# East West University

**Thesis Title**
A Study of Fifth Generation Wireless Cellular Technology

Submitted by:
Adiba Armin
ID: 2013-3-55-008

Faiza Farzana Gunjan
ID: 2014-1-55-007

Bristy Saha
ID: 2014-1-55-023

Thesis Supervisor:
M. Mofazzal Hossain, Ph.D.
Professor,
Department of Electronics and Communications Engineering

# Declaration

We hereby declare that we have completed project on the topic entitled "A Study of Fifth Generation Wireless Cellular Technology" as well as prepared as research report to the department of Electronics and Communication Engineering East West university in partial fulfillment of the requirement for the degree of B.Sc. in Electronics and Telecommunications Engineering, Under the course "Research/Internship (ETE 498)".

We further assert that this report in question is based on our original exertion having never been produced fully and/or partially anywhere for any requirement.

…………………………
Adiba Armin
ID: 2013-3-55-008
Department of ECE
East West University

…………………………
Faiza Farzana Gunjan
ID: 2014-1-55-007
Department of ECE
East West University

…………………………
Bristy Saha
ID: 2014-1-55-023
Department of ECE
East West University

# Acceptance

This research report presented to the department of Electronics and Communications Engineering, East West University is submitted in partial fulfillment of the requirement for the degree of B.Sc. in Electronics and Telecommunications Engineering, under complete supervision of the undersigned.

……………………………
M. Mofazzal Hossain, Ph.D.
Professor,
Department of Electronics and Communication Engineering

# Acknowledgement

First and foremost with all our heartiest devotion we are grateful to almighty Allah for blessing me with such opportunity of learning and ability to successfully complete the task.

A special Thanks with honor to our supervisor Dr. M. Mofazzal Hossain who was kind enough to allocate his valuable time to provide us with his humble guidance, motivating thought and encouragement.

……………………………
Adiba Armin
2013-3-55-008
Department of ECE
East West University

……………………………
Faiza Farzana Gunjan
2014-1-55-007
Department of ECE
East West University

……………………………
Bristy Saha
2014-1-55-023
Department of ECE
East West University

# Abstract

In near future, the major demands from wireless cellular technologies should be high data rate, more capacity to handle users, and lower latency along with better quality of service. To meet all these requirements a vast improvement should be made in wireless cellular network architecture. This thesis is a study over fifth generation (5G) cellular network architecture and some key technologies of 5G cellular network architecture.  These emerging technologies should help to improve the architecture meeting the demands of users. When come to the technologies there is more focus on massive multiple input multiple output (MIMO) technology, and device-to-device (D2D) communication. Together with these other different technologies are studied. These technologies include spectrum sharing with cognitive radio, interface management, ultra dense networks, full duplex radios, multi radio access network technologies, and millimeter wave solution 5G cellular networks, along with cloud technologies for 5G radio access network. In this thesis a general 5G network architecture is studied consisting different technologies. Apparently it is expected that 5G will give a higher data rate up to 50 Gbps with low battery consumption. It will provide improved coverage cell edge with multiple concurrent paths for data transmission. Different artificial intelligent mobile applications can be designed as it has higher speed.  5G also have the feature of VPN and remote diagnostics. 5G will provide protection for private data, which is being reviewed in standardization bodies like 3GPPP, IETF.

# INDEX

**Contents** **Page No**

# List of Acronyms

G – Generation

1G – 1st Generation

2G – 2nd Generation

3G – 3rd Generation

3GPP – 3rd Generation Partnership Project

4G – 4th Generation

5G – 5th Generation

AMPS – Advanced Mobile Phone System

AMTS – Advanced Mobile Telephone System

API – Application Programming Interface

BDMA – Beam Division Multiple Access

CDMA – Code Division Multiple Access

CR – Cognitive Radio

CRAN – Cloud Random Access Network

CPE – Control Plan Entity

D2D – Device-to-Device

DVB – Digital Video Broadcasting

E2E – End-to-End

EDGE – Enhanced Data rate in GSM Environment

ETSI – European Telecommunication Standards Institute

EVDO – Evolution-Data Optimization

FBMC – Filter Bank Multicarrier

FCC – Federal Communications Commission

FDMA – Frequency Division Multiple Access

GPRS – General Packet Radio Service

GSM – Global System for Mobile communication

HD – High Definition

HSDPA – High Speed Downlink Packet Access

HSUPA – High Speed Uplink Packet Access

iDEN – Integrated Digital Enhanced Network

IETF – Internet Engineering Task Force

IMSI – International Mobile Subscriber Identity

IMTS – Improved Mobile Telephone Service

IoT – Internet of Things

ISP – Internet Service Provider

IP – Internet Protocol

LAS-CDMA – Large Area Synchronized Code Division Multiple Access

LMDS – Local Multipoint Distribution System

LTE – Long Term Evaluation

M2M – Machine-to-Machine

MTS – Mobile Telephone System

MBWA – Mobile Broadband Wireless Access

MC-CDMA – Multi-carrier Code-division Multiple Access

MIMO – Multiple Input Multiple Output

MMC – Massive Machine Communication

MMS – Multimedia Message Service

MN – Moving Network

MRC – Maximum Ratio Combining

NFV – Network Function Virtualization

NMT – Nordic Mobile Telephone

NTT – Nippon Telegraph and Telephone

OFDM – Orthogonal Frequency Division Multiplexing

OFDMA – Orthogonal Frequency Division Multiple Access

PTT – Push to Talk

QoE – Quality of Experience

QoS – Quality of Service

RAN – Random Access Network

SDN – Software Defined Networks

SDR – Software Defined Radio

SIM – Subscriber Identity Module

SLA – Service Level Agreement

SMS – Short Message Service

TACS – Total Access Communication System

TDD – Time Division Duplexing

TDMA – Time Division Multiple Access

UDN – Ultra Dense Network

UMTS – Universal Mobile Telecommunication System

UPE – User Plan Entity

URN – Ultra Reliable Network

USIM – Universal Subscriber Identity Module

WIMAX – World-wide Inter-operability for Microwave Access

WLAN – Wireless Local Area Network

XaaS – Anything as a Service (SaaS, PaaS, IaaS)

ZF – Zero Forcing

# Chapter 1

# Introduction

## 1.1. Introduction

In recent future, we cannot think of day without wireless based networks. Now a days wireless based networks should have to advance in different ways. Recent technologies like High-Speed Packet Access (HSPA) and Long-Term Evaluation have been launched for the advancement for todays wireless based technologies. Other auxiliary components may also be established for future new wireless based technologies adjunct to current technologies. These will include different spectrum accessing ways, higher frequency ranges, massive antenna configurations, direct device-to-device communication, and ultra-dense deployments [1].

Mobile wireless communication had been initiated in late 1970s. Since then it has come across from analog voice calls to current modern technologies. Now-a-days modern wireless technologies are capable of providing high quality mobile broadband services which includes end-user data rates of several megabits per second over wide areas whereas tens or even hundreds of megabits per second for local communication. According to potentiality these vast improvements of mobile communication networks conjointly with the initiation of new types of mobile devices like smart phones and tablets, have brought a new era of applications for use in mobile connectivity and results an exponential network traffic growth. In this study report the key challenges for future mobile communication network for enabling networked society has been described. Also some different technologies have defined to overcome these challenges [1].

The imagined future society is networked with unbounded access to information.

Which also includes sharing of data accessible from anywhere in anytime for everyone. New technology components need to be studied to visualize this imagination with the existing wireless based technologies. New technology components will be incorporated with the present technologies like 3GPP LTE, HSPA and Wi-Fi to comply with the needs of the future. Nevertheless, there may be certain scenarios that cannot be adequately addressed along with the evolution of ongoing existing technologies [2].

The remainder of the paper is organized as follows: In Chapter II, we present the evolution of wireless mobile technologies. Chapter III gives the detailed description of the proposed general 5G cellular network architecture. Chapter IV comprises of the advantages and challenges of 5G wireless networks. We conclude our paper in Chapter V.

# References

[1]. R. Baldemair*etal*, “Evolving Wireless Communications: Addressing the Challenges and Expectations of the Future,’’ *IEEE Veh. Technol. Mag.*, vol. 8, no. 1, pp. 24–30, March 2013.

[2]. T. Rappaport, *Wireless Communications: Principles and Practice*, Englewood Cliffs, NJ, USA: Prentice-Hall, 1996.

# Chapter 2

# Evolution of Cellular Technologies

## 2.1. 1$^{st}$ Generation

In 1980s, the first generation wireless mobile communication was invented. It was used for voice services only and based on technology called Advance Mobile Phone System (AMPS). Using Frequency Division Multiple access (FDMA) with a channel capacity of 30KHz and frequency band 0f 824-894MHz, the AMPS system used to modulated the frequency. Only up to 2.4Kbps can supported by it. After that in 1988, with additional 10MHz bandwidth AMPS was allocated. This bandwidth is called as expanded spectrum, first deployed in Chicago. The service area was about to 2100 square miles. IN 1982, US first launched AMPS [1]. But in 1979 the first commercial automated cellular network was launched by NTT (Nippon Telegraph and Telephone) initially in Tokyo in Japan. After 5 year, it became the first nationwide 1G network by covering the whole population of japan. The key idea about 1G was that it divided the geographical area into cell. And the range of cell was typically 10-15Km and each served by a base station. The cell was not adjacent cell. Basically 1G known as early cellular phone technology. 1G compromised services are Mobile Telephone Systems (MTS), Advance Mobile Telephone Systems (AMTS), Push to Talk (PTT), and Improved Mobile Telephone Service (IMTS). Advanced Mobile Phone System (AMPS), Nordic Mobile Telephone (NMT), and Total Access Communication System (TACS) were the major subscribers [2].

## 2.2. 2nd Generation

### 2.2.1 2G

In late 1980s the second-generation wireless mobile communication was introduced. It is a digital technology which uses digital signals for voice transmission. The speed was about 64Kbps. The bandwidth of 2G was about 30-200KHz. In 2G Short Message

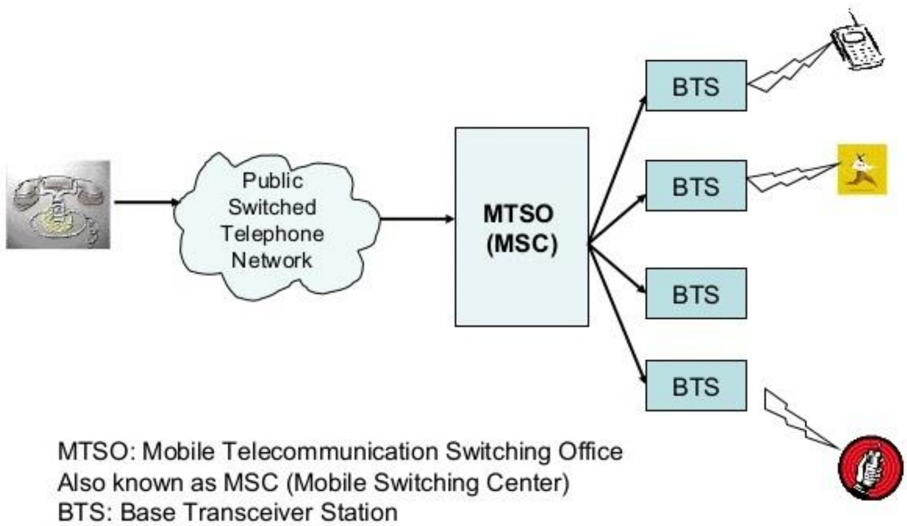


Figure 2.1: 1G AMPS Architecture [1]

Services (SMS), picture messages and Multimedia Message Services(MMS) were first introduced. Digital modulation schemes that used by 2G are Time Division Multiple Access(TDMA) and Code Division Multiple Access(CDMA). TDMA divides the signal into time slot where CDMA provides a special code to the each user to communicate over a multiplex physical channel. GSM, PDC, iDEN, IS-136 are used in TDMA technologies. In CDMA technology IS-95 is used. The most widely used 2G mobile standard is Global System for Mobile communication (GSM). Commercially fist launched 2G on GSM standard was in Finland in 1991. International roaming was first supported by GSM. It provided the better quality and capacity than previous network. The most key benefit of 2G network is it supported Digital encryption. On network spectrum it had higher penetration efficiency. In 2G, as radio signal uses low power so handset battery lasts longer [2].

### 2.2.2 2.5G

To provide better services by improving the GSM technology led to the advance system called as 2.5 Generation (2.5G).It basically lies in between 2G and 3G. In 2.5G packet switched domain was used and because of it the data rate was increased up to 144Kbps.

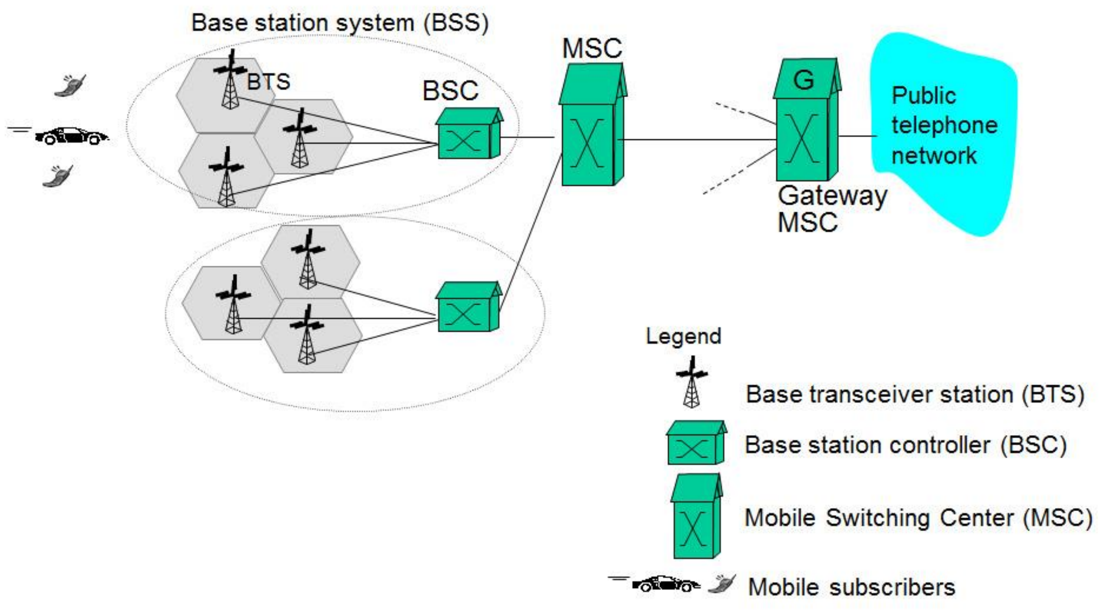


Figure 2.2: 2G Architecture Model

The technologies 2G used such as General Packet Radio Service (GPRS) and Enhanced Data rates in GSM Environment (EDGE). Packet switching protocols, short setup time for ISP connection are provided by GPRS. In GPRS, subscribers are charged according to the uses of the amount of data sent rather than connection time. It also provides continuous connection with the network. The significant step towards 3G is GPRS. Many countries still uses 2G network [3].

