International Journal of Electrical and Electronics Research ISSN 2348-6988 (online)
Vol. 7, Issue 1, pp: (1-9), Month: January - March 2019, Available at: www.researchpublish.com

An Overview of 5G Mobile Technology

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Abstract: **5G Technology stands for 5th Generation Mobile technology or mobile Networks or Wireless Systems. The 5G technology which is expected to be launched by 2020 it is an upgraded version of the existing and establishing network 4G known as LTE (Long Term Evolution) network, this technology started an era of highly-efficient information society. 5G is a name used in some research papers and projects to denote the next major phase of mobile telecommunications standards beyond the upcoming 4G standards. Currently, 5G is not a term officially used for any particular specification or in any official document yet made public by telecommunication companies or standardization bodies such as 3GPP, Wi-MAX Forum or ITU-R. Mobile communication prime objectives can be improved, including increased capacity, higher data rate, low latency, and better QOS. This paper studies 5G Technology, architecture, waveforms, and makes a comparison between these waveforms and OFDM.**

Keywords: **5G Architecture-Nanotechnologies, BDMA, OFDM, UBMC, FBMC, GFDM, Cloud Computing.**

I. INTRODUCTION

Mobile networking is a wireless technology than can provide voice and/or data networking, through a radio transmission. Mobile phone is one of the most famous applications of mobile networking. In past circuit switching was used to transmit voice over a network, then we moved on to use both circuit-switching and packet-switching for voice and data, now presently we are using packet switching only, this is how spectrum has expanded from 1G to 4G [1]. Today and in upcoming future wireless networks need to be improved for meeting the demand for increased data rate, improved capacity, reduced latency and good quality of service. We are in the 4th generation of wireless communication, so now research is going on for developing new standards for the next generation beyond 4G i.e. 5G. With increasing demands of subscribers definitely 4G will be replaced by 5G with the help of some advanced technologies like massive MIMO, device-to-device communication, millimeter wave communication, Beam division multiple access in massive MIMO etc. The technologies used in 4G like High-Speed Packet Access (HSPA) and Long Term Evolution (LTE) will be used as a part of future advancement. For this advancement we may use different methods, It may happen that we may use different spectrum access technique, increased frequency range, deploying large number of antennas etc. Technology which will be used in the 5G network is the most powerful as well as demanding also the challenging part will be the integration of the wide range of technologies into a small device. High Resolution is the main feature offered by 5G for the high end users. Bidirectional huge bandwidth is another milestone to be achieved by the upcoming technology [2]. Error free transmission will be ensured due to the policy based Quality of Service. Technologies used in 1G are: Nordic Mobile Telephone (NMT) & Advanced Mobile Phone System (AMPS). It provides the data rate is 2.4kpbs. It has some limitations which is easy t replaced by second generation. The second Generation is Global System Mobile (GSM). It provides the data rate upto 64kpbs. General Radio Packet Service (GPRS) was introduced in upgrade version of GSM with data rates upto 100kbps. Orthogonal Frequency Division Multiplexing (OFDM) is a multicarrier modulation used in 4G along with Multiple Input Multiple Output (MIMO) antenna technology. Table I shows a general description of the various technologies from 1G to 4G.5G must respond to 4 new challenges: higher data rate, higher capacity, low latency and massive device connectivity [3].The use of multicarrier modulation is for two reasons; the first one is easy to implement & the second is easier equalization especially with larger bandwidth, and higher multipath distortion [4].Another challenge that 5G has to address is to ensure low latency with a round-trip delay of 1ms.

Table I. Mobile Technologies Comparison

Mobile Technology	1G	2G	3G	4G
Year	1981	1992	2001	2010
Technology used	NMT/TACS/AMPS	GSM/GPRS/EDGE	UMTS	LTE, Wi-MAX
Advantages	Simple N/W	Multimedia N/W	Roaming	MIMO Technology
Limitations	Interference	Low N/W ranges	High power Consumption	Complicated & difficult to implementation
Data rates	2.4kbps	64kbps	2Mbps	1Gbps
Switching	Circuit	Circuit	Packet	Packet
Applications	Voice Calling	Voice Calling/Short Messages	Video Conference	Mobile TV
Access technology	FDMA	TDMA/FDMA	WCDMA	OFDMA/SC-FDMA

The paper is structured according to the following sections: In Section I, give an introduction. In Section II consists of 5G wireless communication system. In Section III consists of Nanotechnology. In Section IV contains cloud computing. In Section V discuss the All IP Network. In Section VI contains BDMA. In section VII describes 5G Waveforms. In Section VIII gives the MIMO Concept. In Section IX, conclusion of the paper followed by references.

