International Journal of Science and Research (IJSR)
ISSN: 2319-7064
ResearchGate Impact Factor (2018): 0.28 | SJIF (2018): 7.426

# Cellular Mobile Technologies (1G to 5G) and Massive MIMO

**MD. Hasan Mahmud**

Pabna University of Science and Technology, Department of Information and Communication Engineering, Rajapur, Pabna-6600, Bangladesh

**Abstract:** ***Cellular network technology supports a hierarchical structure formed by the base transceiver station (BTS), mobile switching center (MSC), location registers and public switched telephone network (PSTN). The BTS enables cellular devices to make direct communication with mobile phones. The unit acts as a base station to route calls to the destination base center controller. The base station controller (BSC) coordinates with the MSC to interface with the landline-based PSTN, visitor location register (VLR), and home location register (HLR) to route the calls toward different base center controllers.In the past few decades, mobile wireless technologies have experience 4 or 5 generations of technology revolution and evolution, namely from 0G to 4G. Current research in mobile wireless technology concentrates on advance implementation of 4G technology and 5G technology. Currently 5G termis not officially used.Multiple-Input Multiple-Output (MIMO) is a wireless technology that uses multiple transmitters and receivers to transfer more data at the same time. All wireless products with 802.11n support MIMO. The technology helps allow 802.11n to reach higher speeds than products without 802.11n.In this knowledgebase article we will focus on the evolution and development of various generations of mobile wireless technology along with their significance and advantages of one over the other. The main contribution of this paper is the basic concept of cellular mobile communication with their generations (1G to 5G).The proposal in this paper also related to Multiple-Input Multiple-Output (MIMO).Some potential areas of research and development (R&D) are also presented.***

**Keywords:** CELLULER, BTS, PSTN, BSC, 1G, 2G, 3G, 4G, 5G, MIMO,GSM

## 1. Introduction

Wireless communication is the transfer of information over a distance without the use of enhanced electrical conductors or "wires". The distances involved may be short (a few meters as in television remote control) or long (thousands or millions of kilometers for radio communications). When the context is clear, the term is often shortened to "wireless". It encompasses various types of fixed, mobile, and portable two-way radios, cellular telephones, Personal Digital Assistants (PDAs), and wireless networking.

Mobile wireless industry has started its technology creation, revolution and evolution since early 1970. From Mid 1990's the cellular communication industry has witnessed explosive growth [1]. Wireless communication networks have become much more pervasive than anyone could have imagined when the cellular concept was first deployed in 1960's and 1970's. Mobile cellular subscribers are increasing 40% per year, and by the end of 2010 there will be 4 times more mobile cellular subscription than fixed telephone lines.

In 1895, Guglielmo Marconi opened the way for modern wireless communications by transmitting the three-dot Morse code for the letter 'S' over a distance of three kilometers using electromagnetic waves [2]. From this beginning, wireless communications has developed into a key element of modern society. Wireless communications have some special characteristics that have motivated specialized studies. First, wireless communications relies on a scarce resource – namely, radio spectrum state. In order to foster the development of wireless communications (including telephony and Broadcasting) those assets were privatized. Second, use of spectrum for wireless communications required the development of key complementary technologies; especially those that allowed higher frequencies to be utilized more efficiently. Finally, because of its special nature, the efficient use of spectrum required the coordinated development of standards.

The first generation (1G) mobile wireless communication network was analog used for voice calls only. The second generation (2G) is a digital technology and supports text messaging. The third generation (3G) mobile technology provided higher data transmission rate, increased capacity and provide multimedia support [3]. The fourth generation (4G) integrates 3G with fixed internet to support wireless mobile internet, which is an evolution to mobile technology and it overcome the limitations of 3G. It also increases the bandwidth and reduces the cost of resources.5G stands for $5^{th}$ Generation Mobile technology and is going to be a new revolution in mobile market which has changed the means to use cell phones within very high bandwidth. User never experienced ever before such high value technology which includes all type of advance features and 5G technology will be most powerful and in huge demand in near future.

## 2. Use of Wireless Communication

Wireless technologies are differentiated on the basis of their range. Some offer connectivity within few feet's viz. Bluetooth and other cover medium sized office space. The mobile phone covers whole continents [4]. Wireless technology offer e-commerce more flexible and in-expensive ways to send and receive data. The four key benefits of wireless technology are as under:-

1) **Handoff:** A handoff refers to the process of transferring an active call or data session from one cell in a cellular network to another or from one channel in a cell to another. A well-implemented handoff is important for delivering uninterrupted service to a caller or data session user [5].
2) **Cell sectoring:** In cell sectoring a single omni-directional antenna at base station is replaced by several

directional antennas, each radiating within a specified sector.

3) **Increased efficiency:** High technology communication systems lead to faster transfer of information within business and between customers.
4) **Rarely out of touch:** No need to carry cables or adapters in order to access office Networks.
5) **Greater flexibility for users:-** Wireless workers in the office can be networked without sitting at dedicated PC's.
6) **Reduced Cost:** Wireless networks are mostly cheaper to install and maintain than wired networks.

## 3. The Global Mobile Cellular Revolution

The global boom in mobile cellular communications has been truly astounding. At the end of 1998 there were more than 300 million subscribers around the world, up from just 11 million in 1990. By theend of this decade there will be more than half a billion mobile users[2].Mobile cellular already accounts for almost one-third of all telephoneconnections. It seems highly likely that the number of mobile cellularsubscribers will surpass conventional fixed lines during the first decadeof the next millennium. Both developed and developing countries aresharing in this revolution: in developed countries, users are flocking to mobile cellular as a complement to existing fixed-lines; in developing nations, mobile cellular is emerging as a substitute for shortages of fixed-lines.