## 2.3. 3rd Generation

### 2.3.1. 3G

3G stands for third generation wireless mobile communication system. In 2000, it was first introduced. The goal of 3G system was to increase the data rate. The desire rate was from 144 Kbps to 384Kbps in wide coverage area. In local coverage area, desire data rate was 2Mbps. It is a generation which fulfilled the international telecommunication union standards for mobile phones and mobile telecommunication services. Wide Brand Wireless network was used to increase the clarity. Packet switching is used to send data and circuit switching is used for voice calls [3]. Basically based on Internet Protocol (IP) third generation marge high speed mobile access services [2]. Data services along with voice communication, access to TV and videos, Web browsing, e-mail, video conferencing, paging, fax and navigational maps were introduced in 3G. It used a bandwidth of 15-20MHzfor high speed internet, video chatting etc. 3G Technology uses Wideband CDMA, WLAN, Bluetooth, Universal Mobile Telecommunication Systems (UMTS), High Speed Downlink Packet Access (HSDPA) with the transmission rate, for maintaining QoS some unconventional improvement was made. By fulfilling the IMT-2000 standards, an organization called 3rd Generation Partnership Project (3GPP) defined 3G mobile systems. It was TSI driven and called UMTS (Universal Mobile Telecommunication System) in Europe NTTDocomo launched first 3G network Commercially in Japan, in 2001. With additional benefits like global roaming, fast internet,3D gamming and multiplayer gaming and the improved quality of voice made 3g as a remarkable generation. 3G handsets require more power than 2G handset models. If we think about expenses than 3G plans are more expensive than 2G plans [3].

### 2.3.2. 3.5G

With the technologies that evolved like High Speed Uplink/Downlink Packet Access (HSUPA/HSDPA) and Evolution-Data Optimized (EVDO) has made an intermediate wireless generation named as 3.5G with improved data rate of 5-30 Mbps [2].

### 2.3.3. 3.7G

The latest service 3.7G is using Long-term Evolution Technology (LTE) and fixed Worldwide Interoperability for Microwave Access (WIMAX). LTE and WIMAX can provide the service of high speed by which user can access video, peer to peer file sharing and web services. It offers better coverage than previous for less cost.

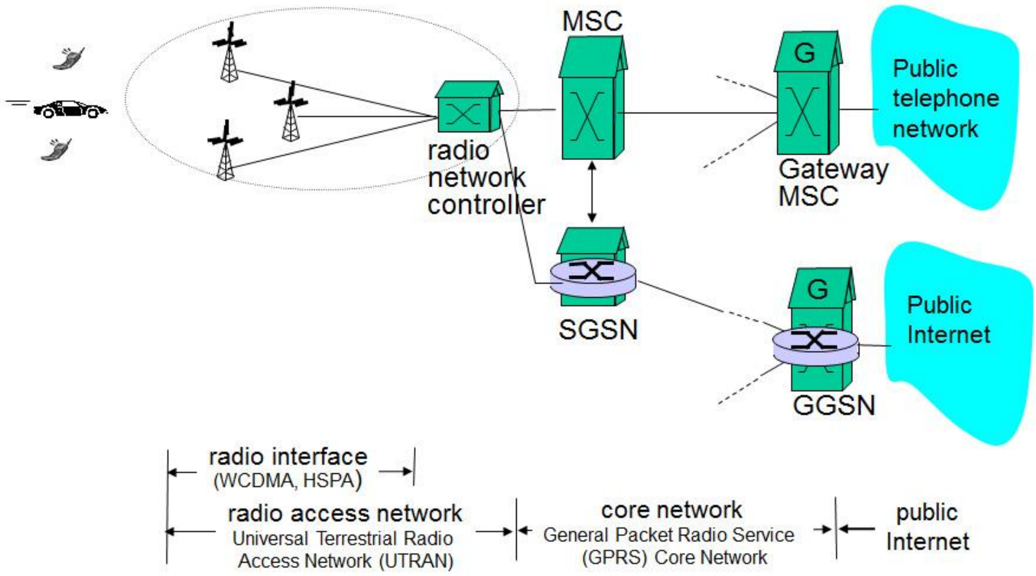


Figure 2.3: 3G Architecture Model

## 2.4. 4th Generation

In the late 2000s the fourth generation mobile system was introduced. In March 2008, a set of requirements for 4G standards was specified by the International telecommunications Union-radio communication sector. By these requirements the peak speed for 4G service is at 100 Megabits per second (Mbps) for high mobility communication, for low mobility communication it is 1 Gigabit per second (Gbps). It was all IP based network system. Providing high speed, high quality, high capacity, security and low cost data and voice services, internet and multimedia over IP were the main goal of 4G. Making a common platform to all the technologies developed so far, was the reason behind this IP based network. After having the ability of selecting the target wireless system multimode user terminals can use 4G mobile network. A key factor in 4G is mobility as it wants to provide wireless services anytime and everywhere. Automatic roaming between different wireless networks can be connoted by Terminal mobility. To provide movement freedom and uninterrupted roaming from one technology to another, 4G technology integrated many technologies like advanced LTE standard based on the GSM/EDGE and UMTS/HSPA, OFDM, MC-CDMA, LAS-CDMA,MIMO, Smart Antenna Technology, Network-LMDS, MBWA. In 2005, in japan first successful field trial happened. Multimedia Messaging Services (MMS), Digital Video Broadcasting (DVB), and video chat, High Definition TV content mobile are the applications that will use 4G network [1, 3].

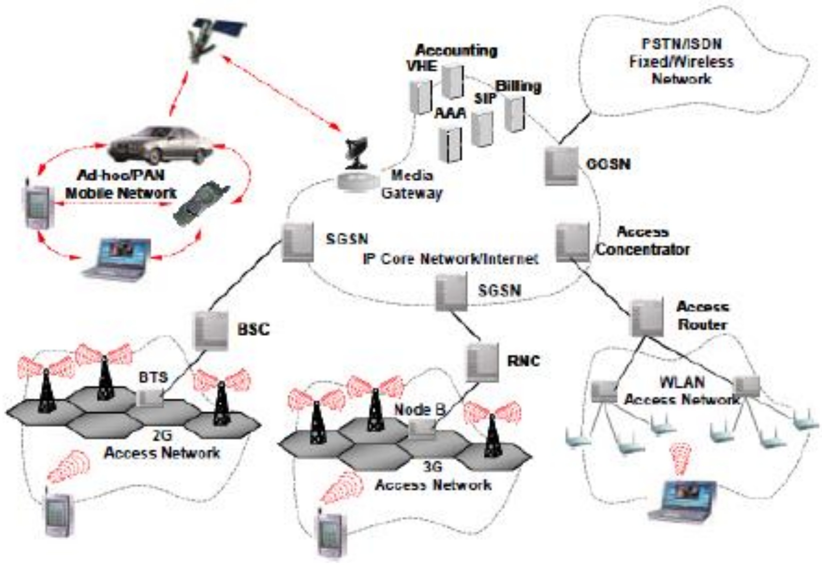


Figure 2.4: 4G Architecture Model [4]

# References

[1]. A. U. Gawas, “An Overview on Evolution of Mobile Wireless Communication Networks: 1G-6G”, *International Journal on Recent and Innovation Trends in Computing and Communication*, ISSN: 2321-8169, Volume: 3 Issue: 5, P: 3130–3133, May 2015.

[2]. A. Gupta, R. K. JHA, “A Survey of 5G Network: Architecture and Emerging Technologies”, *Special Section On Recent Advances In Software Defined Networking for 5G Networks*, July 28, 2015.

[3]. V. S. Jain, S. Jain, L. Kurup, A. Gawade, “Overview on Generations of Network: 1G, 2G, 3G, 4G, 5G”, *Int. J. Computer Technology & Applications*, Vol 5 (5), P: 1789-1794, September-October 2014.

[4]. M. Vishwanathan, S. Nanduri, “Viability of 4G Mobile Network Deployment in Botswana” *International Conference on Computational Techniques and Mobile Computing (ICCTMC'2012)*, December 14-15, 2012.

# Chapter 3

# Overview of 5G Cellular Technology

## 3.1. 5th Generation

The demand of the users is increasing exponentially so that 5G will replace 4G easily. 5G has an advanced access technology named Beam Division Multiple Access (BDMA) and Non- and quasi-orthogonal or Filter Bank multi carrier (FBMC) multiple access. BDMA technique is basically considered the communication of base stations with the mobile station. To each mobile station there will be allocated an orthogonal beam and for giving the advantage of the multiple accesses to the mobile stations, BDMA will be used to divide the antenna beam according to locations of the mobile stations. It will increase the system capacity correspondingly. According to the demand, six challenges that are not addressed by 4G but 5G must address these. The challenges are capacity, Data rate, End-to-End latency, Massive number of connections, and quality of experience (QoE). Basically the main motto of 5G is to connect all things together through internet. Here from figure 3.1 we can see data rate vs. mobility situation with the evolution of generations [1]. The below table 3.1 shows the detailed comparison between all the generations from 1G to 5G.

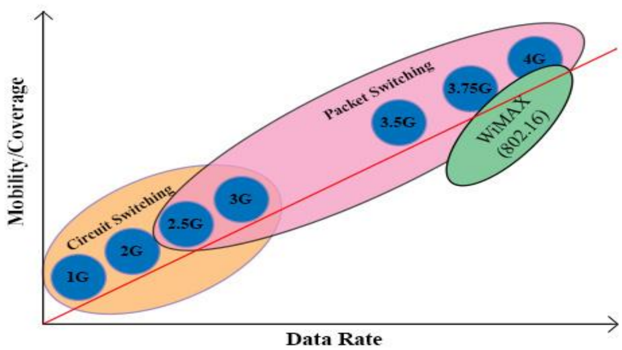


Figure 3.1: Data rate Vs. Mobility coverage

Table 3.1: Comparison of Different Generations

| Generation → Category ↓ | 1G | 2G | | | | 3G | | | | | | 4G | | 5G |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | 2G | | 2.5G | | 3G | | 3.5G | | 3.75G | | | | |
| **ACCESS TECHNOLOGY** | AMPS, FDMA | GSM, TDMA | CDMA | GPRS | EDGE | WCDMA/ UMTS | CDMA-2000 | HSUPA/ HSDPA | EVDO | LTE,OFDMA/SC-FDMA | Scalable/ Fixed WIMAX | LTE-A, OFDMA/ SC-FDMA | Scalable/ Fixed WIMAX | BDMA, FBMC Multiple Access |
| **BANDWIDTH** | 30KHz | 200KHz | 1.5MHz | 200KHz | 200KHz | 5MHz | 1.25MHz | 5MHz | 1.25MHz | 1.4 - 20MHz | 3.5 MHz and 7MHz in 3.5GHz Band 10MHz in 5.8GHz Band | 1.4 - 20MHz | 3.5MHz, 7MHz, 5MHz, 10MHz and 8.75MHz Initially | 60GHz |
| **FREQUENCY BAND** | 800MHz | 850/900/1800/1900MHz | | 850/900/1800/1900MHz | | 800/850/900/1800/1900/2100MHz | | 800/850/900/1800/1900/2100MHz | | 1.8GHz, 2.6GHz | 3.5GHz, 5.8GHz | 1.8GHz, 2.6GHz | 2.3GHz, 2.5GHz, 3.5GHz | 1.8GHz, 2.6GHz Expected: 30-300GHz |

| | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|
| **DATA RATE** | 2.4Kbps | 10Kbps | 50 Kbps (GPRS) 200Kbps (EDGE) | 384Mbps | 5-30Mbps | 100-200Mbps | DL-3Gbps UL-1.5Gbps | 100-200Mbps | 10-50Gbps Expected |
| **FORWARD ERROR CORRECTION** | NA | NA | NA | Turbo Code | Turbo Code | Concatenated Code | Turbo Code | | LDPC (Low Density Parity Check code) |
| **SWITCHING** | Circuit | Circuit | Circuit/Packet | Circuit/Packet | Packet | Packet | Packet | | Packet |
| **APPLICATION** | voice | Voice, Data | Voice, Data | Voice, Data, Video calling | Voice, Data, Video calling | Online G0aming, HD T.V | Online Gaming, HD T.V | | UHDV, VR |

## 3.2. 5G Cellular Network Architecture

To examine 5G organize in the market now, it is obvious that the multiple access technique in the system are practically at a still and requires sudden change. Current advances technologies like OFDMA will work at any rate for next 50 years. In addition, there is no need a change in the wireless setup which had happened from 1G to 4G. Then again, there could be just the expansion of an application or enhancement done at the fundamental network to please user prerequisites. This will incite the package suppliers to drift for a 5G network as right on time as 4G is commercially set up [2]. To meet the requirements of the user and to overcome the difficulties that has been advanced in the 5G systems, an uncommon change in the procedure of planning the 5G wireless cellular architecture is required. A general perception of the specialists has appeared that the greater part of the wireless users remain inside for roughly 80 percent of time and outside for around 20 percent of the time. Now in recent wireless cellular architecture, for a mobile user to impart whether inside or outside, an outside base station display amidst a phone helps in correspondence. So for inside users to speak with the outside base station, the signs should go through the dividers of the inside, and this will bring about very high penetration loss, which correspondingly costs with decreased spectral efficiency, data rate, and energy efficiency of wireless communication. To overcome this challenge, a new idea or designing technique that has come in to existence for scheming the 5G cellular architecture is to distinct outside and inside setups[2]. With this designing technique, the penetration loss through the dividers of the building will be slightly reduced. This idea will be supported with the help of massive MIMO technology, in which geographically dispersed array of antenna's are deployed which have tens or hundreds of antenna units. Since current MIMO systems are using either two or four antennas, but the idea of massive MIMO systems has come up with the idea of utilizing the advantages of large array antenna elements in terms of huge capacity gains.

For building or constructing Massive MIMO system, firstly the outside base stations will be fitted with large antenna arrays and among them some are scattered around the hexagonal cell and connected to the base station through optical fiber cables, with the help Massive MIMO technologies. The mobile users show outside are normally fitted with a specific number of antenna units however with participation a huge virtual antenna array can be constructed, which together with the antenna arrays of base station frame virtual massive MIMO links. Also, every building will be introduced with antenna arrays from outside, to speak with open air base stations with the assistance of viewable pathway parts. The wireless access points inside the building are connected with the large antenna arrays through cables for communicating with indoor users. This will significantly enhances the energy efficiency, cell average throughput, data rate, and spectral efficiency of the cellular system but it increases the cost of infrastructure. With the introduction of such an architecture, the inside users will only have to connect or communicate with inside wireless access points while larger antenna arrays remained installed outside the buildings [2]. For indoor communication, certain technologies like WiFi, Small cell, ultra-wideband, millimeter wave communications, and visible light communications are useful for small range communications having large data rates. But technologies like millimeter wave and visible light communication are utilizing higher frequencies which are not conventionally used for cellular communications. But it is not an efficient idea to use these high frequency waves for outside and long distance applications because these waves will not infiltrate from dense materials efficiently and can easily be dispersed by rain droplets, gases, and flora. Though, millimeter waves and visible light communications technologies can enhance the transmission data rate for indoor setups because they have come up with large bandwidth. Alongside the presentation of new range, which is not by and large conventionally utilized for wireless communication, there is one more strategy for solving the spectrum shortage issue by enhancing the range usage of current radio spectra through cognitive radio (CR) systems [3].