II. 5G WIRELESS COMMUNICATION SYSTEM

5G has under the many research from the demand of 4G network. It changes to use in the mobile phone very high bandwidth. 5G technology use CDMA/W-CDMA and BDMA with millimeter wireless and that enable to greater than 100Mbps to 1Gbps data rates. The major difference between 4G and 5G is the maximum throughput, higher spectral efficiency, high data bit rate in large coverage area, support more applications.

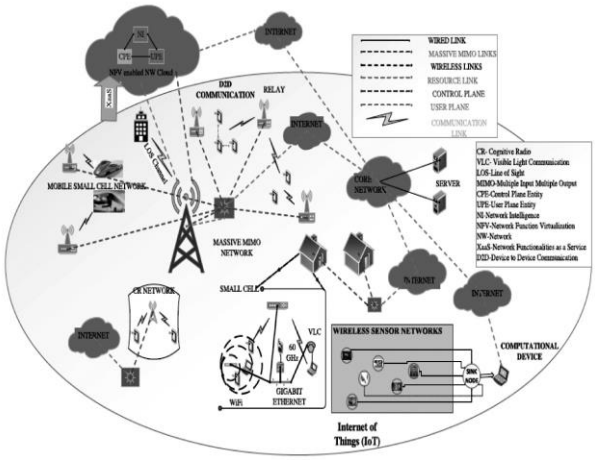

Figure 1: General 5G Cellular network architecture.

5G network has following features:

- It can be figured out up to 65,000 connections.
- Support Cloud computing network structure.
- It employing distributed antenna and Radio-over-Fiber technique.
- It allows different radio technologies to share the same spectrum efficiently with multiple data path.
- It enable World Wide Wireless Web (WWWW), wireless based web applications include multimedia capability beyond 4G speed.
- Support high QoS from end to end between network elements.

- 5G networks assigned IPV6 of all mobile IP address according to location and connected network.
- It has Dynamic Ad-hoc Wireless Network (DAWN), MANET, WMN combined with smart antenna.
- Improved modulation & coding system techniques.
- Low power consumption.
- Lower outage probability.
- Better coverage and high data rates.
- Many concurrent data transfer paths.
- More secure better cognitive radio/SDR Security.
- More system level spectral efficiency.
- Full multimedia accessibility.
- Applications cumulative with Artificial Intelligent (AI).
- Not harmful to human health.
- Smart beam antenna systems.
- Huge Memory.
- Fast Dialing Speed.
- HD Quality picture.
- Peak Uploading & Downloading.
- Remote Diagnostics.
- High Quality services to avoid errors.
- Bi-directional large bandwidth.

The following Capabilities of 5G:

- Performance of Network
- Lower Latency
- High availability & Reliability
- Very large System Capacity

III. NANOTECHNOLOGY

Nanotechnology is the application of Nanoscience to control process on nanometer scale. i.e. between 0.1 and 100nm.The field is also known as molecular nanotechnology (MNT).MNT deals with control of the structure of matter based on atom-by-atom and molecule by molecule engineering. The term nanotechnology was introduced by Nori Taniguchi in 1974 at the Tokyo international conference on production engineering. Nanotechnology is the next industrial revolution, and the telecommunications industry will be radically transformed by it in a few years.

Introduction of the Graphene's transistor is the milestone to be achieved. A transistor which is been built using the new material by name Graphene, mainly consists of a form of graphite that consists of a single layer of carbon atoms which has been arranged in the form of honeycomb pattern. The particular structure will help the electrons to travel through it very quickly and gives greater efficiency than the commonly existing transceiver chip material. The latest achieved frequency by the Graphene's transistor is 26GHz which is miles away from the current technology standards. Frequencies above 1THz are been used for the military for seeing the concealed weapons and medical uses for imaging without using harmful x-rays. At conventional frequencies, transceivers based on graphene will be able to make both the cell phone and base stations more sensitive for the betterment in picking weak signals. The main challenge is to distinguish the radio signals from the other waves around it. A more sensitive mobile device with a better signal to noise ratio will be able to take better advantage of the signal available from the nearest cell tower. Cell phones enhanced with the carbon nanotube will be introduced soon which comes under the nanotechnology.