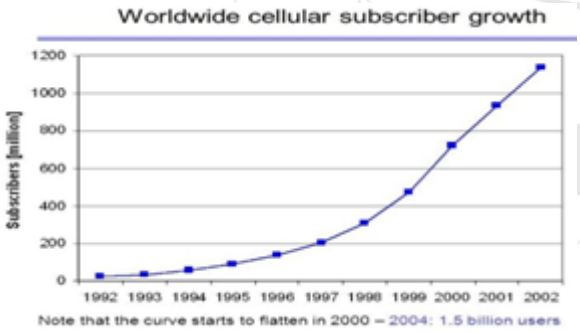


**Figure 1:** Worldwide cellular subscriber growth

The growth of worldwide cellular subscriber increasing day by day.

### 1) Evolution

Mobile communication has become more popular in last few years due to fast reform from 1G to 5G in mobile technology. This reform is due to requirement of service compatible transmission technology and very high increase in telecoms customers[4]. Generation refers change in nature of service compatible transmission technology and new frequency bands. In 1980 the mobile cellular era had started, and since then mobile communications have undergone considerable changes and experienced massive growth.

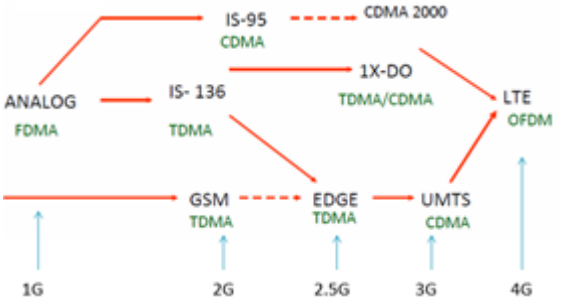


**Figure 2**: Evolution of mobile technology 1G to 4G.

### 2) Zero Generation Technology (0G – 0.5G)

0G refers to pre-cellular mobile telephony technology in 1970s. These mobile telephones wereusually mounted in cars or trucks, though briefcase models were also made[6]. Mobile radio telephonesystems preceded modern cellular mobile telephony technology. Since they were the predecessorsof the first generation of cellular telephones, these systems are sometimes referred to as 0G (zerogeneration) systems. Technologies used in 0G systems included PTT (Push to Talk), MTS (MobileTelephone System), IMTS (Improved Mobile Telephone Service), AMTS (Advanced MobileTelephone System), OLT (Public Land MobileTelephony) and MTD .0.5G is a group of technologies with improved feature than the basic 0G technologies [3]. These earlymobile telephone systems can be distinguished from earlier closed radiotelephone systems in that they were available as a commercial service that was part of the public switched telephone network, with their own telephone numbers, rather than part of a closed network such as a policeradio or taxi dispatch system. These mobile telephones were usually mounted in cars or trucks,though briefcase models were also made.

### 3) First Generation Technology (1G)

In 1980 the mobile cellular era had started, and since then mobile communications have undergonesignificant changes and experienced enormous growth [7]. First-generation mobile systems usedanalog transmission for speech services. In 1979, the first cellular system in the world becameoperational by Nippon Telephone and Telegraph (NTT) in Tokyo, Japan. Two years later, thecellular epoch reached Europe. The two most popular analogue systems were Nordic MobileTelephones (NMT) and Total Access Communication Systems (TACS). Other than NMT and TACS,some other analog systems were also introduced in 1980s across the Europe [2]. All of these systemsoffered handover and roaming capabilities but the cellular networks were unable to interoperatebetween countries. This was one of the inevitable disadvantages of first-generation mobile networks. The AMPS system was frequency modulated and used frequency division multiple access (FDMA) with a channel capacity of 30 KHz and frequency band of 824-894MHz. Its basic features are:

- Speed-2.4 kbps
- Allows voice calls in 1 country
- Use analog signal.
- Poor voice quality
- Poor battery life
- Large phone size
- Limited capacity
- Poor handoff reliability

- Poor security
- Offered very low level of spectrum efficiency

**Paging networks**

This is one of the oldest technology which includes caller and a pager. What happens is that a caller calls a pager and leaves a short message [1]. Fig.3 shows the paging network. Example of paging networks - BellSouth Clamshell Pager with keyboard.

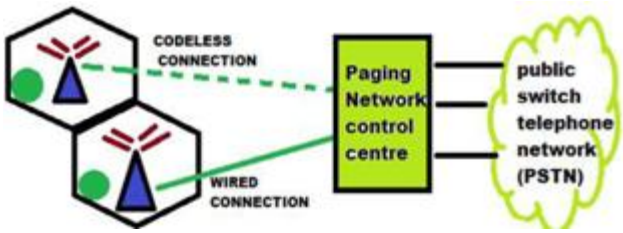


**Figure 3**: Concept of Paging system.

**There are various advantages of paging networks-**

- It is very easy to operate.
- Penetrates efficiently through the building.
- Users have an open option to use it numerically, alphanumerically, tow way.
- Message storage.
- Not at all expensive.

**Limitations of paging networks are as follows-**

- There is an extra cost of two-way paging.
- Data transfer rate is 1200bps i.e. very slow.
- Overloading and delay is also caused.

**4) Second Generation (2G –Digital System)**

Based on digital transmission, 2G cellular network was introduced in the late 1980s [8]. There are various advantages of digital system over analog system 2G refers to the second generation based on GSM and was emerged in late 1980s. It uses digital signals for voice transmission. Main focus of this technology was on digital signals and provides services to deliver text and picture message at low speed (in kbps) [9]. It use the bandwidth of 30 to 200 KHz. Next to 2G, 2.5G system uses packet switched and circuit switched domain and provide data rate up to 144 kbps. e.g. GPRS, CDMA and EDGE.