Since the 5G cellular architecture is heterogeneous, so it must introduce and include macro cells, micro cells, small cells, and relays. A mobile small cell concept is an unabated part of 5G wireless cellular network and partially includes of mobile relay and small cell concepts [3]. It is being introduced to put up high mobility users, which are inside the automobiles and high speed trains. Mobile small cells are positioned inside the moving automobiles to communicate with the users inside the automobile, while the massive MIMO unit consisting of large antenna arrays is placed outside the automobile to communicate with the outside base station. User's opinions are, a mobile small cell is realized as a regular base station and its kindred users are all observed as a single unit to the base station which proves the above idea of splitting indoor and outdoor setups. Mobile small cell users have a high data rate for data rate services with considerably reduced signaling overhead, as shown in [2]. As the 5G wireless cellular network architecture consists of only two logical layers and that are a radio network and a network cloud. Different types of components performing different functions are constituting the radio network. The network function virtualization (NFV) cloud consists of a User plane entity (UPE) and a Control plane entity (CPE) that perform higher layer functionalities related to the User and Control plane, respectively. Special network functionality as a service (XaaS) will provide service as per need, resource pooling is one of the examples. XaaS is the connection between a radio network and a network cloud [9].

The 5G cellular network architecture is explained properly in 3.2. It both has same importance in terms of front end and backhaul network respectively. A general 5G

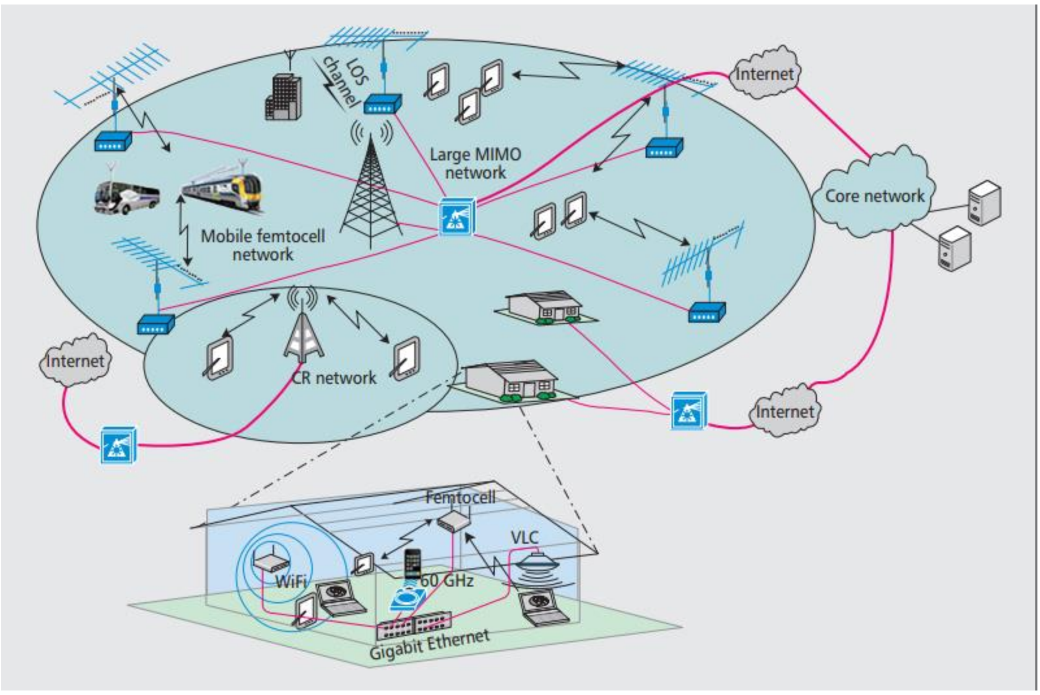


Figure 3.2: A general 5G cellular network architecture.

cellular network architecture has been proposed as shown in figure 3.2. It shows the interconnectivity among the different emerging technologies like Massive MIMO network, Cognitive Radio network, and mobile and static small-cell networks. It also explains the role of network function virtualization (NFV) cloud in the 5G cellular network architecture. The concept of Device to Device (D2D) communication, small cell access points and Internet of things (IoT) has also been incorporated in this proposed 5G cellular network architecture. In general, this proposed 5G cellular network architecture may provide a good platform for future 5G standardization network.

## 3.3. Emerging Technologies

It is expected that mobile and wireless traffic volume will increase a thousand-fold over the next decade which will be driven by the expected 50 billion connected devices connected to the cloud by 2020 and all need to access and share data, anywhere and anytime. With a rapid increase in the number of connected devices, some challenges appear which will be responded by increasing capacity and by improving energy efficiency, cost and spectrum utilization as well as providing better scalability for handling the increasing number of the connected devices. For the vision of all-communicating world relative to today's network, the overall technical aim is to provide a system idea that supports [5]:

• 1000 times increased data volume per area

• 10 to 100 times increased number of connected devices

• 10 to 100 times increased typical user data rate

• 10 times extended battery life for low power Massive Machine Communication (MMC) devices

• 5 times reduced End-to-End (E2E) latency in this paper, we will cover a wide area of technologies with a lot of technical challenges arises due to a variety of applications and requirements of the user.

To provide a common connected platform for a variety of applications and requirements for 5G, we will research the below technology components [5]

• Radio-links, includes the development of new transmission waveforms and new approaches of multiple access control and radio resource management.

•Multi-node and multi-antenna transmissions, includes designing of multi-antenna transmission/reception technologies based on massive antenna configurations and developing advanced inter-node coordination schemes and multi-hop technologies.

• Network dimension, includes considering the demand, traffic and mobility management, and novel approaches for efficient interference management in complex heterogeneous deployments.

• Spectrum usage includes considering extended spectrum band of operation, as well as operation in new spectrum regimes to provide a complete system concept for new spectrum regimes that carefully addresses the needs of each usage scenario.

Now the topics which will integrate a subset of the technology components and provides the solution of some of the goals which are identified earlier are [5]:

• Device-to-Device (D2D) communications refers to direct communication between devices allowing local exchange of user plane traffic without going through a network infrastructure.

• Massive Machine Communications(MMC) will form the basis of the Internet of Things with a wide range of application fields including the automotive industry, public safety, emergency services and medical field.

• Moving Networks (MN) will enhance and extend linking together potentially large populations of jointly moving communication devices.

• Ultra-dense Networks (UDN) will be the main driver whose goals are to increase capacity, increase energy efficiency of radio links, and enable better exploitation of under-utilized spectrum.

• Ultra-reliable Networks (URN) will enable high degrees of availability.

In this section, we identify several technologies, ranked in perceived importance, which will be crucial in future wireless standards.

**3.3.1. MASSIVE MIMO:** Massive MIMO nothing but an evolving technology of current MIMO technology. In massive MIMO, it uses array of antenna which contains few hundred antennas. These type of antennas can serve many tens of user terminals at the same time using different frequency slot. On a large scale, it has all the same benefits of MIMO technology. MIMO is energy efficient, secure spectrum efficient and robust. Firstly Massive MIMO depends on spatial multiplexing, then it depends on the base station to have the information about channel both for uplink and downlink. It is easier in the case of uplink then downlink as pilot is sent by the terminals. The channel response of the terminals are estimated by the basis of pilots. In conventional MIMO systems, the pilot waveforms are sent to the terminals and the terminal estimate the channel by basing on this waveforms. For massive MIMO system, this is not stable process. Especially in high mobility conditions it is not stable for two reason. The first reason is among the antennas the downlink pilot's sends from the base station must be orthogonal. According to the requirement of time with the increase of the number of antennas frequency slots for downlink pilot also increases. Actually massive MIMO requires huge similar slots then conventional MIMO system. Second reason is with the increasing number of base station number of channel estimations also increases for each terminals. So it need hundred times more uplink slots to response the channel feedback to the base station. Working in time division duplexing (TDD) mode and depending on reciprocity within the uplink and downlink channel are the general solution of this problem. Though the massive MIMO technology is based on phase coherent signal from all the antennas of base station but the process of signal computation is easy. In figure 7a massive MIMO system has been showed. A few positive things or a massive MIMO is discussed below:

**3.3.1.1.** Massive MIMO can enhance the radiated energy 100 times better. During this time it also can increase capacity of the order 10 or more. Using of spatial multiplexing technique, the capacity increases in Massive MIMO system. The radiated energy efficiency increases because of increasing number of antennas. Now the energy can be evaporated in the small regions in the space. The principle of coherent superposition of wave fronts is the main base of it. After thetransmission of the shaped signal from the antennas, the base station only confirmthat the emitted wave will be added constructively at the intended terminals or destructively everywhere. To inhibit the residual interference zero forcing is used between the

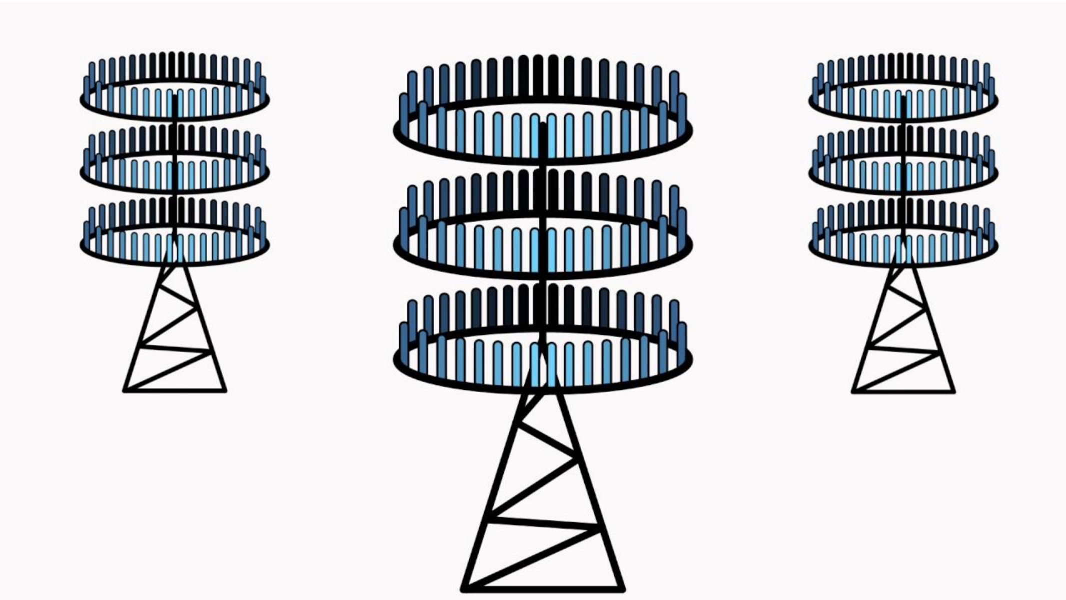

Figure 3.3: Massive MIMO system.

terminals though it increases the transmitted power. The desirability of maximum ratio combining (MRC) is more as related to zero forcing (ZF) because of its computational ease. The computation ease that is multiplying the received signal by their response of conjugate channel for executing in a desired mode autonomously at every antenna element. MRC normally does not works well equally as ZF for an orthodox MIMO system. The fundamental reason behind those efficient utilization of the MRC with huge MIMO directing, including vast number from claiming build station antennas, the channel reactions unified for separate terminals tend will a chance to be Practically orthogonal. With the utilization of MRC collector, we are working in a commotion confined framework. MRC in Massive MIMO framework will downsize the ability to a degree conceivable denied of truly disquieting the general ghastly efficiency and multiuser obstruction, however the impacts of equipment deficiencies are probably going to be overwhelmed by the warm clamor. Be that as it may, the aim behind the general 10 times higher otherworldly efficiency when contrasted with regular MIMO is on the grounds that 10 times more terminals are served simultaneously in a similar time recurrence asset.

**3.3.1.2.** Massive MIMO Systems Can Be Put Together With The Help Of Low Power And Less Costly Components. Massive MIMO has thought of a change regarding idea, plans and execution. Huge MIMO frameworks utilize several more affordable amplifiers in regard to costly ultra-straight 50 Watt amplifiers on the grounds that prior are having a yield control in the milliwatt extend, which is greatly improved than the last which are by and large being utilized as a part of regular frameworks. It is not at all like traditional cluster plans, as it will utilize just a little receiving wire's that are being nourished from high power amplifiers yet having a remarkable effect. The most significant change is about the expulsion of countless and monstrous things like substantial coaxial links. With the utilization of a substantial number of reception apparatuses in huge MIMO innovation the commotion, blurring and equipment deficits will be arrived at the midpoint of on the grounds that signs from countless are joined together in the free space. It consolidates the breaking points on exactness and linearity of each and every amplifier and radio recurrence chain and by and large what makes a difference is their aggregate activity. This will expand the power of gigantic MIMO against blurring and disappointment of one of the receiving wire components. An enormous MIMO framework has degrees of flexibility in abundance. For instance, with 100 radio wires, 10 terminals are demonstrating nearness while the rest of the 90 degrees of flexibility are as yet accessible. These accessible degrees of flexibility can be misused by utilizing them for flag molding which will be equipment neighborly. Specifically, every reception apparatus with the utilization of extremely shoddy and power proficient radio recurrence amplifiers can transmit signals having little top to normal proportion and steady envelope[11] at an unobtrusive cost of expanded aggregate transmitted power. With the assistance of steady envelope multiuser pre-coding, the signs transmitted from every receiving wire are not being framed regarding shaft nor by weighing of an image. Or maybe, a wave field is made and inspected as for the area of the terminals and they can see accurately the signs what we expected to influence them to see. Gigantic MIMO has an essential property which makes it conceivable. The enormous MIMO channel has substantial invalid spaces in which about everything can be locked in without aggravating the terminals. Accurately modules can be put into this invalid space that makes the transmitted waveforms fulfill the favored envelope limitations. All things considered, the agent channels in the midst of the base station and each terminal, can be continued without the inclusion of PSK sort tweak and can take any flag heavenly body as information [6]. The extensive change in the vitality efficiency encourages monstrous MIMO frameworks to work two stages of lower extent than with existing innovation on the aggregate yield RF control. This is imperative in light of the fact that the cell base stations are devouring a great deal of energy and it is a territory of concern. Moreover, if base stations that devour less power could be driven by sustainable assets like sun powered or wind and in this way it is useful to send base stations to the spots where power isn't accessible. Alongside this, the expanded worries of electromagnetic introduction will be impressively less.

**3.3.1.3.** Massive MIMO permits a substantial decrease in latency on the air interface. For next generation networks latency is one of the main concern. In wireless communication, fading is the reason of latency. The phenomenon occurs between the base station and terminals. After the transmission of the signal from the base station it travels different multiple paths because of scattering, reflections, diffraction before reaching the desire terminal. The signal will interfere either constructively or destructively after reaching the terminal through the multiple paths. When the signal interfere destructively, the strength of received signal is considering at a low point. If the terminal is caught in a fading dip, until any data can be received, terminal need to wait for the transmission channel to change. As Massive MIMO uses a large number of antenna sand with the idea of beamforming so that it can avoid fading dip and latency cannot be further decreases.