A. NANO EQIUPMENT (NE):

Mobile phone has become more than a communication device in modern world it has turned into an identity of an individual. In 5G Nanocore, these mobile are referred as NanoEquipment as they are geared up with nanotechnology. One of the central visions of the wireless industry aims at ambient intelligence: computation and communication always available and ready to serve the user in an intelligent way. This requires that the devices are mobile. Mobile devices together with the intelligence that will be embedded in human environments – home, office, public places – will create a new platform that enables ubiquitous sensing, computing, and communication.

The specification of NanoEquipment given as follows:

• Self Cleaning – the phone will get cleaned by itself

• Self powered – the phone acquires power from natural resources like the sun, water, or air.

• Sense the environment – the phone will tell the weather, temperature information and the amount of pollution in air, etc.

• Flexible – it can be bent easily but will not break.

• Transparent – 5G phones are "see through" phones.

IV. CLOUD COMPUTING

Cloud computing is a unique and an innovative technique to access various documents, videos and music files etc from any place without carrying any data storage devices. Best example is Gmail. By uploading the data on the cloud, user can access it anytime and anywhere in the whole world. It is a technology that uses internet and central remote server to maintain its applications and data. In Nanocore, users try to access their private account form a global content provider in form of a cloud. Cloud computing shows the significance of networks and promotes network development. It requires reliable and secure service providers and capabilities that operators have deep expertise in. This could make users to obtain much more real-time applications to utilize 5G network efficiently.

Three main segments of Cloud computing are:

- ✓ Applications
- ✓ Platform
- ✓ Infrastructure

V. ALL IP NETWORK

The All-IP Network (AIPN) is introduced by 3GPP system to meet the highly increasing demands of the mobile telecommunications market. For the real-time data applications delivered over mobile broadband, televisions, landlines, internet and related services etc, wireless operators are turning to flat IP network architectures (common language), that reduces the number of technologies used and make easier to develop new services.

The key benefits of flat IP architectures are:

• Lower costs

• Universal seamless access

• improved user experience

• reduced system latency

• decoupled radio access and core network evolution

A. Support IPv6:

In the 5G system, each cell phone will have permanent "Home" IP address and "care of address" which represents its actual location. When a computer on the Internet wants to communicate with cell phone after that first, it sends a packet to the home address and subsequently server on home address send a packet to the actual location through the tunnel. Server also sends a packet to the computer to inform the correct address so that future packets will send on that address. Because of multiple layer of sub- netting and many addresses IPv6 is needed for mobility. IPv6 addresses are 128 bit, which is four

times more than 32 bit IPv4 address. This 128 bit address will be divided into four parts. The first 32-bit part may be defined as the home address of a device, second part may use for care of address, Third part for tunnelling to establish a connection between wire-line and wireless network and last part of IPv6 address may be used for VPN sharing. The goal of 5G network is to replace current core mobile network with a single worldwide network standard based on IPv6 for control, packet data, video and voice.

VI. BEAM DIVISION MULTIPLE ACCESSES (BDMA) FOR 5G

The goal of mobile communication systems is to provide improved and flexible services to a larger number of mobile users at lower costs. This objective results in a big challenge for the wireless technology that is increasing system capacity and quality within the limited available frequency spectrum. The challenge in mobile communication system is to communicate using limited frequency and time. In order to achieve this target multiple

Access technique is required. There are Frequency Division Multiple Access (FDMA), Time Division Multiple Access (TDMA), Code Division Multiple Access (CDMA), Orthogonal Frequency Division Multiple Access (OFDMA) techniques, etc. as examples of typical multiple access technology developed up to now.

FDMA - The FDMA technique divides frequency resource and allots them to respective mobile stations, allowing giving multiple accesses.

TDMA - The TDMA technique divides time resource, and allots respective mobile stations to give multiple accesses.

CDMA - The CDMA technique allots orthogonal codes to respective mobile stations, which allows the mobile stations to give multiple access

OFDMA - The OFDMA technique divides and allots an orthogonal frequency resource to maximize resource utility efficiency.