**The main features of 2G:**

- Data speed was up to 64kbps.
- Use digital signals.
- Enables services such as text messages, picture messages and MMS (Multimedia message).
- Provides better quality and capacity.
- Unable to handle complex data such as videos.
- Required strong digital signals to help mobile phones work. If there is no network coverage in any.
- Specific area, digital signals would weak

Benefits of 2G over its predecessor 2G allows far greater phone penetration hence has more efficient spectrum [10].

2G cellular network is digitally encrypted. SMS text messaging and other services were started with 2G cellular network.

**5) Limitations of 2G networks are as follows**

- 2G digital system sometimes have dropouts under very easy with the analog systems to use slightly worse conditions whereas analog system is same phone numbers with different headsets static.
- Particular problem on 2G cellular system is that digital system are more secured as compared sometimes weaker digital system may not reach the to 1G that was based on the analog system. cell tower.
- Digital has a jagged steppy curve whereas analog Cellular telecoms. has a smooth decay curve.

**6) 2.5G - GPRS (General Packet Radio Service)**

2.5G, which stands for "second and a half generation," is a cellular wireless technology developed in between its predecessor, 2G, and its successor, 3G [11]. The term "second and a half generation" is used to describe 2G-systems that have implemented a packet switched domain in addition to the circuit switched domain. "2.5G" is an informal term, invented solely for marketing purposes, unlike "2G" or"3G" which are officially defined standards based on those defined by the International Telecommunication (ITU). GPRS could provide data rates from 56 kbit/s up to 115 kbit/s. It can be used for services such as Wireless Application Protocol (WAP) access, Multimedia Messaging Service (MMS), and for Internet communication services such as email and World Wide Web access [12]. GPRS data transfer is typically charged per megabyte of traffic transferred, while data communication via traditional circuit switching is billed per minute of connection time, independent of whether the user actually is utilizing the capacity or is in an idle state.2.5G networks may support services such as WAP, MMS, SMS mobile games, and search and directory.

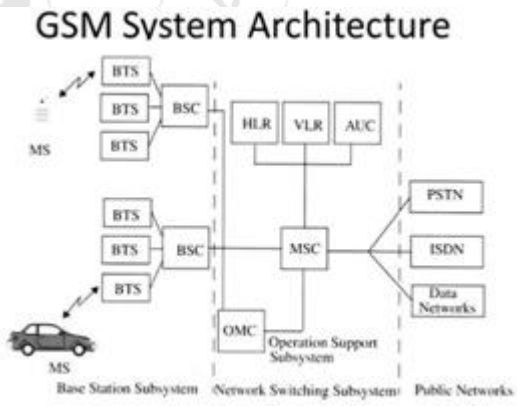


**Figure 4:** GSM System Architecture.

**The main features of 2G :**

- Provides phone calls.
- Send/receive e-mail messages.
- Web browsing.
- Speed: 64-144 kbps.
- Camera phones.
- Take a time of 6-9 mins. to download a 3 mins. MP3 song.

**7) 2.75–EDGE (Enhanced Data rates for GSM Evolution)**

EDGE (EGPRS) is an abbreviation for Enhanced Data rates for GSM Evolution, is a digital mobile phone technology

which acts as a bolt-on enhancement to 2G and 2.5G General Packet Radio Service (GPRS) networks [3].

EDGE refers to Enhanced Data Rates for GSM Evolution and is a next phase after GPRS. Data rates up to 500 kbps could be delivered by EDGE. To overcome the limitations of GPRS, EDGE has been designed. Data rates in GPRS are much lower than they actually display or advertise however to achieve data transmission of 172.2kbps, a single user would require all the 8 timeslots. GPRS is based on GMSK (Gaussian Modulation Shift Keying) whereas EDGE is based on 8PSK (Eight-Phase Shift Keying) [14].3G also uses 8PSK as it allows higher data rates.

This technology works in GSM networks. EDGE is a superset to GPRS and can function on any network with GPRS deployed on it, provided the carrier implements the necessary upgrades. EDGE technology is an extended version of GSM. It allows the clear and fast transmission of data and information. It is also termed as IMT-SC or single carrier. EDGE technology was invented and introduced by Cingular, which is now known as AT& T. EDGE is radio technology and is a part of third generation technologies. EDGE technology is preferred over GSM due to its flexibility to carry packet switch data and circuit switch data. The use of EDGE technology has augmented the use of black berry, N97 and N95 mobile phones. EDGE transfers data in fewer seconds if we compare it with GPRS Technology. For example a typical text file of 40KB is transferred in only 2 seconds as compared to the transfer from GPRS technology, which is 6 seconds [5]. The biggest advantage of using EDGE technology is one does not need to install any additional hardware and software in order to make use of EDGE Technology. There are no additional charges for exploiting this technology. If a person is an ex GPRS Technology user he can utilize this technology without paying any additional charges.

**8) Third Generation Technology (3G – 3.75G)**

3G refers to the third generation of mobile telephony (that is, cellular) technology. The third generation, as the name suggests, follows two earlier generations. The first generation (1G) began in the early 80's with commercial deployment of Advanced Mobile Phone Service (AMPS) cellular networks. Early AMPS networks used Frequency Division Multiplexing Access (FDMA) to carry analog voice over channels in the 800 MHz frequency band [15].3G technologies enable network operators to offer users a wider range of more advanced services while achieving greater network capacity through improved spectral efficiency. Services include wide area wireless voice telephony, video calls, and broadband wireless data, all in a mobile environment. Additional features also include HSPA data transmission capabilities able to deliver speeds up to 14.4Mbit/s on the downlink and 5.8Mbit/s on the uplink. Spectral efficiency or spectrum efficiency refers to the amount of information that can be transmitted over a given bandwidth in a specific digital communication system. High-Speed Packet Access (HSPA) is a collection of mobile telephony protocols that extend and improve the performance of existing UMTS protocols [2].