**3.3.1.4.** The multiple access layer can be made simple by Massive MIMO. In massive MIMO the cannel strengthens and now frequency domain scheduling is not enough. Each subcarrier that is provided by OFDM in a massive MIMO system with considerably the same channel gain. And with this channel gain a complete bandwidth can provide to each and every terminal. This reduces most of the physical layer control signaling terminated.

**3.3.1.5.** The strength equality against unintended man made interference and intended jamming is increased by Massive MIMO. The Wireless system jamming of the civilian is prime area concern. It can also poses a serious threat to cyber security. The distribution of information over frequency just is not possible as it has limited bandwidth. With the help of multiple antennas, the methods of improving robustness of wireless communication are offered by massive MIMO. It provides with an excess of degrees of freedom which can be useful for canceling the signals from intended jammers. If massive MIMO systems use estimation of joint channel and decoding instead of uplink pilots for estimation of channel, then the problem from the intended jammers is reduced considerably. The advantages of massive MIMO systems can be described from an information theoretic point of view. Massive MIMO systems can obtain the gain of the promising multiplexing of massive point to point MIMO systems, while eliminating problems due to unfavorable propagation environments [6].

**3.3.2. INTERFACE MANAGEMENT:** Reuse is being used by many specification of cellular wireless communication system for efficient utilization of limited resources. To improve the traffic capacity and user throughput densification of the network in one of the key aspect. With the introduction of reuse and definition concept, between macro cells and local access networks there will be an additional enhancement in terms of efficient load sharing. Though it has a lot of advantages, there has a problem. The density and load of network also increases considerably and correspondingly so receiver terminals in the network suffer from increased co-channel interference, mainly at the cell boundaries. Thus co-channel interference poses a threat, which is inhibiting the further improvement of 4G cellular systems. So an interference management scheme is vital. Below there are given two interference management technique [7]:

**3.3.2.1.** Advanced Receiver: Modern day and growing cellular system, interference grow as a big threat, so to mitigate or manage interference, an appropriate interference management technique is the need of the hour. Advanced management system at a receiver or an advanced receiver that is a technique which can help to interference management. Within the modulation constellation, coding scheme, channel, and resource allocation it will detect and even try to decode the symbols of the interference signal. On the detector output, the interference signals can be reconstructed and cancelled from the received signal. So it improves the anticipated signal decoding performance [7]. Advanced receivers limits the interference at the cell boundaries and also inter cell interference as in the case of massive MIMO.

According to LTE-Advanced 10, with up to eight antennas has equipped every base station which will call for intra cell interference, as the number of antennas increases [7].

**3.3.2.2.** Joint Scheduling: According to LTE standard, the only interference management strategies that were considered is interference randomization through scrambling of transmitting signals. There were no advanced co-channel interference management strategies. But in 3GPP LTE-Advanced, through probability readings, it was realized that there was a space for additional performance improvement at the cell edges with the help of synchronized transmission among multiple transmitters dispersed over different cell sites. For calibrating the development, some typical coordinated multipoint schemes, like to coordinate scheduling, coordinated beamforming, dynamic point selection, and joint transmission, were normally conferred. To refer advanced interference management of cellular systems and link variation, joint scheduling is broadly used from the network side. The transmission rated and schemes of multiple cells are not autonomously determined as coordinated multipoint schemes. In the case of fast network distribution and interoperability, advanced interference management schemes by joint scheduling from the network side need to be stated in detail in the 5G systems, without separating it entirely as an employment issue. For attracting maximum coordination, the user equipment and network side, advanced interference management must be deliberated instantaneously [7].

**3.3.3. SPECTRUM SHARING**: For realizing the performance there is a need of considerably more spectrum and wider bandwidths as a compared to the current available spectrum to hold the performance targets of future mobile broadband system. To overcome this difficulty, under horizontal or vertical spectrum sharing systems, spectrum will be made available. The significance of spectrum sharing is probable to increase, dedicated licensed spectrum access is expected to remain the baseline approach for mobile broadband which provides reliability and investment certainty for cellular mobile broadband systems.it can play a balancing role in network spectrum using joint spectrum [8]. There are mainly two spectrum sharing techniques that enable mobile broadband systems to share spectrum and are classified as distributed solutions and centralized solutions [8]. While in a centralized solution each system coordinates discretely with a central unit, in a distributed solution the systems coordinate between each other. The system do not directly interact with each other.

**3.3.3.1.** Distributed Spectrum Sharing Techniques: Distributed spectrum sharing techniques has more efficiency as it can take place in a local framework. Those transmissions that really create interference amid systems are to be managed by its principle. Distributed coordination can be entirely included into standards. The can work without the need for commercial contracts between operators [8]. Through the clear exchange of messages unswervingly between the sharing systems through a distinct interface in a peer to peer coexistence protocol, the management of horizontal spectrum sharing happens. The performance of the nodes on the receiving of certain messages or taking place of certain events are described by this protocols [1]. The frameworks every now and again transmit for the most part comprehended signs that will demonstrate nearness, movement factor and the time when they will transmit in a concurrence reference point based arrangements. The other system can use the information that is available openly to adjust their spectrum access performance to provide fair spectrum sharing. For both Horizontal and Vertical sharing setup, coexistence beacons are possibly the solution. The 802.22.1 standard is one of the example of its implementation [1]. A MAC protocol which is designed for horizontal spectrum sharing is used MAC behavior based schemes. WLAN systems using request to send and Bluetooth using frequency hopping are the examples of it. With WI_FI systems, a WI-FI coexistence mode is adapted for a horizontal coexistence. The MAC protocol may leave silent periods for Wi-Fi systems to operate and use a listen before talk method which allows Wi-Fi systems to gain access to the channel. On the basis of measurement results like energy detection or feature detection there has a selected spectrum sensing, dynamic frequency and operating frequency dynamically. To detect the aforementioned coexistence be a cons, feature detection is highly useful. Due to a hidden node problem, this method is not considered as a very dependable method [8].

**3.3.3.2.** Centralized Spectrum Sharing Techniques: this technique is useful for the system having granularity of spectrum sharing on a level of high than the actual radio resource granularity of allocation. As it is conservative and possibly separate users on orthogonal resources without complete information on whether they would actually interfere or not so this technique has restrains. While the benefits are as far as dependability, conviction and control. Geo-location database strategy is a case of an incorporated sharing method which includes the questioning of a database to acquire data about the assets accessible at a specific location. This has a requirement that is classical vertical sharing solution for accessing the locally unused TV bands. The spectrum broker approach is one of the example of a centralized sharing technique in which horizontally sharing systems negotiate with a central resource management unit for getting short term grants to use spectrum resources on a limited basis [10]. Horizontal sharing between unlicensed systems may be additionally supported by both of the Geo-location database and the spectrum broker approach [8]. With these two explained spectrum sharing techniques most easily usable bans also been allocated, but studies shows that these bands are significantly underutilized. A technology which will encounter with the upcoming demands both in terms OD spectrum efficiency and performance of certain application has become a concern for the researcher. To encounter the demand of the future, a disruptive technology revolution has made. And it will empower the future wireless world. And the technology is Cognitive Radio. Cognitive radios are completely programmable wireless devices and have an extensive adaptation property for achieving better network and application performance. It can sense the environment and dynamically performs adaptation in the networking protocols, spectrum utilization methods, channel access methods and transmission waveform used. There is an expectation that the cognitive radio technology will be able to arise as a programmable radio for general purposes. Similar to the role of microprocessors in the computation, cognitive radio will also serve as a universal platform for wireless system expansion. But the task of successfully building and large scale deployment of cognitive radio networks to dynamically improve spectrum use is an intricate task. It is an area of concern that the academic researchers and the industry in this area has reached a point of fading returns. On the multi institutional research teams, its future will be depended. The team is working on a new approach with real world experimental deployments of cognitive radio networks.

**3.3.4. DEVICE TO DEVICE COMMUNICATION SYSTEM:** By Visualizing a two level 5G cellular network Device to Device Communication system can be explained and named them as macro cell level and device level. The macro cell level comprises of the base station to device communications as in an orthodox cellular system. The device level comprises of device to device communications. When a device links the cellular network through a base station, then it will be operating in the macro cell level and when a device links directly to another device or apprehends its transmission through the support of other devices, then it will be on the device level. In these sorts of frameworks, the base stations will persevere to go to the gadgets of course. Be that as it may, in the congested ranges and at the cell edges, an impromptu work organize is made and gadgets will be allowed to speak with each other . In the insight of device level communications, the base station either have full or partial control over the resource allocation amid source, destination, and relaying devices, or not have any control. The subsequent of four main types of device-level communications can be described (Figures. 3.4-3.7) [11].

**3.3.4.1.** Device Relaying with Base Station Controlled Link Formation: This type of communication can be applied for a device which is at the edge of a cell, that is, in the coverage area which have poor signal strength. In this communication by relaying their information through other devices, the devices will communicate with the base station. This sort of correspondence will be useful for the gadget to achieve a higher nature of administration and individual expanded battery life. For incomplete or full control interface development, the base station communicates with the reliable devices (figure 3.4)

**3.3.4.2.** Direct Device to Device Communication with Base Station Controlled Link Formation: This type of communication happens when the source and destination devices are exchanging data with each other without the involvement of a base station, but they are supported by the base station for link formation (figure 3.5).

**3.3.4.3.** Device Relaying with Device Controlled Link Formation: In this kind of communication, a base station is neither associated with connect development nor for communication reason. In this way, source and goal devices are absolutely in charge of synchronizing correspondence utilizing transfers in the midst of each other (figure 3.6).

**3.3.4.4.** Direct Device to Device Communication with Device Controlled Link Formation: This type of communication happens when the source and destination devices have direct communication with each other. By devices without any assistance from the base station, the link formation is controlled itself. Consequently, the asset ought to be used by the source and destination devices in an approach to confirm restricted interface with different devices in a similar level and the large scale cell level. For a significant progression in overabundance of conventional cell framework engineering, a dualistic cell framework ought to be planned. Security and interference management issues are the some technical issues which are the concern for introducing device to device communication [11]. As in device to device communication, the routing of user data is through the devices of the other users, so the main area of concern is about security because the privacy need to be maintained. For the devices closed access will ensure their security that want to operate in the device level. In close access, a device has a rundown of certain dependable devices, similar to the users in the nearby region or office to whom you know about, generally the user that host been legitimated through a solid get-together like an affiliation, can unswervingly communicate with each other, maintaining a level of prudence, though the devices not on this rundown need to utilize the large scale cell level to communicate with it. Also to prevent divulging of their information to other devices in a group, one can set an appropriate encryption amongst one another. Instead of this, in open access, each device can turn in to relay for other devices deprived of any limits. Meanwhile, in such an instance security is an open research problem. In device to device communication security problem contain the empathy of possible attacks, threats, and weakness of the system. To talk security issues in open access device to device, the exploration on the security issues of machine to machine communication [11].can be used. Second specialized issue of a dualistic framework that should be tended to is of impedance administration. In gadget transferring correspondence with the base station controller and direct gadget to gadget correspondence with base station controlled, the base station can execute the asset allotment and call setup process. So, the base station, to a certain degree can ease the problem of interference management by using centralized methods. In any case, in device relaying communication with device controller and direct device to device communication with gadget controller, asset designation between gadgets won't be administered by the unified unit. Devices will unavoidably impact macro cell clients since they are working in the same authorized band. So to confirm the ostensible impact on the execution of winning macro cell base stations, a dualistic system should be viewed as that includes distinctive impedance administration methods and asset portion plans. In addition to the interference amid the macro cell and device levels, interference amid users at the device level is also of prime concern. In device relaying communication with the base station controller, as appeared in Figure 3.4, since the base station is one of the conveying units, so the previously mentioned difficulties can be tended to with the assistance of the base station like verifying the transferring devices through encryption for keeping up sufficient security of the data of the devices [1]. The challenge of spectrum allocation amid the relaying devices to prevent them from interfering with other devices will also be managed by the base station. Circuitous device to device communication with base station controlled, appeared in Figure 3.5, the devices discuss specifically with each other, yet the base station controls the development of connections between them. Definitely, crafted by the base station is to confirm the entrance, control the association development, asset allotment, and furthermore manages financial communication amid devices. Basically the base station has complete control over the device to device connections, like connection setup and maintenance, and resource allocation. Since device to device connections share the cellular licensed band in the device level with the regular cellular connections in the macro cell level. So to assign resources to each device to device communication, the system can either appoint resources in an indistinguishable way as a standard cell association or as a committed asset pool to all device to device communication [11]. In device relaying communication with device controller and direct device to device communication with device controller, there is no base station to control the communication amid devices. As appeared in figures 3.6 and 3.7, a few devices are communicating with each other by utilizing steady or non-strong communication by assuming the part of transfers for alternate devices. Since there is no unified supervision of the relaying, so disseminated techniques will be utilized for forms like association setup, impedance administration, and resource allotment. In this kind of communication, two devices need to find each other and the neighboring transfer's first by occasionally communicating their character data. This will mindful alternate devices of their essence and afterward they will choose whether or not to begin a device to device direct or device relaying communication [1]. Presently to know the impact of relays, let us ponder a framework demonstrate for transfer helped device to device communication as appeared in figure 3.7. For contemplating it, let us consider that the cell user equipment eNodeB joins are ominous for coordinate communication and need the help of transfers. The device-to-device user equipments are likewise upheld by the transfer hubs because of long separation or poor connection condition between peers.

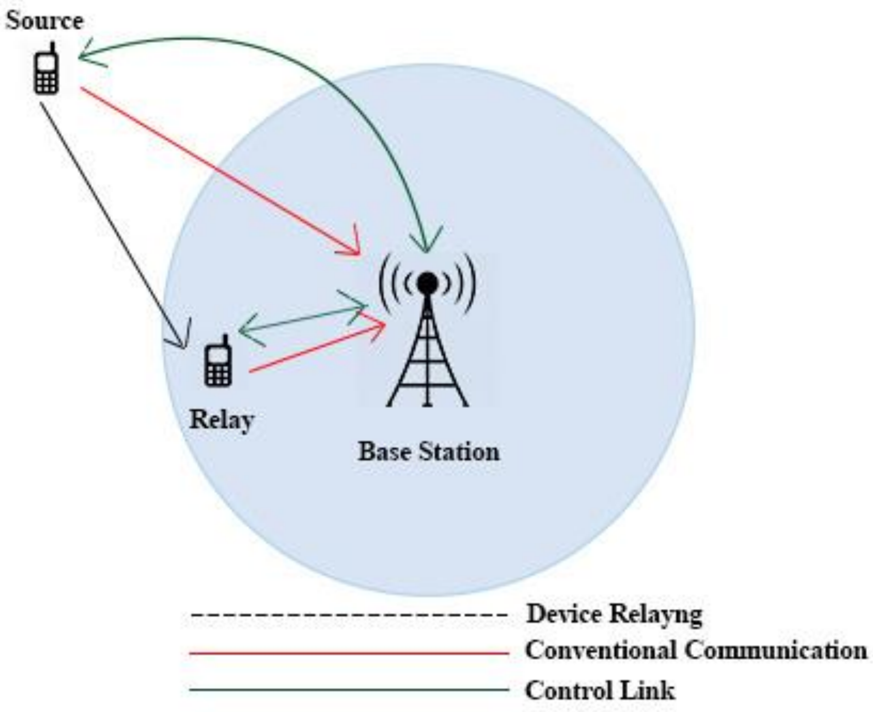


Figure 3.4: Device relaying communication with base station controlled link formation.