In the mobile communication system, limited frequency and time are divided to be used among multiple users, and a capacity of the mobile communication system is limited depending on given frequency and time. It is expected that a capacity required in a mobile communication system will increase as the number of mobile stations increase in future and an amount of data required in respective mobile stations is increased. However, since frequency/time resources which respective systems can use are limited, there is a demand for a technical development, which uses other resources than frequency/time resources in order to increase a capacity of the system.

Concept of BDMA:

When a base station communicates with mobile stations, an orthogonal beam is allocated to each mobile station. The BDMA technique of the present invention divides an antenna beam according to locations of the mobile stations to allow the mobile stations to give multiple accesses, thereby significantly increasing the capacity of the system. Mobile stations and a base station are in an LOS (Line of Sight) state, when they exactly know each other's positions; they can transmit beams which direct to each other's position to communicate without interfering with mobile stations at cell edge.

VII. 5G WAVEFORMS

This section presents the main waveform candidates for 5G systems.

A) Orthogonal Frequency Division Multiplexing (OFDM) Transceiver:

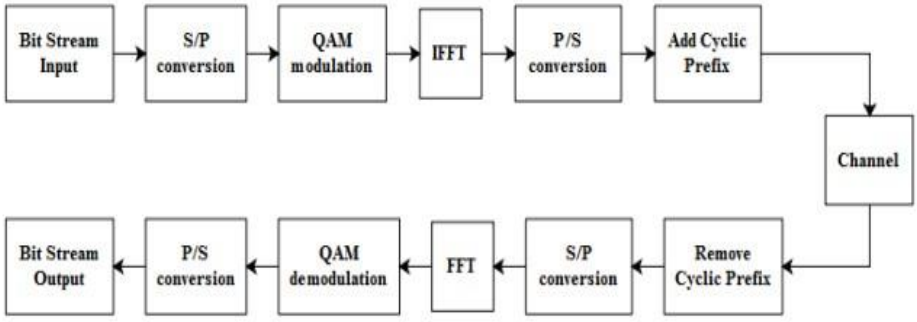

Figure.2: OFDM Transceiver.

Orthogonal Frequency Multiplexing (OFDM) is a multicarrier modulation technique allowing the transmission of large amounts of digital data over a radio wave. The main objective of OFDM is to divide the spectrum into orthogonal sub-bands with high efficiency but in specific conditions such as: perfect frequency synchronization & tight time alignment with in the duration of the cyclic prefix. OFDM uses the square windowing pulse shaping in time domain & sine shape infrequency domain.

At the transmitter, a serial to parallel conversion is done (by using SIPO shift register) before a QAM, the parallel QAM symbols are mapped to subcarriers using an Inverse Fast Fourier (IFFT). The parallel result is serialized through a parallel to serial conversion (by using PISO Shift register), and then CP is inserted in order to eliminate Inter Symbol Interference (ISI) and Inter Carrier Interference (ICI). The channel is Multi-path channel which characteristics depend on the propagation environment, device characteristic and the used band.

At the receiver, the guard interval is removed in order to mitigate the ISI generated by the arrival of OFDM symbols with different delay, then the signal is parallelized and FFT is applied, and finally a QAM demodulation & parallel to serial conversion is performed to retrieve the binary information sent by the transmitter.