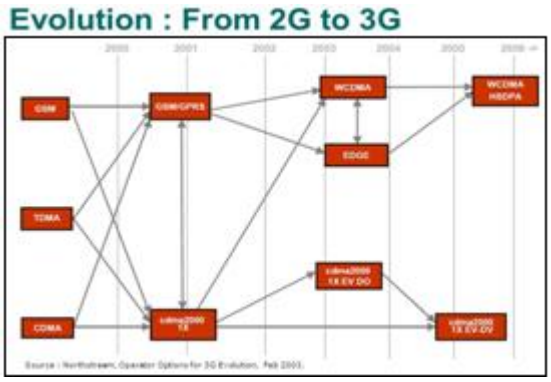


**Figure 5**: Evolution from 2G to 3G.

**The main features of 3G are:-**

- Speed 2 Mbps
- Typically called smart phones
- Increased bandwidth and data transfer rates to accommodate web-based applications and audio and video files.
- Provides faster communication
- Send/receive large email messages
- High speed web/more security/video conferencing/3D gaming
- Large capacities and broadband capabilities
- TV streaming/mobile TV/Phone calls
- To download a 3 minute MP3 song only 11 sec-1.5 min time required.
- Expensive fees for 3G licenses services
- It was challenge to build the infrastructure for 3G
- High bandwidth requirement
- Expensive 3G phones
- Large cell phones

3G mobile system was called as UMTS (Universal Mobile Telecommunication System) in Europe, while CDMA2000 is the name of American 3G variant [4]. Also the IMT2000 has accepted a new 3G standard from China, i.e. TD-SCDMA. WCDMA is the air-interface technology for UMTS.

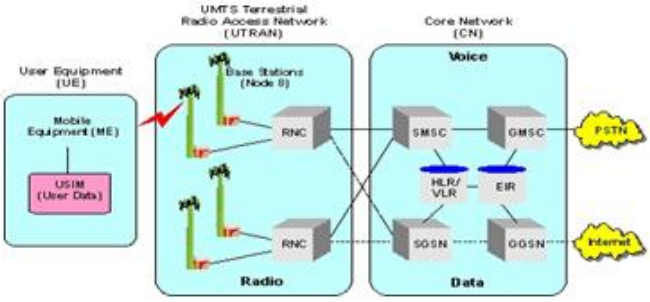


**Figure 6:** WCDMA System Architecture.

**9) 3.5G – HSDPA (High-Speed Downlink Packet Access)**

High-Speed Downlink Packet Access(HSDPA) is a mobile telephony protocol, also called 3.5G (or"3½G"), which provides a smooth evolutionary path for UMTS-based 3G networks allowing for higher data transfer speeds [5]. HSDPA is a packet-based data service in W-CDMA downlink with data transmission up to 8-10 Mbit/s (and 20 Mbit/s for MIMO systems) over a 5MHz bandwidth in WCDMA downlink. HSDPA implementations includes

Adaptive Modulation and Coding (AMC), Multiple-Input Multiple-Output (MIMO), Hybrid Automatic Request (HARQ), fast cell search, and advanced receiver design.

**10)3.75G – HSUPA (High-Speed Uplink Packet Access)**

The 3.75G refer to the technologies beyond the well defined 3G wireless/mobile technologies. High Speed Uplink Packet Access (HSUPA) is a UMTS / WCDMA uplink evolution technology [6]. The HSUPA mobile telecommunications technology is directly related to HSDPA and the two are complimentary to one another. HSUPA will enhance advanced person-to-person data applications with higher and symmetric data rates, like mobile e-mail and real-time person-to person gaming. Traditional useful applications along with many consumer applications will benefit from enhanced uplink speed [7]. HSUPA will initially boost the UMTS / WCDMA uplink up to 1.4Mbps and in later releases up to5.8Mbps.

**11)Fourth Generation (4G)**

4G refers to the fourth generation of cellular wireless standards. It is a successor to 3G and 2Gfamilies of standards. The nomenclature of the generations generally refers to a change in the fundamental nature of the service, non-backwards compatible transmission technology and new frequency bands [5]. The first was the move from 1981 analogue (1G) to digital (2G) transmission in1992. This was followed, in 2002, by 3G multi-media support, spread spectrum transmission and at least 200 kbit/s, soon expected to be followed by 4G, which refers to all-IP packet-switched networks, mobile ultra-broadband (gigabit speed) access and multi-carrier transmission. Pre-4Gtechnologies such as mobile WiMAX and first-release 3G Long Term Evolution (LTE) have been available on the market since 2006and 2009 respectively. It is basically the extension in the 3G technology with more bandwidth and services offers in the 3G.The expectation for the 4G technology is basically the high quality audio/video streaming over end to end Internet Protocol. If the Internet Protocol (IP) multimedia sub-system movement achieves what it going to do, nothing of this possibly will matter. WiMAX or mobile structural design will become progressively more translucent, and therefore the acceptance of several architectures by a particular network operator ever more common. Some of the companies trying 4G communication at 100 Mbps for mobile users and up to 1 Gbps over fixed stations [2]. They planned on publicly launching their first commercial wireless network around2010. As far as other competitor's mobile communication companies working on 4G technology even more quickly. Sprint Nextel was planned to launch WiMAX over 4 G broadband mobile networks in United States. Some of the other developed countries like United Kingdom stated a plan to sale via auction of 4G wireless frequencies couple of years back [3]. The word "MAGIC" also refers to 4G wireless technology which stands for Mobile multimedia, Any-where, Global mobility solutions over, integrated wireless and Customized services.