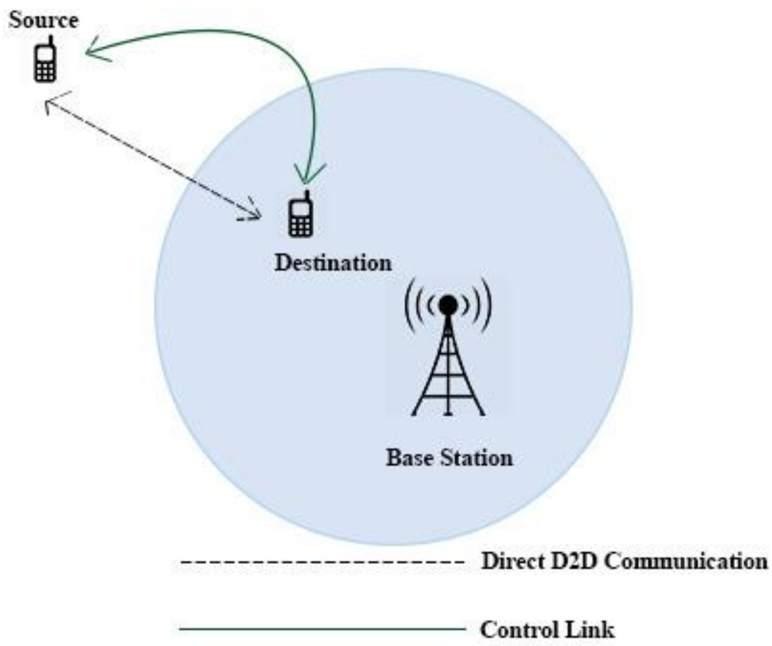


Figure 3.5: Direct device to device communication with base station controlled link formation.

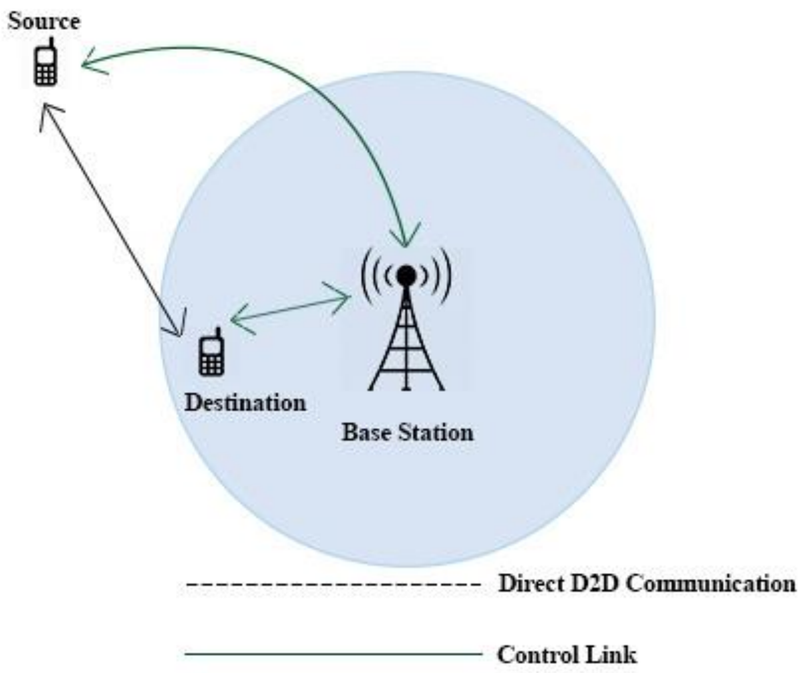


Figure 3.6: Device relaying communication with device controlled link formation.

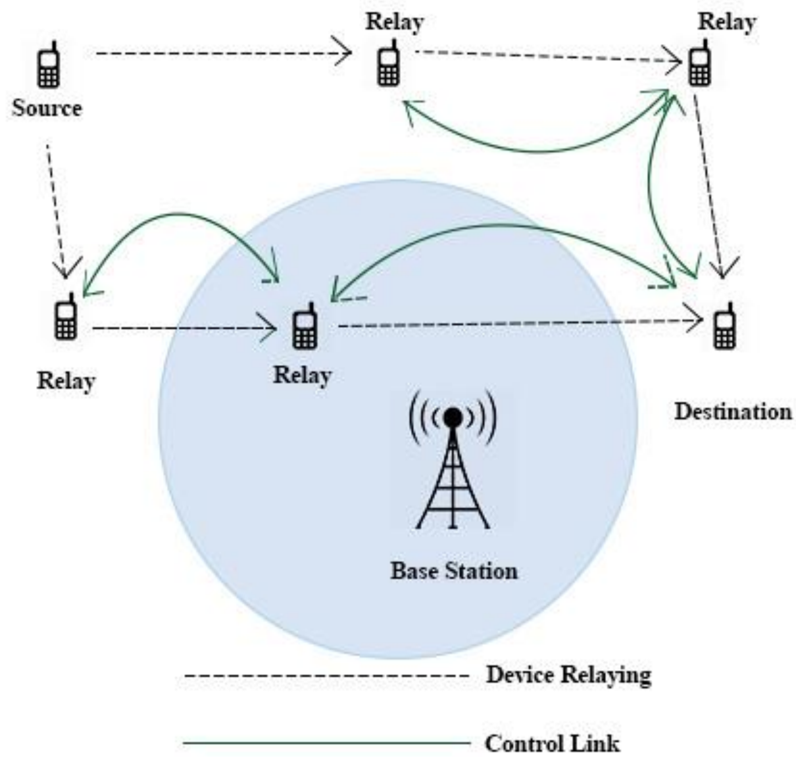


Figure 3.7: Direct device to device communication with device controlled link formation.

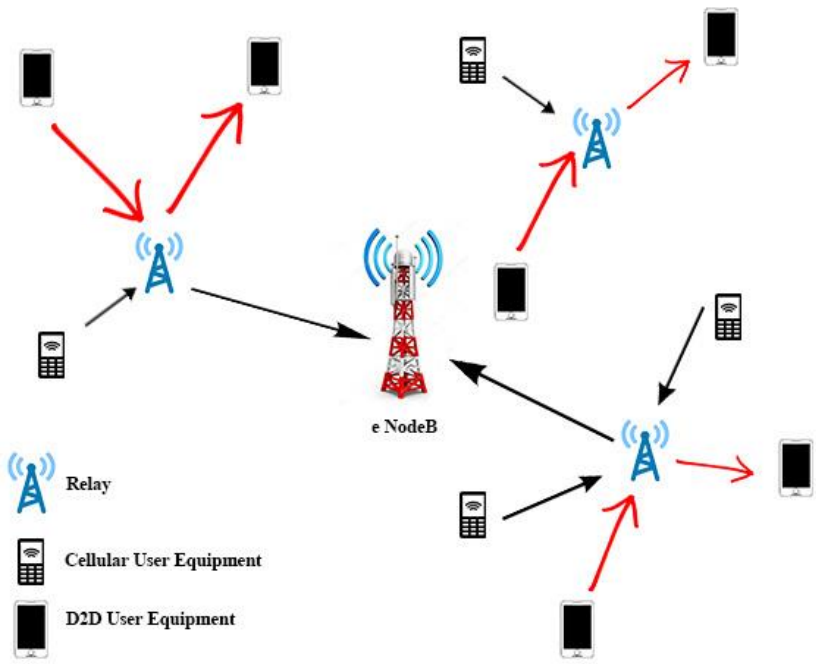


Figure 3.8: A single cell with multiple relay nodes.

**3.3.5. ULTRA DENCE NETWORK:** To meet the increasing traffic requests because of the increasing number of clients, densification of the foundation will be the earlier part of 5G interchanges. Be that as it may, for accomplishing ultra-dense, heterogeneous network systems will play a significant part. With the presentation of moving systems and specially appointed informal communities, the heterogeneous systems are ending up more powerful. In spite of the fact that thick and dynamic heterogeneous systems will offer a new challenge to present circumstances as far as obstruction, mobility and backhauling. To defeat these difficulties, there emerges a necessity of outlining new network layer functionalities for expanding the performance from the plan of the current physical layer. In introduce systems like Long Term Evolution (LTE), there exists interference mitigation techniques like improved Inter-Cell Interference Coordination and autonomous component carrier selection. Be that as it may, these techniques are applicable just to itinerant and dense small cell arrangements and have limited flexibility. So for 5G systems, the interference mitigation technique ought to be more flexible and open to the varieties as changes in the traffic and organization are relied upon to happen more quickly than existing systems [23]. With the introduction of smart wireless devices, the interactions between these devices and with the environment are destined to increase. To meet the challenges that have arisen because of the increasing density of nodes and interchanging connectivity options, there arises a need of the user independent algorithms. So future smart devices are designed such that with the assistance of the context information, they will learn and choose how to deal with the availability. Contextual information perhaps will be the moving toward service profile, battery position of a device or a total information procured through either in constructed sensors, cloud servers or serving base station. For instance, to empower quicker instatement of direct Device-to-Device communication and local multicast group making, setting data about the interpersonal interaction will be extremely useful as it will diminish the signaling overhead in the system. Setting data can likewise give sustenance to the system to diminish vitality utilization in base stations on account of the exchanging of cells by enhancing the versatility and traffic management procedure and nearby handover strictures [12]. So, future small devices and small cell systems will be fit for giving the best wireless connectivity with least interference and less power utilization. Alongside this, they ought to be quickly versatile to the changing adaptable devices and radio access network.

**3.3.6. MULTI RADIO ACCESS TECHNOLOGY ASSOCIATION:** As we are heading towards 5G, the networks are ending up more heterogeneous. The fundamental aspect that has pulled in many, is the instigation among various radio access advancements. A distinctive 5G helped devices should to be made whose radios not only support another 5G standard like millimeter wave frequencies, yet in addition 3G, different arrivals of 4G LTE, various sorts of Wi-Fi, and potentially guide device to device communication, the whole way across different spectral bands [12]. Defining of standards and utilization of spectrum to which base station or users will be a really intricate job for the network. Defining of the optimal user affiliation is the prime region of concern which relies upon the signal to interference and noise ratio from each and every users to each and every base station, the choices of different users in the system, the heap at each and every base station, and the essential to apply a similar base station and standard in both uplink and downlink for streamlining the operation of control channels for resource designation and criticism [1]. Thus, certain systems must be actualized to beat these issues. To build edge rates by as much as 500%, a straightforward, evidently exceedingly problematic highly suboptimal association methods fixated on forceful however static biasing towards small cells and blanking about portion of the macro cell transmissions has been indicated in[12]. The combined problem of user association and resource allocation in two tier heterogeneous networks, with adaptive tuning of the biasing and blanking in each cell. A model of hotspot traffic shows that the optimal cell association is finished by rate proportion bias, rather than power level basis. A dynamic model of cell range extension, the traffic arrives base as a Poisson procedure in time and at the conceivable landing rates, for which a steadying planning strategy subsists. With massive MIMO at the base stations, user association and load adjusting in a heterogeneous networks. An energizing amusement theoretic approach is utilized as a part of [13].for the issue of radio access innovation choice, in which union to Nash equilibrium and the Pareto-efficiency of these equilibrium are pondered [13]. All in all, there is a huge extension for modeling, investigating and improving base station-user association in 5G

**3.3.7. FULL DUPLEX RADIOS:** For a long duration of communication period, it is accepted in the wireless networks design that radios need to work into half duplex mode. It implies that it will not transmit and receive on a similar channel. Numerous researchers, scholastics and analysts at various universities and research group shave endeavored to undermine this assumption by proposing many ideas and designs to work in-band full-duplex radios. However, the acknowledgment to build full duplex radio has a considerable measure of suggestions. The cellular networks should lessen their spectrum range demands to half as just a single channel is utilized for accomplishing a similar performance. As in LTE, for both uplink and downlink, it utilizes same and equal width separates channels for empowering radios to acknowledge full duplex. For communicating in the full duplex mode, the self-impedance comes about because of its own transmission to the got signal must be totally evacuated. Let us a chance to consider the instance of Wi-Fi signals which are transmitting at 20dBm (100mW) average power with the noise floor of around −90dBm. So the transmit self-interference should be wiped out by 110dB (20dBm-(−90dBm)) to accomplish the similar level as of the noise floor and lessen it to insignificant. In the event that any leftover self-interference is not totally wiped out, at that point it will goes about as noise to the received signal, which thus decreases SNR and along these lines throughput [13].

**3.3.8. A MILLIMETER WAVE SOLUTION FOR 5G CELLULAR NETWORK:** The Wireless industries has been developing step by step and disregarding the efforts by the industrial researchers for creating the proficient wireless technologies, the wireless industry continuously confronting the overwhelming capacity demands from its present innovations. Recent innovations in figuring and communications and the landing of smart handsets alongside the need to get to the web postures new tensions before the wireless industries. These demands and anxieties will develop in the moving toward years for 4G LTE and demonstrates that at some point around 2020, there will emerge an issue of blockage in wireless networks. It will be must for the research industry to execute new innovations of technologies and structures for taking care of the increasing demands of the users. The continuous work designs a wireless future in which data rates increases to the multi gigabit every second range. These high data rates can be feasible with the assistance of steerable antennas apparatuses and the millimeter wave range and in the meantime will bolster mobile communication and backhaul systems. Recent researches have put forward that mm-wave frequencies of 2.6 GHz radio spectrum possibly will supplement the presently saturated 700 MHz band for wireless communications. Feasibility of millimeter wave wireless communications is supported by the fact that the use of high gain, steerable antennas at the mobile and base station and cost effective CMOS technology can now operate well into the millimeter wave frequency bands. Also, with the utilization of millimeter wave carrier frequencies, large transmission capacity like bandwidth distributions will think of higher data rates and specialist organizations that provides service that are by and by utilizing 20 MHz channels for 4G users will now significantly extend the channel data transmissions means Bandwidth [30]. With the expansion in Bandwidth, capacity will likewise increases, while the latency will get diminished, which offer ascent to better internet based access and applications like real time streaming. Since the wavelength of millimeter wave frequencies are very small, so it will use polarization and different spatial handling systems like Massive MIMO and adaptive beam forming [4]. With the significant increment in bandwidth, the data connects to densely populated regions will now deal with more capacity limit than show 4G systems. Similarly the base stations are always decreasing the coverage regions of the cell for spatial reuse, cooperative MIMO, transfers and obstruction relief between base stations. Since the base stations are bottomless and all the more densely scattered in urban zones, which will diminish the cost per base station. Range appropriations of spectrum distribution is more than 1 GHz of bandwidth are presently being used in the 28 GHz and 38 GHz bands. By far as for the concern of building a prototype, the antenna is essentially being positioned in very close vicinity to the 28 GHz Radio Frequency Integrated Circuit and the front end module because there will be high signal attenuation at 28 GHz. Understanding the receiving wire exhibit straightforwardly on the printed circuit leading group of the 5G cell devices will limit the addition misfortune between the reception apparatus and Radio Frequency Integrated Circuit. This infers that an employment of the Radio Frequency blocks in the 5G architecture before the intermediate frequency stage will be reliant on the placement of the 28 GHz antenna array in the cellular phone. Taking this concept into a thought, a minimum set of two 28 GHz antenna arrays is proposed for millimeter wave 5G cellular applications in [14], the two antenna arrays are employed

Table 3.2: 28 GHz antenna array configuration for 5G cellular network comparison with the 4G.

| **Cellular standard** | **4G** | **5G** |
|---|---|---|
| **Antenna type** | Sub wave length antennas | Phased array antennas |
| **Radiation patterns** | Omnidirectional | Directional and fan beam |
| **Diversity and MIMO** | Yes | Yes |
| **Polarization** | Single and constant | Multiple and reconfigurable |

in the top and bottom part of the cellular device. Antenna array configuration of 28 GHz for 5G cellular is given in table 3.2.

