership Project 2. The organisation that is responsible for the specifications for the 3G developments for CDMA2000.

2.5. 4G-LTE

4G refers to the fourth generation which was introduced in year 2010. It enables same feature as 3G and also provides additional services. It provides mobile ultra-broadband Internet access.

Both 3GPP and 3GPP2 are currently working on further extensions to 3G standards, named Long Term Evolution and Ultra Mobile Broadband, respectively. Being based on an all-IP network infrastructure and using advanced wireless technologies such as MIMO-OFDM, these specifications display features characteristic for IMT-Advanced (4G), the successor of 3G. However, falling short of the bandwidth requirements for 4G (which is 1 Gbit/s for stationary and 100 Mbit/s for mobile operation), these standards are classified as 3.9G or Pre-4G.3GPP plans to meet the 4G goals with LTE Advanced.

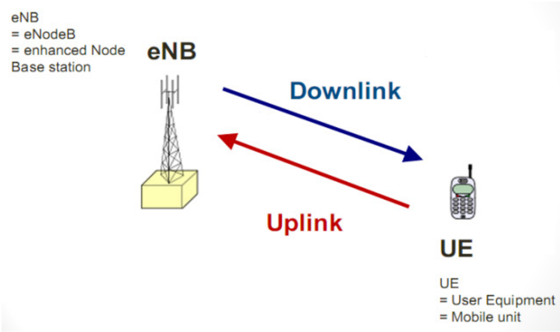

Figure 2. The uplink and downlink nomenclature for LTE networks

Summary from 1G to 4G networks are presented in Table 1 below:

Table 1. Summary

Generation	Features	Applications
First Generation	Uses analog technology.	Voice communication
Second Generation	Primary technologies used	slow-rate data.
Third Generation	144Kb/s for mobile	Advanced applications
Fourth Generation	Require ability of 40Mhz	More rate data

2.5. 5G

5G refers to the fifth generation. Various types of advanced features are included in 5G.

Features

1. Interactive multimedia, voice, internet and others services are supported by 5G
2. It is more effective and attractive as compare to other generation.

For 5G technology IMT 2020 vision [2] has set the limit of peak data rate of 50 Gbps within a minimum latency of 1ms. This puts a requirement of design of advanced efficient channel coding technique in the physical layer to handle such a data rate with minimum BER and low power consumption.

Although 5G is still in the standardization phase, some of the typical performance parameters for 5G are stated in Table 2 and peak data rates in Table 3 below:

Table 2. Suggested performance parameters for 5G [1]

Important Parameters	Values
Data Rate	100 Mbps – 1 Gbps
Peak Data Rate	20 Gbps
Spectral Efficieny	3 times more than 4G
Mobility	500 km/h
Latency	1 ms

Table 3. Evolution of Peak data rates

Technology	**Theoretical peak data rate (at low mobility)**
WCDMA (UMTS)	1.92 Mb/s
HSDPA (Rel 5)	14 Mb/s
HSPA+ (Rel 6)	84 Mb/s
WiMAX (802.16e)	26 Mb/s
LTE (Rel 8)	300 Mb/s
WiMAX (802.16m)	303 Mb/s
LTE-Advanced (Rel 10)	Gb/s

3. Key Technology OFDM and MIMO

3.1. OFDM

Multicarrier communication systems depending on Orthogonal Frequency Divison Multiplexing (OFDM) have attained great interest in recent times as they alleviate ISI which takes place due to the delay spread of wireless channels efficiently. Hence, numerous wireless systems along with standards such as 3GPP LTE wireless cellular systems, HSPA etc. exploit them. OFDM carries out transmission in both the spectral and temporal domains, while MIMO technology utilizes the spatial domain via several antennas at the transmitter and the receiver. Under the conditions of worst propagation and limited spectrum, the MIMO technology offers guaranteed solution. It raises the spectral efficiency via spatial multiplexing gain and enhances link reliability owing to antenna diversity gain.

OFDM is a MCM approach that relies on parallel data transmission, to worsen the effect of multipath fading with the simpler modelling of complex equalizers. Several low data rate carriers are united into a high data bit stream in OFDM, thus transforming frequency selective fading channel into N flat fading channels.

A very important feature of the OFDM access technology is that it allows for a multi-user system called orthogonal frequency division multiple access (OFDMA). However, there are also some problems with OFDM that need to be resolved. The first is the synchronization problem. An OFDM system is more sensitive to time errors such as frequency offset and phase noise. Thus, frequency jitter and Doppler shift between the transmitter and receiver cause Inter-Carrier Interference (ICI), which becomes a challenge in case of medium or high mobility. If the synchronization problem is not addressed properly, it will significantly reduce the performance of OFDM. The next major problem is the occurrence of higher peak-to-average power ratio (PAPR) in OFDM systems. The high PAPR of the OFDM signal places a strict requirement on power amplifiers [Peled & Ruiz, 1980]. For this reason, 3GPP LTE employs SC-FDMA for transmission to reduce the strict requirement on power amplifiers in MSs.