**The main features of 4G are:**

- Capable of provide 10Mbps-1Gbps speed.
- High quality streaming video.
- Combination of Wi-Fi and Wi-Max.
- High security.
- Provide any kind of service at any time as per user requirements anywhere.
- Expanded multimedia services.
- Low cost per-bit.
- Battery uses is more.
- Hard to implement.
- Need complicated hardware.
- Expensive equipment required to implement next generation network.

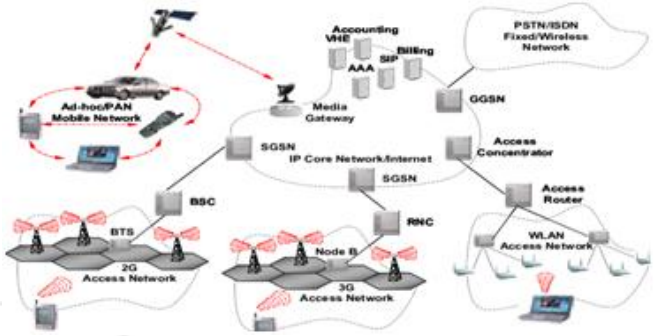


**Figure 7**: 4G System Architecture

**12) Fifth Generation (5G)**

5G (5th generation mobile networks or 5Th generation wireless systems) is a name used in some research papers and projects to denote the next major phase of mobile telecommunications standards beyond the upcoming 4G standards, which are expected to be finalized between approximately 2011 and 2013 [4]. Currently 5G is not a term officially used for any particular specification or in any official document yet made public by telecommunication companies or standardization bodies such as 3GPP, WiMAX Forum or ITU-R. New 3GPP standard releases beyond4G and LTE Advanced are in progress, but not considered as new mobile generations [3].5G Technology stands for 5th Generation Mobile technology. 5G technology has changed the means to use cell phones within very high bandwidth. User never experienced ever before such a high value technology. Nowadays mobile users have much awareness of the cell phone (mobile) technology. The 5G technologies include all type of advanced features which makes 5G technology most powerful and in huge demand in near future. The gigantic array of innovative technology being built into new cell phones is stunning. 5Gtechnology which is on hand held phone offering more power and features than at least 1000 lunar modules [16]. A user can also hook their 5G technology cell phone with their Laptop to get broadband internet access. 5G technology including camera, MP3 recording, video player, large phone memory, dialing speed, audio player and much more you never imagine. For children rocking fun Bluetooth technology and Piconets has become in market.5G technology going to be a new mobile revolution in mobile market. Through 5G technology now you can use worldwide cellular phones and this technology also strike the china mobile market and a user being proficient to get access to Germany phone as a local phone. With the coming out of cellphone alike to PDA now your whole office in your finger tips or in your phone [17]. 5G technology has extraordinary data capabilities and has ability to tie together unrestricted call volumes and infinite data broadcast within latest mobile operating system. 5G technology has a bright future because it can handle best technologies and offer priceless handset to their customers.

May be in coming days5G technology takes over the world market.

The main focus of 5G will be world-Wireless World Wide Web (WWWW). It is a complete wireless communication with no limitations.

**The main features of 5G are :**

- It is highly supportable to WWWW (wireless World Wide Web)
- High speed, high capacity
- Provides large broadcasting of data in Gbps.
- Multi-media newspapers, watch TV programs with the clarity(HD Clarity)
- Faster data transmission that of the previous generation
- Large phone memory, dialing speed, clarity in audio/video
- Support interactive multimedia, voice, streaming video, internet and other
- More effective and attractive

**Features of 5G**

- The current trend of 5G technology has a following feature.
- The 5G technology is providing up to 25 Mbps connectivity speed 5G technology offer high resolution for cell phone user and bi- directional large bandwidth sharing.
- 5G technology is providing large broadcasting of data in Gigabit which supporting almost 65,000 connections.
- The uploading and downloading speed of 5G technology touching the peak
- The 5G technology also support virtual private network.
- The 5G terminals will have software defined radios and modulation schemes as well as new error control schemes that can be downloaded from the Internet.
- The development is seen towards the user terminals as a focus of the 5G mobile networks. E.g.
- The advanced billing interfaces of 5G technology makes it more attractive and effective,
- The 5G technology network offering enhanced and available connectivity just about the world
- The terminals will have access to different wireless technologies at the same time and the terminal should be able to combine different flows from different technologies.
- The vertical handovers should be avoided, because they are not feasible in a case when there are many technologies and many operators and service providers.

**13) Challenges Facing 5G**

- **Integration of various standards:-** One of the big challenges facing 5G is standardization. There are already multiple groups working to come up with standards around interoperability, backward compatibility with older technologies (4G, 3G), and making sure the network will be future-proof [7].
- **Common Platform:-** There is no common architecture for interconnecting various engineering practices. One common governing body is required, which creates a common platform for all engineering practices to regularize the interconnectivity issues as well as knowledge sharing.
- **Building the infrastructure:-** It is a huge task, with issues around spectrum and installing new antennas. 5G is likely going to rely, at least in part, on higher-frequency bands. There is more space in those airwaves available, but at such high frequencies, signals can't travel nearly as far as they can over the frequencies used for 4G, resulting in a poor connection [16].
- **Obstacles:-**Like buildings, trees and even bad weather can also cause interference. To offset that, carriers will need to install more base stations to ensure better coverage, and use antenna technologies like MIMO.