The millimeter wave range is under-utilized and is left sit without moving until present years. The primary purpose for the underutilization is its unsuitability for cellular communications Because of hostile channel conditions like path loss impact, assimilation because of climate and rain, small diffraction and entrance about obstructions and through items individually. There is one more reason of unsuitability is because of strong phage noise and excessive contraption costs. However, the overall reason is that the huge unlicensed band around 60 GHz [14], were appropriate basic ally for short range transmission. Semiconductors are additionally developing, as their expenses and power utilization esteems are diminishing quickly because of the development of the previously mentioned short range standers. In figure 3.10millimeter wave system has been seen. The main engendering issues with respect to millimeter wave spread for 5G cell communication are [15]:

**3.3.8.1.** Path Loss: The free space path loss is dependent on the carrier frequency, as the size of the antennas is kept constant which is measured by the wavelength $\lambda$ =c/fc, where fc is the carrier frequency. Now as the carrier frequency increases, the size of the antennas got reduced and their effective aperture increases with the factor of $\lambda^2/4\pi$, while the free space path loss between a transmitter and a receiver antenna grows with $fc^2$. So, if we increase the carrier frequency fc from 3 to 30 GHz, it will correspondingly add 20 dB of power loss irrespective of the transmitter-receiver distance. But for increased frequency, if the antenna aperture at one end of the link is kept constant, then the free-space path loss remains unchanged. Additionally, if both the transmitter and receiver antenna apertures are kept constant, then the free space path loss decreases with $fc^2$ [15].

**3.3.8.2.** Blocking: Microwave signals are less inclined to blockages however it break down because of diffraction. In the opposite, millimeter wave signals endure less diffraction than the microwave signals and exhibit specular propagation, which makes them considerably more powerless against blockages. This will aftermath as almost bimodal channel subject to the presence or absence of Line of Sight. Recent studies reveal that, with the expansion in the transmitter and collector remove the way misfortune expands to20dB/decade under Line of sight engendering, however plummets to40dB/decade in addition to an additional blocking loss of 15– 40dB for non-observable pathway [15]. So because of the nearness of block ages, the set association will instantly move from usable to unusable which will brings about vast scale obstructions that can't be maintained a strategic distance from with average little scale decent variety countermeasures.

Atmospheric and Rain Absorption: Inside the unlicensed 60-GHz band, the ingestion because of rain and air especially the 15 dB/km oxygen absorption are more noticeable. Be that as it may, these absorption are insignificant for the urban cellular deployments, where base station dispersing's strength be in light of the request of 200 m. Regardless, these sort of absorption are helpful as it will efficiently expand the isolation of every cell by additionally weakening the foundation impedance from more far off base stations. So from the above clarification, it is derived that the propagation losses for millimeter wave frequencies are resolvable, however just by guiding the beam energy with the assistance of large antenna array sand at that point gather it rationally [15].

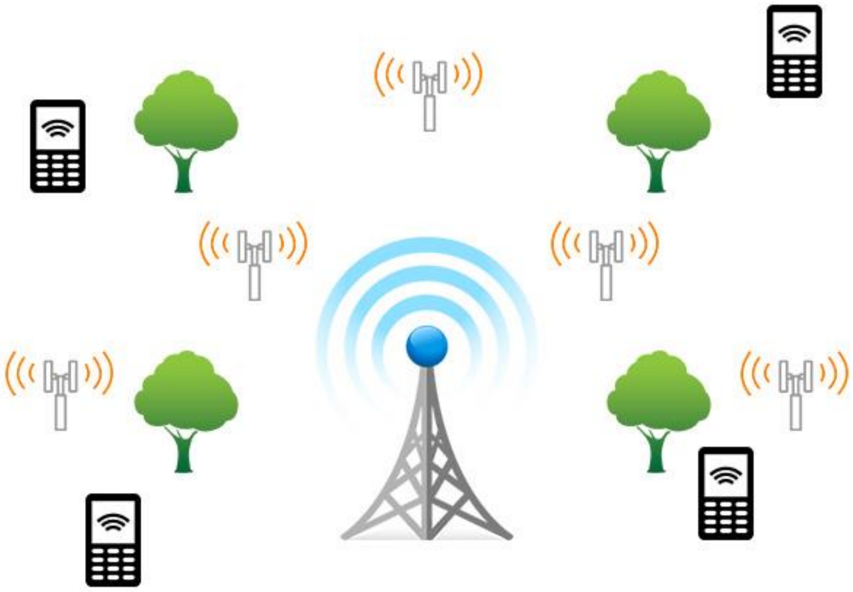

Figure 3.10: Millimeter Wave system.

Be that as it may, for handy feasibility, the idea of narrow beam communications is fresh for cellular communications and poses issues like:

i. Link Acquisition: The main problem that the narrow beams are facing is in establishing links amid users and base stations for both initial access and handoff. The user and base stations will have to locate each other by scanning lots of angular positions where the possibility of a narrow beam is high. This problem poses an important research challenge predominantly in the perspective of high mobility [15].

ii. Need of New Transceiver Architectures: Wireless millimeter wave systems have experienced significant positive changes yet at the same time there are some equipment issues which will influence the planning of the communication system. The analog to digital and digital to analog converters needed for large bandwidth are the prime reason for control utilization. A prime reason of power consumption is a result of the utilization of large area antenna arrays. Alongside these, high receiver sensitivities are expected to manage the way path loss since it isn't attainable that every antenna will be provided with ordinary fully beam formers [15].

### 3.3.9. CLOUD TECHNOLOGIES FOR FLEXIBLE 5G RADIO ACCESS NETWORKS:

**3.3.9.1.** Mobile Cloud Computing: During this recent years, cloud computing for mobile has become much familiar as it is an alignment of many computing fields. Computing, storage, services, and applications over the Internet are offered by it. It also can reduce cost, disconnect services from the existing technology. It gives flexibility in terms of resource provisioning. So mobile cloud can be defined as a chamber of commerce of cloud computing technology with mobile devices. This integration will make the mobile devices resource full in terms of computational power, memory, storage, energy, and context awareness. With different concepts of the mobile cloud, it can be explained. In the first method, let consider that the other mobile devices will also act as resource providers as in [1]. So the consolidated assets of the various cell phones and other accessible stationary gadgets in the neighborhood be abused as appeared in figure 3.11. This strategy underpins client versatility and identifies the capability of portable mists to perform aggregate detecting. The cloudlet idea of the second technique is for versatile distributed computing. This technique is clarified in figure 3.12, where a nearby cloudlet incorporated by various multi center PCs with network to the remote cloud servers is utilized by the cell phone to alleviate from its workload. Attachment Computers having structure factor, assorted variety and low power utilization can be considered as great contenders for cloudlet servers. Be that as it may, these PCs are perfect for little scale servers in slowed down in people in general association since they have the comparative general design as an ordinary PC and are less effective, littler, and less exorbitant. Henceforth, these cloudlets ought to be introduced out in the open zones like eateries so cell phones can associate specifically with the cloud let rather than a remote cloud server to expel idleness and data transfer capacity issues [93]. Mobile cloud computing follows the basic concepts of cloud computing. There are some specific requirements that need to counter in a cloud like adaptability, scalability, availability and self-awareness. So mobile cloud computing should also fulfill these requirements. For example, a mobile computing cloud should be cognizant of its availability and dynamically plug themselves in, depending on the requirements and workload. An appropriate technique of self-pretentious one's own quality Is desirable for mobile users to proficiently take advantage of the cloud, as the internal status and the external environment is subject to change. Others facets like mobility, low connectivity and limited source of power also needed to be considered [16].

**3.3.9.2.** Radio Access Network as A Service: Centralization is the prime objective of 5G mobile networks because processing and management will need to be flexible and adapted to the actual service requirements. This will lead to a compromise between the decentralized today's network and fully centralized cloud radio access network. This compromise is addressed by the radio access network as a service concept, which partly centralizes functionalities of the radio access network depending on the needs and characteristics of the network. The Radio access network as a service is an application of the software as a service paradigm, so every function may be packed and distributed in the form of a service within a cloud platform. This will cause increased data storage and processing capabilities, as provided by a cloud platform accommodated in data centers. The design of radio access network as a service based on cloud enables flexibility and adaptability from different perceptions. Recent advances in Cloud radio access network is given in [17],with the introduction of this functional split, degrees of freedom increases. The left side demonstrates a traditional LTE employment in which all functionalities up to admission/congestion control are locally employed at the base station. The right side illustrates the cloud radio access network approach in which only the radio front-end is locally employed, and all the rest functionality is centralized. But radio access network as a service does not fully centralize all radio access network functionalities. Functional split realization poses a serious challenge for the radio access network. Theoretically, the functional split occur on every protocol layer or on the interface amid each layer. Present architecture involves restraints on the functions between discrete protocol layers. So with a restrained backhaul, most of the radio protocols tack and radio resource management will accomplished locally, while functions with less restrained requirements like bearer management and load balancing are placed in the radio access network as a service platform. So when a high capacity backhaul is available, lower-layer functions like PHY and MAC are shifted for a higher degree of centralization into the radio access network as a service platform. Major characteristics of a radio access network as a service implementation similar to the basic characteristics of a cloud computing platform and is explained in [18].

**3.3.9.3.** Joint Radio Access Network Backhaul Operation: The main reliability factor of 5G wireless networks is densely spread small cell layer which necessitates to be connected to the radio access network as a service platform. Though, the need of deployment of small cells is in the places where the line of sight centered microwave solutions are either hard or too costly to deploy for backhaul. Hence, the need to connect small cells at diverse locations made backhaul network a Critical part of the infrastructure .In particular, there is a need of flexible centralization for dynamic adaptation of network routes. The degree of radio access network centralization depends on available backhaul resources. So there is a need of a refined transport network design that can convey the data headed towards the central unit free of the degree of centralization. This is an important necessity for maximum flexibility when the introduction of the new functionalities to the network is taking place. But the complications increases in routing and classification of data packets according to their quality of service. On the other hand, software defined network provides quicker reaction to link/node letdowns, higher utilization of the accessible resources, and faster deployment of new updates with ease. These advantages have come up with a centralized control example, which streamlines the arrangement and management, but with increased computational efforts, as algorithmic complexity increases. Also for spectrum utilization, software defined radio (SDR) and software defined networks (SDN) are the optimum solution and the study in [104].revealed that the co-existence of SDR and SDN is essential, and the optimal results can be attained only by co-existence and joint compliments [18]

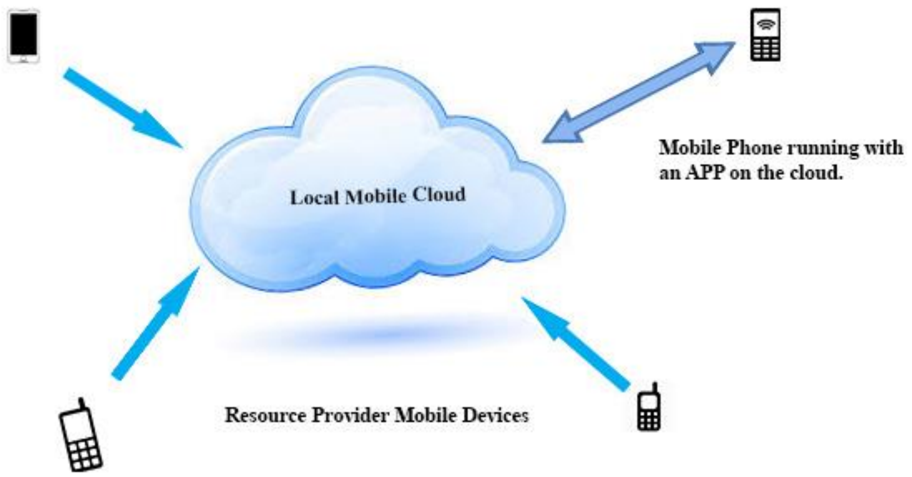


Figure 3.11: Virtual resource cloud made up of mobile devices in the vicinity.

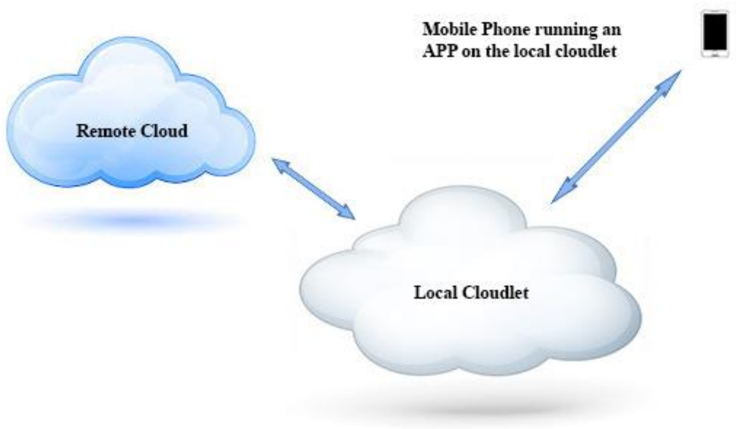


Figure 3.12: A cloudlet enabling mobile devices to bypass latency and bandwidth issues while benefitting from its resources.

## 3.4. Trends and Quality of Service Management In 5G

5G technologies are likely to appear in the market in 2020. It is expected to significantly improve customers Quality of Service (QoS) in the context of increasing growth of data volume in mobile networks and the growth of wireless devices with variety of services provided. Some general trends related to 5G can be explained in terms of machine to machine traffic and number of machine to machine connections in mobile [1]. In 2018 the number of machine to machine (M2M) connections in the networks of mobile operators will surpass 15 billion, which is 2 times more than the present rate, and in 2022 mobile operators will have more than 26 billion machine to machine connections. At the same time the stake of machine to machine connections of the total number of connections in the mobile operator’s networks will rise from the present 5% to 15% in 2018 and to 22% in 2022 [18]. A key trend relates to mobility, as broadband mobile usage, with more than 2.4 billion users globally (as of June 2012) is expected to be dominant over the coming years. For data traffic and machine-to-machine communications, an expected 40-fold increase between 2010 and 2015 is shown and a 1000 fold increase is predicted over a decade. This level of growth forces the network operators to provide global broadband access to all types of heterogeneous and modified Internet based services and applications. While the Quality of

Service management in 5G can be realized in terms of cell spectral efficiency and latency. Demand to the cell's spectral efficiency in 5G networks for diverse transmission channels are shown in Fig.16. Increased spectral efficiency of 5G networks can be attained using non-orthogonal access methods in radio access networks and by using non-orthogonal signals. Comparison of these demands with the same demands to 4G networks shows the progress of spectral efficiency by 3-5 times [19].