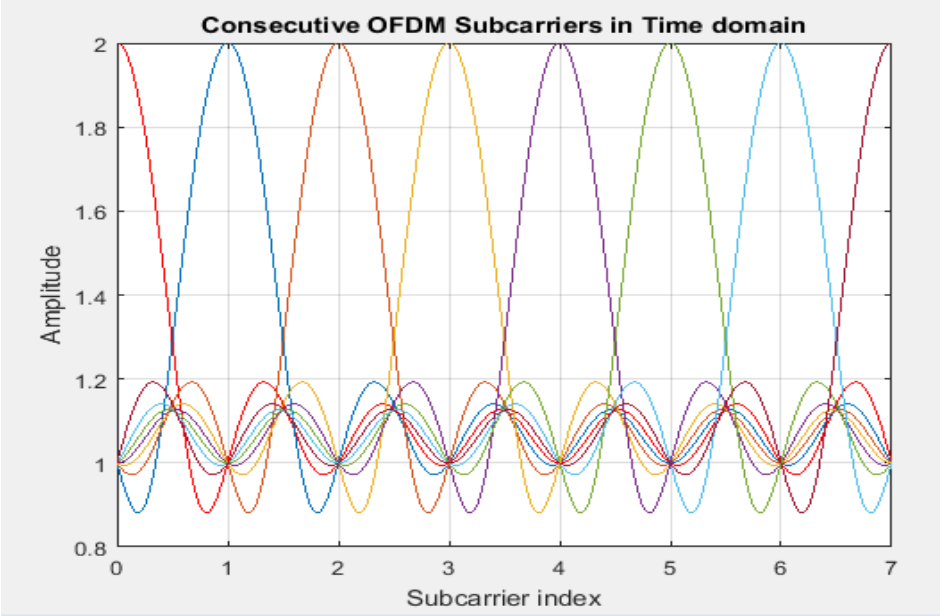

Figure.3: OFDM Signal in Frequency domain.

B) Filter Bank Multicarrier (FBMC) Transceiver:

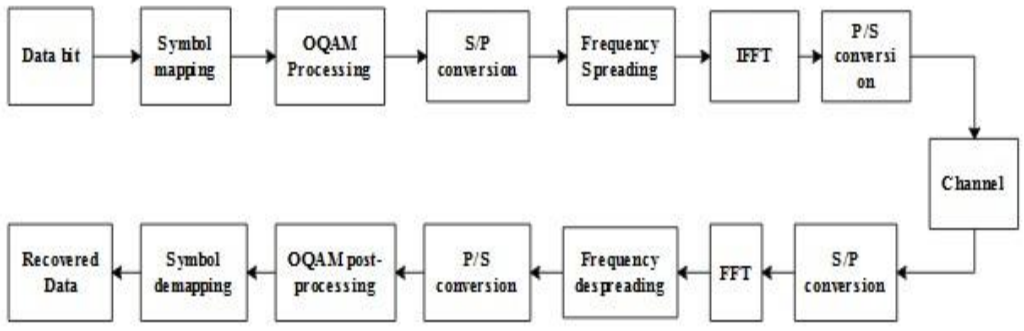

Figure.4: FBMC Transceiver.

Filter Bank multicarrier is a primary waveform for 5G.It is a development of OFD wherein subcarriers are passed through a bank of filters. The filters are characterized by the overlapping factor k, which is the no. of multicarrier symbols that overlap in the time domain. There are two main variants of FBMC:

i) Filter Multitone based on QAM and FBMC/OQAM.

ii) Variant maximizes spectral efficiency by ensuring orthogonality in real domain.

The data bits are mapped then an Offset QAM is employed in order to achieve full capacity. In addition to that, the imaginary and real parts of complex data symbol are not transmitted at the same time i.e. the imaginary is delayed by half duration of symbol. The symbols are filtered in frequency domain, and then the result feeds an IFFT. The advantage of FBMC in 5G is greater robustness against distortion and its flexibility.

C) Universal Filtered Multicarrier(UFMC) Transceiver:

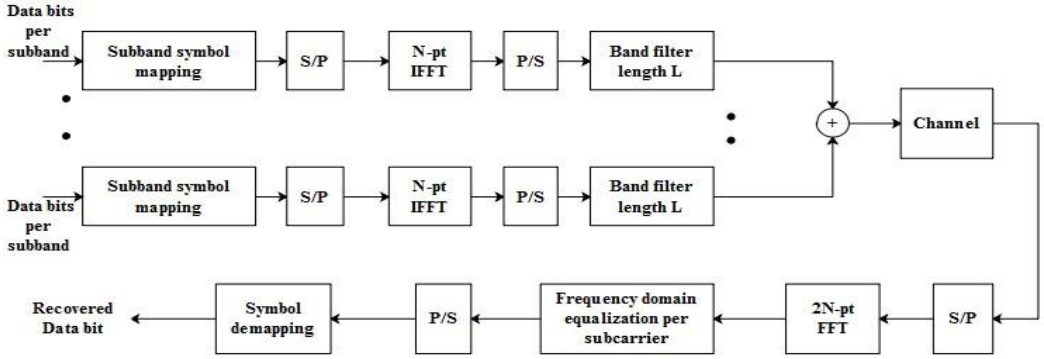

Figure.5: UFMC Transceiver

Universal Filtered Multicarrier (UFMC) is one of the enabling techniques for 5G. The main concept of UFMC is to split the signal into a group of sub-bands which are then filtered. In UFMC, the insertion of CP is optional; it can be added to improve the ISI protection. The advantage of UFMC is better spectral efficiency in time and band-limited transmission, and it provides high robustness against any sources of ICI.