**14) 5G Specification**

Although the standards bodies have not yet defined the parameters needed to meet a 5G performance level yet, other organizations have set their own aims that may eventually influence the final specifications [4]. Typical parameters for a 5G standard may include:

**Table 1:** 5G Wireless Performance

| *Parameter* | *Performance* |
|---|---|
| Network Capacity | 10000 times |
| Peak Data Rate | 10 Gbps |
| Cell Edge Peak Data Rate | 100 Mbps |
| Latency | <1 Mbps |

These are some of the ideas being put forwards for a 5G standard, but they are not accepted by any official bodies yet.

**Applications of 5G**

- Applications of 5G are beyond our imagination. User never experienced ever before such high value technology which includes all type of advance features. Some of the applications of 5G are:
- We can able to charge our mobile using our own heart beat
- We can able to feel our grandmother's sugar level with our mobile
- We can able to know the exact time of our child birth in nano seconds.
- Our mobile rings according to our mood.
- We can vote from our mobile
- We can able to visualize lively all the planets anduniverse. Also we can able to navigate a train for which we are waiting.
- We can able pay all our bills in a single payment with our mobile
- We can able to sense Tsunami/Earthquake before it occurs.
- We can access our office desktop, Laptop, car, bike using our mobile,
- We can identify our stolen mobile within nanoseconds
- Our mobile can share our workload, identify the best server and also intimate us before the call drops.
- We can able to expand our coverage using mobile phones.
- We can able to fold our mobile as per our desire.

**15) GSM (Global System for Mobile Communication)**

GSM or global system for mobile communication is a digital cellular system [2]. It was originated in Finland Europe. However now it is throughout the world. GSM (Global

System for Mobile Communication) accounts for 80% of total mobile phone technologies market. There are over more than 3 billion users of GSM (Global System for Mobile Communication) now [3]. GSM technology got its popularity, when people used it to talk to their friends and relatives. The use of GSM (Global System for Mobile Communication) is possible due to the SIM (subscribers identity module) GSM (Global System for Mobile Communication) is easy to use, affordable and helps you carry your cell phone everywhere. GSM (Global System for Mobile Communication) is a 2G technology. There are many frequency ranges for GSM (Global System for Mobile Communication) however 2G is the most used frequency [5]. GSM (Global System for Mobile Communication) offers moderate security. It allows for encryption between the end user and the service base station. The use of various forms of cryptographic modules is part of GSM technology.

### 16) MIMO Concept

MIMO stands for multiple input and multiple output. Since there are multiple inputs and multiple outputs therefore the capacity is increased. More data can be added to the wireless channels as there are multiple antennas at the transmitter and the receiver [8]. From Fig.8 it is seen that there is multipath propagation in which more than one data signal on the same radio signal is sent and received and hence energy efficiency, spectral efficiency and reliability can be improved [9].

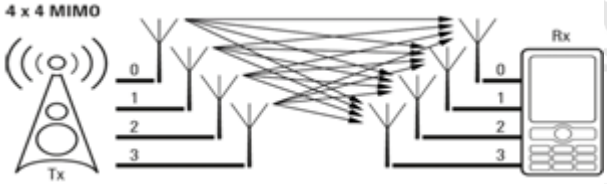


**Figure 8:** MIMO Architecture

### Types of MIMO Systems

There are two major categorizations to determine the types of MIMOs

- Single-User MIMO (SU-MIMO)
- Multi-User MIMO (MU-MIMO)
- Open-loop MIMO
- Close-loop MIMO

**Single-User MIMO (SU-MIMO):-** Single-user MIMO can be defined as increase in the data rate for a single user equipment (UE).

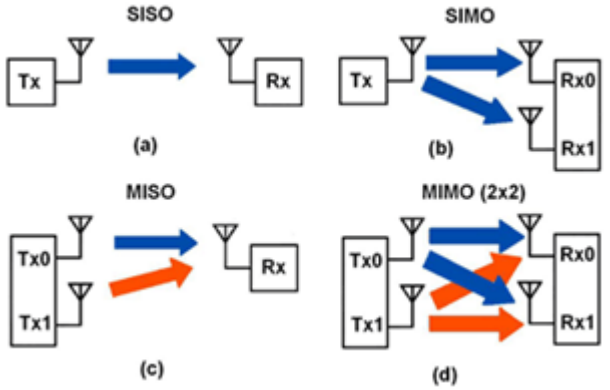


**Figure 9**: Single-User MIMO (a), (b). Multi-User MIMO (c), (d).

**Multi-User MIMO (MU-MIMO):-** If the industrial streams are allocated to numerous users, this is known as multi-user MIMO. This MIMO mode is mostly useful in the uplink based on the complexity placed on the user equipment side, and it can be kept to a minimum range by using only one antenna. This MIMO is also known as Collaborative MIMO [10].

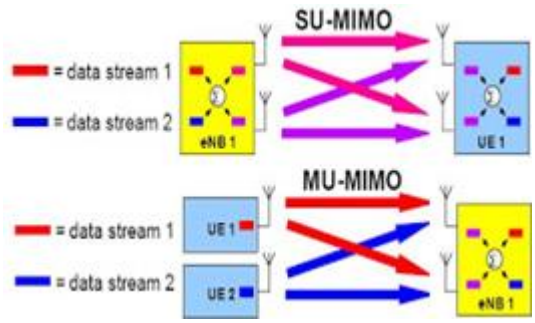


**Figure 10:** Data stream structure of Single-User MIMO andMulti-User MIMO.

**Open loop MIMO:**--By using this Open-Loop MIMO, the communications' channel does not use explicit information towards the propagation channel [11]. The common Open-Loop MIMO systems consist of Space Time Transmit Diversity (STTD), Spatial Multiplexing (SM) and Collaborative Uplink MIMO.