## 3.5. Practical Considerations and Infrastructure Requirements

The many technological advances addressed in the previous section are viable solutions to the problems and challenges stated prior and may be able to meet the proposed requirements for 5G networks when considered all together. However, turning these possible solutions into actual, implemented hardware and infrastructure will be a gargantuan task with many obstacles in the way. These types of concerns are rarely discussed in scholarly articles; however they are a critical concern in the deployment of mobile networks, being a consumer business, and factors greatly into the design of the system. In a Global mobile Suppliers Association survey of the industry on the challenges to meeting the 5G goals, most all surveyed scored the list of barriers at least at a 3, and most close to a 4. Cost, lack of suitable spectrum, and delay of standards/interoperability were the three highest ranked issues.

**3.5.1. Cost:** Previous generations of mobile technology certainly had increased costs when transitioning, but for the most part, the changes were minimal. Hardware needed to be changed at the base stations and central office, but little more was done. The solutions considered in this paper will require an enormous increase in infrastructure costs. Network virtualization of functions will require large upgrades of the core servers to control the network. Changes will need to be made at every base station in order to accommodate the cloud-based computing and control of the towers. Perhaps most costly will be the additional small cell deployments. According to wirelessestimator.com, there are currently about 120,000 cell towers in the US. Assuming only one additional small cell per current tower, that doubles the current number of towers. These new cells may not need full size towers, however, because they may be placed on buildings and will be located in more densely populated areas. But that does not negate the fact that the available real estate must be found, then purchased or leased, properly zoned, and power and backhaul utilities run to the locations.

A look back shows how the current paradigm (the one large macro cell tower) is augmented with multiple antennas throughout the macro cell and femtocells on trains, buses, and buildings. There is also a reliance on femtocells in homes routing their wireless communications through hardwired internet connections. To get the speeds of 5G, houses will have to have fiber run to every home, which is usually only done today in brand new developments because ISPs do not find it cost effective to run it everywhere. Most homes have only copper connections. The goals of ultra-low latency may be great, but that is only on the radio network side. The overall latency of the user is a factor of the radio network, but also of all other connections on the internet to get the content desired. The cost to get low latency on the radio network, which is only part of the entire latency string, is not something most consumers would want to pay for.

**3.5.2. Lack of Suitable Spectrum:** Government entities that regulate the radio spectrum in their countries have control of what and how much of a frequency can be allocated to mobile telecommunications. The process to open new spectra can sometimes be a slow, arduous task that does not keep up with the speed at which industry desires. It may also be done in a way that hampers the full and fair usage of that spectrum. In the US, the FCC recently opened several large sections of high frequency spectrum for 5G usage. However, some fear that it is not enough and that the big carriers will license portions that they will then not use completely, only covering large city centers and venues with 5G and leaving the rest of the country without. (Goovaerts 2016) This locking down of frequencies will prevent true and full deployment of 5G in all areas.

**3.5.3. Delay of Standards / Interoperability:** The standards for any technology define what can and can't be done with it. These standards then define how carriers will design and implement their networks. That design then leads to hardware designs (both the radio network and mobile devices) using the standards that are then manufactured, and then ultimately deployed. Though some capital can be expended prior, it is not necessarily in the best interest of the carriers to go out early on their own and presume certain 5G requirements. The more complicated the 5G design, the more important it is to get a solid standard, and that takes time. (Kinney 2015) The amount of interoperability and backwards compatibility will also be a concern. If these networks have to support 4G, 3G, and possible prior generations, it will affect how the system is designed to be able to still communicate with the older technologies, yet remain able to meet the goals of 5G. The reliance on other communication types, such as Wi-Fi, device-to-device communication and consumer internet service provider access, will cause an entire other set of concerns. Those networks will be required to work together in order to meet the 5G goals. The entire industry of communications, from wireless carriers to wired carriers, and the manufactures of all the devices used by those carriers, will have to come together and agree on how to operate interchangeably across the different networks and establish rules for cost accounting and sharing. These agreements will only add on to the delay created by a late standard.

# References

[1]. A. Gupta, and R. K. Jha, "A Survey of 5G Network: Architecture and Emerging Technologies", *IEEE Access*, vol. 3, pp. 2169-3536, 2015.

[2]. C. W. Wang et al., "Cellular architecture and key technologies for 5G wireless communication networks", *IEEE Commun. Mag.*, vol.52, No.2, pp. 122–130, February 2014.

[3]. X. Hong, C. -X. Wang, H. –H. Chen, and Y. Zhang, "Secondary Spectrum Access Networks", *IEEE Veh. Technol. Mag.*, vol. 4, No. 2, pp. 36–43, Jun 2009.

[4]. P. Agyapong, M. Iwamura, D. Staehle, W. Kiess, and A. Benjebbour, "Design Considerations for a 5G Network Architecture", *IEEE Commun. Mag.*, vol. 52, no. 11, pp. 65–75, November 2014.

[5]. A. Osseiran, "Scenarios for 5G Mobile and Wireless Communications: The Vision of the METIS Project", *IEEE Commun. Mag.*, vol. 52, no. 5, pp. 26–35, May 2014.

[6]. E. G. Larsson, F. Tufvesson, O. Edfors, and T. L. Marzetta, "Massive MIMO for Next Generation Wireless Systems", *IEEE Commun. Mag.*, vol. 52, no. 2, pp. 186–195, February 2014.

[7]. W. Nam, D. Bai, J. Lee, and I. Kang, "Advanced Interference Management for 5G Cellular Networks", *IEEE Commun. Mag.*, vol. 52, no. 5, pp. 52–60, May 2014.

[8]. T. Irnich, J. Kronander, Y. Selen, and G. Li, "Spectrum Sharing Scenarios and Resulting Technical Requirementsfor5G Systems",*Proc.IEEE24th PIMRC*, London, U.K., pp. 127–132, September 2013.

[9]. G. J. Buchwald, S. L. Kuffner, L. M. Ecklund, M. Brown, and E. H. Callaway, "The Design and Operation of the IEEE 802.22.1 Disabling Beacon for the Protection of TV White space in Cumbents", *Proc. 3rd IEEE Dy SPAN*, pp. 1–6, October 2008.

[10]. J. Huang, R. A. Berry, and M. L. Honig, “Auction-based Spectrum Sharing”, *Mobile Netw. Appl.*, vol. 11, no. 3, pp. 405–418, Jun2006.

[11]. M. N. Tehrani, M. Uysal, and H. Yanikomeroglu, “Device-to-device Communicationin5G Cellular Networks: Challenges, Solutions, and Future Directions”, *IEEE Commun. Mag.*, vol. 52, no. 5, pp. 86–92, May 2014.

[12]. T. Ihalainen, “Flexible Scalable Solutions for Dense Small Cell Networks”, *Proc. WWRF*, Oulu, Finland, vol. 30, April 2013.

[13]. J. G. Andrews, “What Will 5G Be?”,*IEEE J. Sel. Areas Commun.*, vol. 32, no. 6, pp. 1065–1082, Jun 2014.

[14]. Z. Pi, and F. Khan, “An Introduction to Millimeter-wave Mobile Broadband Systems”, *IEEE Commun. Mag.*, vol. 49, no. 6, pp. 101–107, Jun 2011.

[15]. A. R. Khan, M. Othman, S. A. Madani, and S. U. Khan, “A Survey of Mobile Cloud Computing Application Models”, *IEEE Commun. Surveys Tuts.*, vol. 16, no. 1, pp. 393–413, First Quarter 2014.

[16]. L. Mei, W. K. Chan, and T. H. Tse, “A Tale of Clouds: Paradigm Comparisons and Some Thoughts on Research Issues”, *Proc. Asia-Pacific Services Comput. Conf. (APSCC)*, pp. 464–469, December 2008.

[17]. M. Peng, X. Xie, Q.Hu, J. Zhang, and H. V. Poor, “Contract-based Interference Coordination in Heterogeneous Cloud Radio Access Networks’, *IEEE J. Sel. Areas Commun.*, vol. 33, no. 6, pp. 1140–1153, Jun 2015.

[18]. P. Rostetal, “Cloud Technologies for Flexible5G Radio Access Networks”, *IEEE Commun. Mag.*, vol. 52, no. 5, pp. 68–76, May 2014.

[19]. *4G America’s Summary of Global 5G Initiatives*, A One-Time Overview of Global 5G Initiatives as of the First Quarter of 2014, Jun. 2014.

[20]. X. Ge, H. Cheng, M. Guizani, and T.Han,“5G Wireless Backhaul Networks: Challenges and Research Advances.”, *IEEE Network*, vol. 28, pp. 6-11, 2014.

# Chapter 4

# Advantages and Challenges of 5G

## 4.1. Why 5G

3G and 4G parts made for one landmass is not generally perfect with another mainland sue to conveying recurrence groups. Another conspicuous issue in 4G frameworks is to make higher piece rates accessible in bigger bit of the cell, particularly to clients in an uncovered position in the middle of a few base stations. In momentum investigate, this issue is tended to by full-scale assorted variety methods, otherwise called assemble helpful hand-off, and furthermore by Beam-Division Multiple Access (BDMA)[5]. Pervasive systems are a hypothetical idea where the user can be at the same time associated with a few remote access advancements and can consistently move between them. This innovation has not yet been productively executed [1].

While 4G was composed to a great extent on account of mobile broadband, 5G enables engineers to take a look at the horizon of new uses. Distinctive utilize cases put different demand on the network, and effect different areas of the economy. 5G must consider, for instance, the different networking requirements of industrial automation, exactness farming, and increased reality. Where requests push up against the limits of what is at present conceivable with 4G network, analysts begin to consider jumps to entire new advances rather than incremental augmentations to the LTE particular. Development of 5G is driven by the central difficulties that current network confront. The difficulties can be generally separated into whether they are essentially for human users or for machine users. Maybe more hopefully, the utilizations cases that require the development of 5G can be assembled under three general headings: upgraded portable broadband; Internet of Things (IoT); and basic foundation or open wellbeing. Actually 5G has many criteria that can explain why we will use 5G and that are given below [2]:

- Low battery consumption
- Improve coverage area at cell edge
- Higher data rate availability at cell edge. It provides more than hundreds of channels without streaming. The uploading and downloading speed is very high in 5G network.
- Multiple Concomitant paths for data transmission.
- Multiple concurrent paths for hand over
- 5G uses different modulation techniques and error-control techniques [2].
- 5G supports interactive media, voice, video, internet, and so many broadband services which will be more attractive and which will have bidirectional accurate traffic statistics.
- Higher system level spectral efficiency.
- Provides large broadcasting of data in Gigabit. At a time, with a large broadcast capacity to 65,000 connections, an estimation of data rate of mobility over 1GHz.
- Much better cognitive radio or software development radio with an improved security features.
- A wireless based web applications which is represented by World Wide Wireless Web (WWWW) and it has included the capability of full multimedia beyond 4G speed[1].
- In mobile devices several artificial intelligent applications can be added because of the high speed.
- Offers high resolution for crazy cell phone user and bidirectional large bandwidth shaping.
- Offers transporter class gateway with unparalleled consistency [1].

- The terminals that have been used for 5G technology have software defined radios.
- Virtual private networks are supported by 5G network.
- One of the great feature of 5G is remote diagnostics.

## 4.2. Main Challenges

The standards for 5G have not yet been created, with future approval expected to occur in 2020. However, telecommunications companies and the International Telecommunication Union have been working on requirements for the next generation since the last standardization of the International Mobile Telecommunications – Advanced standard in 2008, but specifically for 5G since 2015. Much of the problem creating the need for a new generation of mobile telecommunications comes from a wide expansion of use cases. What once only needed to transmit voice grew to data. And what was once just a handheld device need is growing into many disparate devices, many of which have no human interaction whatsoever. These new use cases, which will be detailed later in this paper, have created a great number of challenges that the current system cannot support, and simple expansion of the current technologies do not seem to be a solution for. The goals of 5G are to support these many new use cases.

**4.2.1. More Capacity**: 5G network architects predict the need to support a 1000-fold increase in traffic compared to 2010. Mobile traffic grew nearly 70% during 2013, reaching 2.5 Exabyte's a month. They expect it to grow to 10 times that monthly amount by 2019. Theodore Rappaport of the New York University Wireless research center says 4G "can never accommodate this new demand." 4G has gotten to where it is capacity wise through radio technology advances and acquisition of new spectrum. These methods are meeting their limits. Most modulation techniques and coding schemes cannot get more efficient, and the spectra best suited for long distance communications has been allocated. Though there is planned to be additional spectra available for use, the advances in capacity are projected to come from other sources [5].

**4.2.2. Higher Data Rate:** 5G goals include data rates at least ten times higher than current peak data rates. Current data rates are limited for the same reasons that capacity is limited. Increased usage of the same frequency space limits the amount of bandwidth that can be used per device. Additionally, the current capabilities of backbone, backhaul, and front haul limit the amount of data that can pass from base stations to mobile devices and vice versa. (Agyapong 2014, 67) Solutions will require expansion beyond current means rather than more efficient usage of the current means to affect data rate [5].

**4.2.3. Lower Latency:** The Internet of Things (IoT) is putting a higher demand on always-on and always–available abilities of wireless networks. Connected devices in traffic control, autonomous cars, healthcare, and industrial automation cannot be subject to latency issues when lives may be on the line. This extremely high reliability and extremely low latency requirement is not supportable by the current model. (Agyapong 2014, 66) Previous generations of mobile telecommunications and their users primarily used static or latency-independent data, such as websites and email. Higher data rates led then to streaming video, which can be affected by latency, though buffering can prevent that. But the expansion of real-time applications, such as teleconferencing and time-critical communications, such as remote controlled medical robots, cannot suffer the effects of latency to properly function [5].

**4.2.4. Connectivity for Massive Number of Devices:** Not only are the numbers of devices exploding due to IoT, but the different connection needs makes this a wideranging challenge. No longer are the needs expected to be similar to previous requirements (voice calls, <150 ms latency acceptable.) Devices need to be able to range from sleeping until needed to always-on, yet get the connectivity when required. Handling the massive number of devices that may pop in and out of connection constantly will be a challenge. 4G is not ideal to handle this because current systems are disconnected, according to Zhiguo Ding of Lancaster University. Bluetooth, RFID, and other various short-distance communication protocols are not set up to communicate with each other. There is no common system. The challenge will be creating a system that is common yet able to support a myriad number of devices with hundreds of different use cases. [5].

**4.2.5. Reduced Cost and Energy:** Energy storage capabilities are not keeping up with the media abilities of current devices, and the desire to increase those abilities will require a reduction in the amount of energy required in order to communicate with the network. The IoT also is affecting this issue because small, low-power devices such as sensors are expected to run on a battery for several years. On the provider's side, base station electricity usage and the cost of equipment upgrades to handle the new requirements is a concern that needs to be solved for the business to remain profitable. Current estimates of the percentage of radio network power usage are 70 to 80 percent of total operations energy usage. This is driving costs higher, and future usage will only increase that. Systems will need to change in order to meet service demands yet maintain reasonable costs [5].