3.2. MIMO

The concept of multiple input and multiple output (MIMO) was first proposed by Bell Laboratories researchers in the mid-1970s when they were looking for a new method to increase system throughput without increasing bandwidth. Since late 1990s, Foschini and Telatar have worked in this field and estimated the measurable improvements in the spectral efficiency. This has increased the research interest.

MIMO has emerged and developed as very significant technology in wireless communications in recent years, owing to its spatial multiplexing and the spatial diversity features (Schmalen et al., 2017). The advantages of MIMO system have good isolation, increased bandwidth and improved radiation with minimized correlation (Jiang and Hanzo, 2007) and bandwidth efficiency (Schmalen et al., 2017). MIMO technology and turbo coding are the two most prominent recent breakthroughs in wireless communication. MIMO technology has shown a significant increase in capacity by exploiting, rather than combating, multipath propagation. The independency of the MIMO channel relies on the presence of rich multipath, which makes the channel spatially selective. Because of its potential for increased throughput, MIMO is included in the 3G (UMTS) cell phone standards, in 802.11n and 802.16 wireless LAN standards.

Further STBC (Space Time Block Code) is a scheme that is exploited in MIMO system so as to transmit numerous replicas of data stream across multiple antennas. It exploits numerous received data versions to enhance the data-transfer reliability. The main objective of MIMO is to maximize the data rate i.e., to improve the average capacity of a wireless link. In addition to providing maximum diversity, it minimizes the outage probability, or maximizes the outage capacity.

4. Advantages and Disadvantages of 5G

Advantages

- It possess very high capacity and speed
- 5G technology act as a backbone for multimedia, voice and internet
- Global access and service portability is also provided by 5G
- High resolution and bi-directional large bandwidth is offered by 5G**.**

Disadvantages

- In some parts of the world it is very difficult to get a high speed.
- Privacy and security problems needed to be improved in 5G
- Old machines needed to be renovated so that they can support 5G technology

5. Challenges in Deployment

The main challenges in deployment in 5G mobile technologies can be summarized as:

1. Network Challenges

- Scarce spectrum- Huge demand for spectrum but availability is limited.
- Demanding applications need multimode handsets that can support multiple features.
- Reliability – To be resistant to channel effects.
- Ubiquitous coverage
- Seamless transfer between indoor and outdoor operation.

2. Device Physical Challenges

- Size, Power, Cost
- MIMO for portable devices
- Multiradio Integration
- Coexistence of multiple standards

3. High mobility - The impact of mobility on transmission can be complex. Mobility also affects addressing and routing. Quality of the transmission depends on distance between the transmitter and receiver. Mobility management

is complex and affects the throughput that the mobile users achieve.

4. Flexibility - Mobile systems should be able to connect to a variety of communication infrastructure, both terrestrial and satellite based, to give true global 'seamless' access.

5. High speed data – The demand for high speed data transfer has been rising day by day. Today many application demand high speed data to the tunes of 10's of MHz and higher. New application even demand data rates to the tunes of 1GHz downlink and 500 MHz uplink. Mobile systems should be capable of providing these. This will require very wide bandwidths, RF operation frequencies in the GHz range, a large number of nanoscale resonators, multiple antennas, high processing speed, more processing power to be put in an even smaller handheld device. Cost, size and extremely low power consumption are the main drivers.

6. Compatibility - Mobile services (5G and beyond) should be compatible with existing networks.

7. Affordability - For commercial success 5G systems should be affordable as today's mobile systems.

6. Conclusion

In this work we presented an overview of several mobile network technologies. It is concluded that the future is 5G wireless networks whereby it promises a Gigabit mobile broadband a reality along with Internet of Things (IoT). It will be available in the market at affordable rates and high peak data rates of 1 Gbps. It helps to provide stronger connection between people working in different fields.

References

[1] "5G Use Cases and Requirements White Paper," in Nokia White Paper, July 2014, [online]. Available: http://resources.alcatel-lucent.com/ asset/200010.

[2] T. S. Rappaport et al., "Millimeter wave mobile communications for 5G cellular: It will work!" IEEE Access, vol. 1, pp. 335-349, May 2013.

[3] Jian Qiao; Xuemin Sherman Shen; Jon W. Mark; Qinghua Shen; Yejun He; Lei Lei "Enabling Device-to-Device Communication in Millimeter-Wave 5G Cellular Networks" IEEE Communications Magazine, vol. 53, pp. 209-215, Jan 2015.