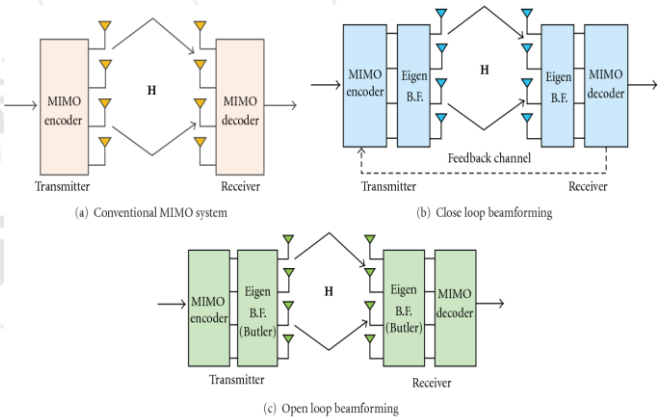


**Figure 11:** (a) Conventional MIMO system. (b) Close loop beam forming. (c) Open loop beam forming.

**Space Time Transmit Diversity (STTD) MIMO:**-Space Time Transmit Diversity (STTD) is a technique of transmit diversity used in UMTSS third-generation cellular systems. Space Time Transmit Diversity is optional in the UTRANN air interface, but compulsory for user equipment [8]. STTD utilizes Space Time Block Code (STBC) to abuse redundancy in multiple transmitted forms of a signal. The same data is coded and transmitted through various antennas that efficiently double the power in the channel. This improves Signal Noise Ratio (SNR) for the cell-edge performance.

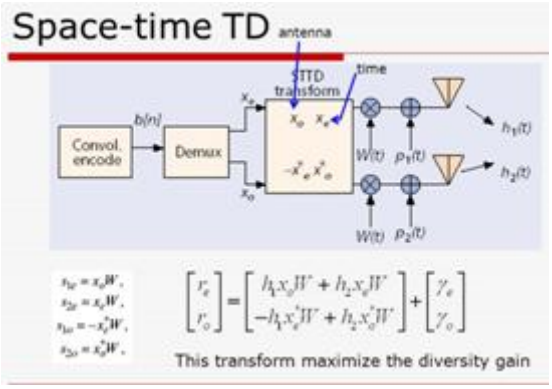


**Figure 12:** Space time transmit diversity (STTD) MIMO

### 17) Massive MIMO for 5G

**Massive MIMO:-**Massive MIMO is the currently most compelling sub-6 GHz physical-layer technology for future wireless access. The main concept is to use large antenna arrays at base stations to simultaneously serve many autonomous terminals. The rich and unique propagation signatures of the terminals are exploited with smart processing at the aray to achieve superior capacity [18]. Massive MIMO splendidly offers two most desirable benefits:

**Excellent spectral efficiency**
achieved by spatial multiplexing of many terminals in the same time-frequency resource. Efficient multiplexing requires channels to different terminals to be sufficiently different, which has been shown to hold, theoretically and experimentally, in diverse propagation environments. Specifically, it is known that Massive MIMO works as well in line-of-sight as in rich scattering

**Superior energy efficiency**, by virtue of the array gain, that permits a reduction of radiated power. Moreover, the ability to achieve excellent performance while operating with low-accuracy signals and linear processing further enables considerable savings.

### 18) The key technological characteristics of Massive MIMO are

- Fully digital processing; each antenna has its own RF and digital baseband chain. Signals from all antennas at each base station are processed coherently together [17]. Core advantages of fully digital processing include the avoidance of specific assumptions on propagation channel, the possibility to measure the complete channel response on the uplink and respond fast to changes in the channel. Interestingly, recent assessments show that the full digital processing may not only offer superior performance but also better energy efficiency, a trend which maybe reinforced by the ongoing development of tailored low-power circuits.
- The reliance on reciprocity of propagation and TDD operation, enabling downlink channels to be estimated from uplink pilots, and obviating the need for prior or structural knowledge of the propagation channel [16].
- Computationally inexpensive pre coding/decoding algorithms, taking the form of maximum-ratio (known also as conjugate beam forming) or zero-forcing processing. Massive MIMO functions equally well with single-carrier transmission and OFDM [5]. Notably, conjugate beam forming with OFDM is equivalent to time-reversal in a single-carrier system.
- Array gain, resulting, in principle, in a closed-loop link budget enhancement proportional to the number of base station antennas.
- Channel hardening that effectively removes the effects of fast fading. Operationally, each terminal-base station link becomes a scalar channel whose gain stabilizes to a deterministic and frequency-independent constant. This greatly simplifies resource allocation problems [4].
- The provision of uniformly good quality of service to all terminals in a cell--facilitated by the link budget improvement offered by the array gain, and the interference suppression capability offered by the spatial resolution of the array. Typical baseline power control algorithms achieve max-min fairness among the terminals.
- Autonomous operation of the base stations, with no sharing of payload data or channel state information with other cells, and no requirements of accurate time synchronization.
- The possibility to reduce accuracy and resolution of transceiver frontends, and the digital processing and number representations in computations.

### 19) Limitations of Massive MIMO

Massive MIMO is scalable with respect to antennas; additional antennas always help. The ultimate limit is dictated by mobility: every coherence interval (coherence time multiplied by coherence bandwidth) needs to accommodate uplink pilots, and payload in the uplink and downlink directions. The higher mobility, the less channel coherence and the fewer pilots can be afforded. In high-mobility macro-cellular environments (highway), this limits the multiplexing gain to some dozen of terminals but in environments with less or no mobility, hundreds or even thousands of terminals could in principle be multiplexed. The number of antennas that ultimately prove useful scales similarly, and are likely to be limited to one or a few hundred in macro-cellular, but potentially thousands in low-mobility applications.