D) Generalized Frequency Division Multiplexing (GFDM) Transceiver:

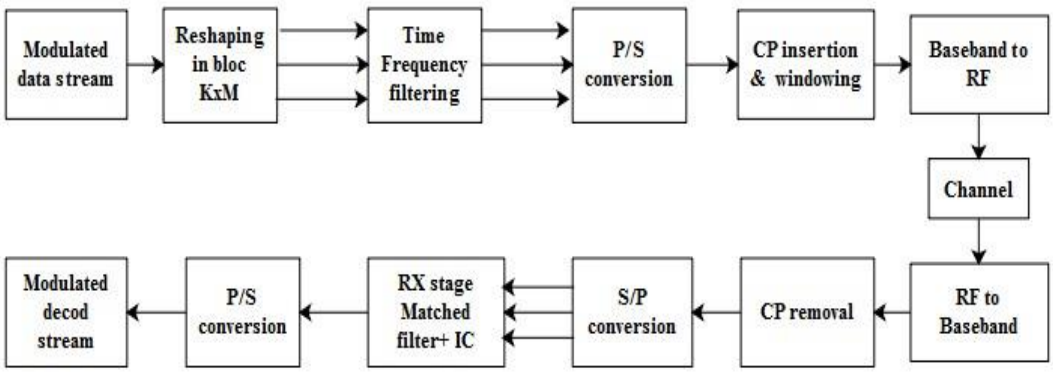

Figure.6: GFDM Transceiver

Generalized Frequency Division Multiplexing (GFDM) has been proposed for the air interface of 5G.The major difference is that the carriers are not orthogonal to each other. It is based on the time-frequency filtering of a data block, which ensures a flexible and non-orthogonal waveform. GFDM is attractive for several applications like cognitive radio or machine-to-machine communications. The main concept of GFDM is that it is based on independent modulation blocks, wherein each blocks has a no. of subcarriers and sub symbols. The advantage of GFDM is better control of the Out Of Band (OOB) and reduces the Peak to Average Power Ratio (PAPR).

VIII. MASSIVE MIMO

MIMO stands for Multiple Input and Multiple Output that means we use multiple antennas at the transmitter and receiver, this is called spatial diversity. If we use multiple antennas at the transmitter we call it as transmitter diversity and at receiver we call it as receiver diversity. By doing so we are increasing the channel capacity and reliability of the wireless network. During the start of this technology point-to-point MIMO were used both transmitter and receiver have multiple antennas, soon it was over taken by multi-user MIMO where there were multiple antennas at the base station which communicated with the single antenna receiver. Due to this cost of the whole system was reduced because now costly antennas were only needed at the base stations, cheap antennas can be used at the single antenna end.

One advantage of this technology is that we can increase the capacity and reliability, the other is that we can reduce the error rate. If we can transmit multiple versions of our message through different channels the probability all the signals will be affected same will be less. At the receiver these multiple copies are received and processed to get our original message. Hence Diversity also helps to stabilize a communication link, improves its performance, and reduces error rate. Due to all these advantages MIMO technology is deployed as a part of communication standards such as 802.11 (WiFi), 802.16 (WiMAX), and LTE.

The communication in MIMO take place in two formats called spatial diversity and spatial multiplexing. In spatial diversity, the same data is transmitted through different paths; the data is received at the multiple antennas and processed. By spatial multiplexing we can improve the reliability of the link. The other technique is spatial multiplexing, where the data is divided into small parts and different part is transmitted through different path, by doing so we are increasing the speed, but reliability is less.

A MIMO system consists of a number of transmitter and receiver antennas and a fading channel through which the data will be sent. Let us consider we have *M*, number of transmitter antennas and *N*, number of receiver antenna i.e. we form a matrix for transmitter and receiver antennas having t number of rows in transition matrix similarly r number of rows in receiver matrix.