**4.2.6. Quality of Experience:** Quality of Experience (QoE) is the user's perception of how the experience of using a device meets expectations. It is related to some of the above challenges, such as data rate and latency, but is combined in such a way in that it creates a balance between them. High data rate and low latency may make a streaming video look good, but it is a larger drain on the battery. However, a low QoE will cause a user to become dissatisfied. Due to 4G architecture, it is difficult to maintain consistent experience at all times and in all locations [5].

**4.2.7. Environmental Concerns:** Current wireless communication systems are mainly powered by traditional carbon-based energy sources. At present, information and communication technology (ICT) systems are responsible for 5% of the world's CO2 emissions [3-4], but this percentage is increasing as rapidly as the number of connected devices. Moreover, it is foreseen that 75% of the ICT sector will be wireless by 2020 [5], thus implying that wireless communications will become the critical sector to address as far as reducing ICT-related CO2 emissions is concerned [6].

## 4.3. Security Characteristics of 5G

The drivers for mobile network evolution have predominantly been tied in with enhancing throughput and latency, and having the capacity to better support for the mobile Internet. The drivers for security have stayed set up to give a reliable essential availability benefit. This essential trust will keep on being a driver for 5G network as a high data rate, mobile broadband services. Whatever, additional key driving factors will enter the scene.

Firstly, 5G network will be designed to serve new capacities for peoples and society, as well as to interface the industries such as manufacturing and processing, intelligent transport, smart grids and e-health. With 5G, it is conceivable to predict new models of how network and communication services are given. Additionally, the idea of terminal and devices will change: unattended machines and sensors will associate; now and again whole narrow systems including tens or several individual devices will all the while append to the 5G network.

New service delivery models will be utilized. Cloud and virtualization technologies and anything-as-an administration will be utilized to lessen costs, and to convey and services all the more quickly. Telecom networks will uncover application programming interfaces (APIs) toward users and third party service providers to co-ops to a higher degree, for instance, with the end goal of enhanced conveyance utilizing area mindfulness, content adjustment and storing. Such improvements will now and again be given by third party programming executing on shared equipment stages close by dedicated telecom software.

The drivers recorded above can be assembled into four categories of 5G systems and their utilization, each with suggestions for security and protection. These qualities are: new trust models, new service delivery models, an evolved threat landscape, and increased security concerns.

**4.3.1. New Trust Models:** Trust models change with time. As an example, consider the bring-your-own-device incline in enterprises. Already, all user devices could be thought to be reliable, as they were the majority of a similar sort, all issued and oversaw by the corporate IT division. Today, users want to utilize their own devices rather, acting dangers like potential Trojan steeds behind corporate firewalls.

For current mobile systems, the trust model is rather straightforward, involving a subscriber (and their terminal) and two operators (the home and serving networks). Since 5G is aimed at supporting new business models and involves new actors, trust models will change, giving rise to extended requirements in areas such as authentication between various actors, accountability and non-repudiation.

The new devices will traverse a to a wide range of security requirements and will in the meantime have altogether different security stances: industry computerization control devices, shipping compartments, vehicles framing whole capillary networks, small atmosphere monitoring sensors and, latest tablets and cell phones. Devices have so far been expected to follow models and not to intentionally endeavor to assault network.

The current trust show clearly does not catch this developed business and innovative landscape of 5G. To guarantee that 5G can bolster the necessities of new plans of action, and guarantee adequate security, the trust demonstrate outline be redrawn. All things considered, this does not really mean totally overhauling security. In any case, it is essential to recognize any noteworthy deficiencies. This must start by defining a new trust model [5].

**4.3.2. Security for New Service Delivery Models:** The utilization of mists and virtualization underscores the reliance on secure programming, and prompts different consequences for security. Current 3GPP-defind systems depend on practical hub particulars and dynamic interfaces amongst them, and thusly give a decent beginning stage to virtualization. Until now, however, dedicated/proprietary hardware has still often been used for these nodes and interfaces. Decoupling software and hardware means that telecom software can no longer rely on the specific security attributes of a dedicated telecom hardware platform. For the same reason, standard interfaces to the computing/network platforms – such as those defined by ETSI (the European Telecommunications Standards Institute) in their Network Functions Virtualization work – are necessary to ensure a manageable approach to security. At the point when administrators have third-party-together applications in their telecom mists, executing on indistinguishable equipment from local telecom administrations, there are expanded requests on virtualization with solid separation properties [5].

**4.3.3. Evolved Threat Landscape:** 5G systems will serve an even more basic part as critical infrastructure. Many individuals will have effectively experienced events when settled phone lines, internet get to and the TV benefit have all quit working in the meantime amid a noteworthy system blackout. What's more, social orders positively would prefer not to lose electrical power, portable communication and more in the meantime.

Today’s networks host various values – examples include revenue streams and brand reputation. The accessibility of these values via the internet has already attracted hacktivists, underground economies, cybercrime and cyber-terrorists. The values hosted in, and generated by, the 5G system are estimated to be even higher, and the assets (hardware, software, information and revenue streams) will be even more attractive for different types of attacks. Furthermore, considering the possible consequences of an attack, the damage may not be limited to a business or reputation; it could even have a severe impact on public safety.

This prompts a need to reinforce certain security practical territories. Assault protection should be a plan thought when characterizing new 5G protocols. Faulty confirmation strategies, for example, username/secret key should be eliminated. All the more in a general sense, in any case, the new dangers accentuate the requirement for quantifiable security confirmation and consistence; at the end of the day, checking the nearness, accuracy and adequacy of the security capacities.

A key asset of the Networked Society will be data. The role that data currently plays in processes such as decision-making and value creation is changing. Being in control of personal data will be crucial for operational reasons, but this will also increase in importance in order to create competitive advantages. As the carriers of this data, 5G networks will need to provide adequate protection in the form of isolation and efficient transport of protected (encrypted/authenticated) data.

The pervasiveness of 5G devices and network won't just influence the mechanical assault surface; the introduction to social designing assaults will likewise increment. Individuals asserting to be work partners or repair professionals, for example, may contact an individual and demand different sorts of access – to the person's data, as well as to their gadgets [5].

**4.3.4. Increased Privacy Concerns:**There have been several recent news stories related to allegations of mass surveillance. Reports have also emerged of rogue base stations tracking users in major cities, and of extracting personal data without user knowledge. The protection of personal data has been discussed within the framework of the EU. It is being reviewed in standardization bodies such as the 3GPP and the IETF (Internet Engineering Task Force), and debated in many other forums.

An especially touchy resource is the user identifier(s). As far back as 2G, user security has been an essential thought. Be that as it may, the advantages of full International Mobile Subscriber Identity (IMSI) security have so far not appeared to exceed the many-sided quality of executing it.

## 4.4. Core 5g Security Topics

**4.4.1. Security Assurance:**5G networks will play a considerably more basic part as basic infrastructures than prior ages, and that security confirmation will enter the photo to a higher degree. This isn't a totally new advancement. The 3GPP has effectively watched the need to expand security details from utilitarian ones for interfaces to confirmation determinations on the hub/interface usage, and has started work known as SECAM. Nonetheless, in mix with cloud-based execution (virtualization and on-request benefit) there is an imaginable need to isolate programming confirmation all the more solidly from stage affirmation, and to permit on demand estimations of confirmation as a major aspect of Service Level Agreements (SLAs) and coordination.

Regarding the role of 5G networks as critical infrastructure, a decision must be made on just how critical these should be, since increasing criticality comes with a price tag in terms of assurance. The standard assurance for IT products is Common Criteria (ISO 15408). If 5G is to become a general platform for the Networked Society vision, it seems clear that Common Criteria compliance could enter as an additional assurance requirement on top of SECAM. However, the impact may not stop there.

To start with, the idea of system cutting could be an imperative apparatus to deal with the exceptionally assorted prerequisites of various applications and client gatherings. Cutting is regularly observed as an approach to give separated sub-arranges, each enhanced for particular sorts of movement qualities. One such trademark could be identified with security and wellbeing prerequisites. By having a legitimately actualized, high-affirmation disengagement system to help cutting, it will be conceivable to bind the effect of security prerequisites to single cuts, instead of the entire system. The cost of high affirmation and accreditation can along these lines be concentrated onto an infrastructures virtualization/isolation layer.

The general approach could be to define a limited number of standardized, interoperable, high-assurance security enablers that are present in all slices as a baseline. On top of this, more application-specific security mechanisms are enabled by boot-strapping into specific slices, providing the additional security functions.

Indeed, with a properly operating virtualization layer, external parties such as enterprises could securely deploy their own (certified) software inside the 5G network, thereby offering governance to organizations using 5G, and at the same time reducing the number of certifications that the 5G network must undergo.

We have the decision to "factor out" security prerequisites from the 5G arrange cuts by just putting the duty in the endpoints; as such, in associated gadgets or association server farms. Information security is a case of an administration that could be taken care of along these lines.

In summary, the fact that 5G is designed to be a platform for a wide range of new user groups and applications does not automatically mean that it is necessary (or even desirable) for the 5G network to carry all security responsibility and related costs. On the other hand, 5G networks clearly can provide some highly valuable security services. Besides the isolation/slicing itself, many other examples of network-enabled security as a service will be attractive to multiple user groups, including network enforced security policies, authentication, key management and data security services.

**4.4.2. Identity Management:**The 4G LTE standard requires USIM on physical Universal Integrated Circuit Cards to gain network access. This way of handling identity will continue to be an essential part of 5G for reasons such as the high level of security and user friendliness. Embedded SIM has also significantly lowered the bar for deployment issues related to machine-to-machine communication. Still, there is a general trend of bring-your-own-identity, and the 5G ecosystem would generally benefit from a more open identity management architecture that allows for alternatives. One example would be to allow an enterprise with an existing, secure ID management solution to reuse it for 5G access. Examining new ways to handle device/subscriber identities is therefore a key consideration that should enter the investigation of the new trust models for 5G. Concepts such as network slicing can provide an enabler for securely allowing different ID management solutions side-by-side by confining usage to virtual, isolated slices of the network.

The danger of IMSI getting, where maverick radio system gear demands cell phones to uncover their personality, was examined amid the 3G and 4G institutionalization process. Notwithstanding, no security component was presented around then, as the anticipated dangers did not appear to legitimize the cost or many-sided quality included. It isn't evident whether this hazard investigation is as yet legitimate, and improved IMSI security merits thought for 5G [3].

**4.4.3. 5G Radio Network Security:** Due to the evolved threat landscape and new technology that provides users with low-cost alternatives to program their own devices (even at radio access level), the attack resistance of radio networks should be a more clearly outspoken design consideration in 5G, analyzing threats such as Denial of Service from potentially misbehaving devices, and adding mitigation measures to radio protocol design.

In spite of the fact that LTE radio access has astounding cryptographic security against spying, there is no assurance against adjusting or infusing client plane movement. With 5G radio access as a building hinder in, for instance, mechanical computerization, the potential advantages of including respectability insurance appear to be deserving of examination [3].

**4.4.4. Flexible And Scalable Security Architecture:** With virtualization and more powerful arrangements entering the photo for 5G, it appears to be consistent to consider a more unique and adaptable security engineering for it. Security for synchronous perspectives like RAN flagging could be found near the entrance with a higher level of freedom from non-concurrent security angles, for example, those identified with the client plane, than today. This would take into consideration more effective security dealing with, and confine dangers to touchy client information in the meantime.

New security designs with higher flexibility could also better address unnecessary conflicts between usability and security. For example, new network APIs could allow the network to perform service chaining, such as traffic optimizations, while still allowing data to be encrypted end-to-end [5].

**4.4.5. Energy-Efficient Security:** While security administrations, for example, encryption accompany a cost, the cost is not any more an issue for cell phones and comparable gadgets. The vitality cost of scrambling one piece is maybe a couple requests of size not as much as transmitting one piece [4]. Be that as it may, for the most obliged, battery dependent gadgets with a long target life time, there might be a need to consider significantly more lightweight arrangements, as each small scale joule devoured could be of significance [3].

**4.4.6. Cloud Security:** Cloud security is as of now to a great degree interesting issue, and it will be added to the rundown of 5G concerns. Whole books have been composed regarding this matter, so there takes after only a short rundown of needs for cloud security in a 5G setting, propelled by the discourses above [5].

- Create hypervisors and organize virtualization with high confirmation on isolation. As said, interests here could pay off, as this would significantly rearrange the treatment of various security prerequisites in a similar foundation.
- Build useful ecosystems and architectures from existing trusted computing tools and concepts for remote attestation, for example.

- Develop easy-to-use, trusted management of cloud systems and the applications that run there. Some of these continue to represent essential academic research topics
- Give more proficient answers for cloud-friendly information encryption

# References

[1]. V. S. Jain, S. Jain, L. Kurup, and A. Gawade, “Overview on Generations of Network: 1G, 2G, 3G, 4G, 5G”, *Int. J. Computer Technology & Applications*, vol. 5 (5), pp. 1789-1794, September-October 2014.

[2]. A. U. Gawas, “An Overview on Evolution of Mobile Wireless Communication Networks: 1G-6G”, *International Journal on Recent and Innovation Trends in Computing and Communication*, ISSN: 2321-8169, Volume: 3 Issue: 5, P: 3130–3133, May 2015.

[3]. “5G Security: Scenarios and Solutions”, *Ericsson White Paper*, Uen 284 23-3269, June 2017.

[4]. C. Margi, B. Trevizan, G. de Sousa, M. Simplicio, P. Barreto, T. Carvalho, M. Näslund, and R. Gold, “Impact of Operating Systems on Wireless Sensor Networks (Security) Applications and Test beds”, *Proceedings of ICCCN 2010,* pp. 1-6, 2010.

[5]. P. K. Agyapong, M. Iwamura, D. Staehle, W. Kiess, and A. Benjebbour, "Design Considerations for a 5G Network Architecture." *IEEE Communications Magazine*, pp. 65-75, November 2014.

[6]. Buzzi, I. Chih-Lin, T. E. Klein, H. V. Poor, C. Yang, and A. Zappone,“A Survey of Energy-Efficient Techniques for 5G Networks and Challenges Ahead Stefano”

# Chapter 5

# Conclusion

## 5.1. Conclusion

In this thesis a detailed study of the performance requirements of 5G wireless cellular communication system have done. These requirements in this thesis have been defined in terms of bandwidth capacity, data rate, spectral efficiency, latency, energy efficiency and Quality of service. A 5G wireless network architecture consisting massive MIMO technology, network function virtualization (NFV) cloud and D2D communication. Different short-range communication technologies like millimeter wave communication, visible light communication, and small cell technology has been explained. These will provide a promising future in terms of increased data rate with better quality. Different emerging technologies like massive MIMO, D2D communication etc have also been discussed which can be used in 5G wireless communication. These technologies have been used in interface management, spectrum sharing with cognitive radio, ultra-dense networks, multi radio access technology, full duplex radios, millimeter wave communication and Cloud Technologies in general with different networks.

Apparently it is expected that 5G will give a higher data rate up to 50 Gbps with low battery consumption. It will provide improved coverage cell edge with multiple concurrent paths for data transmission. Different artificial intelligent mobile applications can be designed as it has higher speed.  5G also have the feature of VPN and remote diagnostics. 5G will provide protection for private data, which is being reviewed in standardization bodies like 3GPPP, IETF.