**Future of Massive MIMO**
Massive MIMO can offer enhanced broadband services in the future, and more. 5G networks are expected to support a great variety of wireless services in areas ranging from infotainment to healthcare, smart homes and cities, manufacturing, and many others. Massive MIMO technology can be tailored to support a massive number of Massive Machine Type Communication (MTC) devices. Also, it is an excellent candidate to realize Ultra Reliable Communication as it can establish very robust physical links.

## 4. Conclusion

This paper gives brief on individual cellulargeneration of mobile wireless technology and itsevolution from 1G and emerging up to 5G.This paper also gives brief about MIMO (Multiple input multiple output) system and how MIMO is connected to 5G.Themodified versions of these cellular networksenabled users to expand their business andcommunicate worldwide. As the use ofcommunication

has reached from personal level toprofessional level, the evolution of 4G has provideda time saving and easy access technology to theprofessionals. Also 5G technologies have highstandards that define capabilities beyond thosedefined in the current 4G standards. User neverexperienced ever before such a high valuetechnology.

## References

[1] Ms. Lopa J. Vora, "EVOLUTION OF MOBILE GENERATION TECHNOLOGY: 1G TO5G AND REVIEW OF UPCOMING WIRELESS TECHNOLOGY 5G," international journal modern trends in engineering and research,scientific journal impact facor(SJIF):1.711.
[2] Nikhil Bhandari, ShivinderDevra, KaramdeepSingh,"Evolution of Cellular Network: From 1G to 5G,"International Journal of Engineering and Techniques - Volume 3 Issue 5, Sep - Oct 2017.
[3] Swati Yadav, Sugandha Singh, "Review Paper on Development of Mobile Wireless Technologies (1G to 5G),"International Journal of Computer Science and Mobile Computing,IJCSMC, Vol. 7, Issue. 5, May 2018, pg.94 – 100.
[4] Erik G. Larsson, "Massive MIMO for 5G" Linköping University, Linköping, SwedenandLiesbet Van der Perre, KU Leuven, Leuven, BelgiumIEEE 5G Tech Focus: Volume 1, Number 1, March 2017.
[5] G. A. Akpakwu, B. J. Silva, G. P. Hancke, A. M. Abu-Mahfouz, "A Surveyon 5G Networks forthe Internet of Things: Communication Technologies and Challenges", IEEE Access, vol. 6, pp. 3619-3647, 2018.
[6] T. S. Rappaport et al., "Overview of millimeter wave communicationsforfifth-generation (5G) wirelessnetworks—with a focusonpropagationmodels", IEEE Trans. AntennasPropag., vol. 65, no. 12, pp. 6213-6230, 2017.
[7] E. G. Larsson, O. Edfors, F. Tufvesson, T. Marzetta, "Massive MIMO for next generation wireless systems", IEEE Commun. Mag., vol. 52, no. 2, pp. 186-195, Feb. 2014.
[8] V. Savic, E. G. Larsson, "Fingerprinting-based positioning in distributed massive MIMO systems", Proc. IEEE 82nd Veh. Technol. Conf., pp. 1-5, 2015.
[9] L. Zeng, “High data rate multiple input multiple output (MIMO) optical wireless communications using white led lighting,” IEEE J. Sel. Areas Commun., vol. 27, no. 9, pp. 1654–1662, Dec. 2009.
[10] A. Sayeed, A. Perrig, "Secure wireless communications: Secret keys through multipath", Acoustics Speech and Signal Processing 2008. ICASSP 2008. IEEE International Conference on, pp. 3013-3016, March 2008.
[11] D. Patron, H. Paaso, A. Mammela, D. Piazza, K. Dandekar, "Improved design of a crlh leaky-wave antenna and its application for doa estimation", Antennas and Propagation in Wireless Communications (APWC) 2013 IEEE-APS Topical Conference on, pp. 1343-1346, Sept 2013.
[12] T. S. Rappaport et al., "Millimeter wave mobile communications for 5G cellular: It will work", IEEE Access, vol. 1, pp. 335-349, May 2013.
[13] E. G. Larsson, O. Edfors, F. Tufvesson, T. Marzetta, "Massive MIMO for next generation wireless systems", IEEE Commun. Mag., vol. 52, no. 2, pp. 186-195, Feb. 2014.
[14] W. H. Chin, Z. Fan, R. Haines, "Emerging technologies and research challenges for 5G wireless networks", IEEE Wireless Commun., vol. 21, no. 2, pp. 106-112, Apr. 2014.
[15] A. Guerra, F. Guidi, D. Dardari, "Position and orientation error bound for wideband massive antenna arrays", Proc. IEEE Int. Conf. Commun. Workshop, pp. 853-858, 2015.
[16] F. Guidi, A. Guerra, D. Dardari, "Personal mobile radars with millimeter-wave massive arrays for indoor mapping", IEEE Trans. Mobile Comput., vol. 15, no. 6, pp. 1471-1484, Jun. 2016.
[17] S. Azzouzi, M. Cremer, U. Dettmar, R. Kronberger, T. Knie, "New measurement results for the localization of UHF RFID transponders using an angle of arrival (AOA) approach", Proc. IEEE Int. Conf. RFID, pp. 91-97, 2011
[18] L. Zeng, “High data rate multiple input multiple output (MIMO) optical wireless communications using white led lighting,” IEEE J. Sel. Areas Commun., vol. 27, no. 9, pp. 1654–1662, Dec. 2009.

## Author Profile

**MD. Hasan Mahmud**.(*jibonpustice@gmail.com*) Student of Pabna University Of Science and Technology, Department Of Information and Communication Engineering, Rajapur, Pabna-6600, Bangladesh.