The basic equation for MIMO system is given by Y= H.X + W

Where, Y = N x 1 Receiver matrix

H = N x M Channel matrix

X = M x 1 Transition matrix

W = Noise

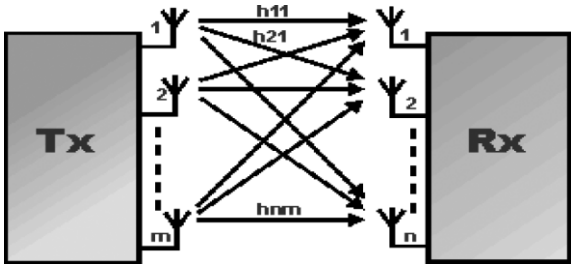

Figure.6: MIMO System

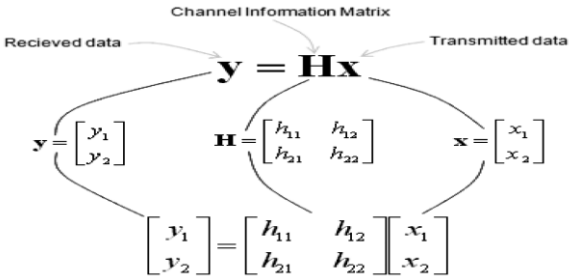

Figure.7: Matrix Representation of MIMO

IX. CONCLUSION

While the future is becoming more difficult to predict with each passing year, an accelerating pace of technological change can be expected. This Paper may help to promote stronger links between people working in different fields creating future concepts of mobile communication, Internet services, Cloud computing, All IP network, and Nanotechnologies. In this paper, a detailed survey has been done on the performance requirements of 5G wireless cellular communication systems that have been defined in terms of capacity, data rate, spectral efficiency, latency, energy efficiency, and Quality of service. 5G wireless network architecture has been explained in this paper with massive MIMO

technology. Massive MIMO is the future technology which will help to attain the requirements of 5G. TDMA, FDMA and other multiple access techniques may not be applicable to provide good capacity efficiency as the frequency and time are limited. So we need a new technique called Beam Division Multiple Access to be used in Massive MIMO to improve the capacity. The channel estimation in massive MIMO is a great challenge so as to provide low bit error rate. By using massive MIMO the system capacity is increased 10times and energy efficiency is improved by 100times. As the cost of infrastructure for 5G will be expensive, so one way to reduce the cost is by reducing the processing at the transmitter and receiver which can be achieved using a appropriate antenna selection algorithm. If all things fall in place 5G may be applicable by 2022/23. Still further 6G technology, 6G wiki, 6G network, 6G mobile are getting familiar with new mobile technology getting evolved.

REFERENCES

[1] Akhil Gupta., et al, "A Survey of 5G Network: Architecture & Emerging Technologies", The Journal for rapid open access Publishing, Vol: 3, 1206-1232, 2015.

[2] Ahmed Farhat Mohamed., et al, "Nanotechnology for 5G", International Journal of Science & Research (IJSR), Vol: 15, issue: 2, 2016.

[3] P.Karthikeyan. et al, "An Overview of Various Technologies in Mobile Computing", International Journal of Emerging Technology in Computer Science & Electronics (IJETCSE), Vol: 3, Issue: 1,694-699, 2015.

[4] Sk.Saddam Hussain., et al, "An Overview of Massive MIMO System in 5G", International Journal of Computer Technology &Application (IJCTA), 4957-4968, 2016.

[5] Sneha Dixit., et al, "Future Wireless Technology", International Journal of Scientific & Research Publications (IJSRP), Vol: 5, Issue: 2, 1-4, 2015.

[6] Toni Janevski., et al, "5G Mobile Phone Concept", IEEE on Wireless Communication,1-2, 2009.

[7] Suvarna patil. et al, "A Review on 5G technology", International Journal of Engineering & Innovation Technology (IJEIT), Vol:1, Issue:1, 26-30,2012.

[8] D.Hema Latha., et al, "A Study on 5th Generation Mobile technology", International Journal of Computer Science & information Technologies (IJCSIT), Vol:5, 8309-8313, 2014.

[9] Nikeeta R. Patel., et al, "An Overview of 5G Technology", national Conference on "Advanced Technologies in Computing & Networking", 418-4121, 2015.

[10] Priya Goyal., et al, "A Study on 5G Evolution & Revolution", International Journal of Computer Network & Application, Vol: 2, Issue: 2, 106-112, 2015.

[11] Rupendra Nath Mitra., et al, "5G Mobile Technology: A Survey", Institute of Computer Technology & Engineering, 132-137, 2016.