AN OVERVIEW OF TECHNOLOGY ENHANCEMENT IN WIRELESS COMMUNICATION SYSTEMS

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Abstract: In the current scenario data traffic in the wireless communication world has been increased exponentially and the current technologies, used in fourth-generation are not proficient to endow with the required capacity. Therefore they are losing their significance. Hence we have to move on new vibrant technologies to meet the rapidly escalating requirements of society and to provide sufficient bandwidth, low latency, and high data rate for reliable communication as well. In this paper technologies used in communication systems and proposed technology is portrait. Which starts from MIMO (Multiple input multiple output) systems to MIMO-OFDM (Orthogonal frequency division multiplexing) system in fourth-generation then Massive MIMO systems in 5G and Ultra massive MIMO system with Beamforming technology in 6G.

Index Terms **- MIMO, OFDM, 6G, Beamforming, Ultra massive MIMO.**

I. INTRODUCTION

Increasing the demanding application of the wireless world by supporting a huge transmission data rate by providing a tremendous increase in spectral efficiency and reliability. The spectral efficiency technical increment offers better quality of service which supports multiple users. In wireless mobile communication process, spectral efficiency can be increased by choosing multiple overlapped but orthogonal sub-carriers for parallel data transmission and this technique is known as OFDM. The important application of OFDM is its usage in wireless network and wire lines. Another technique used in wireless communication networks is multiple-input and multiple-output (MIMO) which supports system capacity enhancement of wireless networks. In MIMO technology, the multiple antennas are to be used in both communication end system. MIMO technology supports reliable communication networks data transmission. MIMO technology provides higher quality of service (QoS) by using gain diversity and also increases link reliability. MIMO plus OFDM provides enhancement in spectral efficiency and system reliability. The applications of MIMO plus OFDM are WMAN, WLAN, and 4G cellular networks. MIMO-OFDM can be designed with lesser complexity by using advanced technology in baseband digital signal processing and VLSI technology. So MIMO-OFDM is used in designing for next-generation wireless communication networks, which supports high data rate transmission.

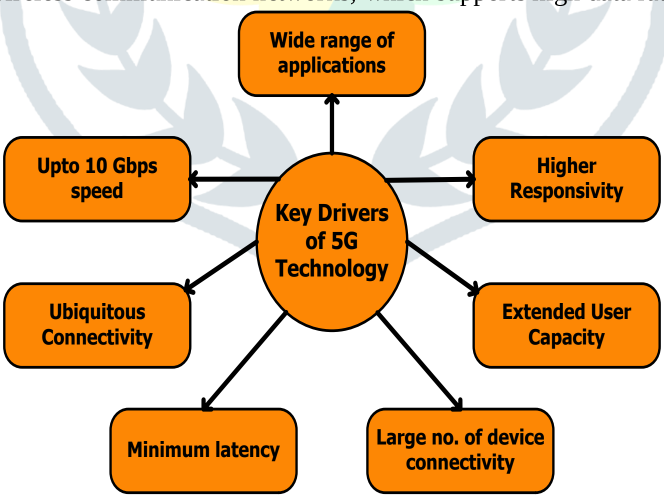

Figure 1: Key drivers of 5G Technology

Today mobile communication is an essential requirement in our life. Mobile communication allows the transmission of voice and multimedia data via mobile techniques or computer which is connected physically or wireless link. Mobile communication demand is rising day by day and it is the daily need of everyday's life due to increase in the number of customers, enhancement in the speed of the network with the low latency. From the first generation to fourth generation of mobile communication the researchers concentrated on improvement in terms of the speed of the network. As the 4G technology is not able to fulfill the exponentially increased demand of the speed of the mobile communication network, so there is the requirement for designing of 5G technology. The fifth generation technology of mobile communication is having many superior qualities than the previous and existing technology (1G to 4G). The important application of 5G technology due to broadband internet connection availability are additional gaming options, faster response time, wider multimedia options, tremendous connectivity everywhere and excellent audio and video quality transfer. The 5G technology features are shown in figure1. This paper gives the brief overview of MIMO and OFDM transmitter and receiver used in MIMO-OFDM technology.

II. EVOLUTION OF WIRELESS TECHNOLOGY

This section summarizes some technologies used in the current generation and technologies, which may adopt by service providers in next-generation i.e. 5 Gen, and 6 Gen.

A. MIMO

MIMO systems, In wireless communication are a unique type of transmission systems. Conservatively it is known that a system where transmitter having a solo antenna and the same number of antenna at receiver end, is recognized as Single input Single output (SISO) transmission scheme. MIMO system architecture can be explained by putting multiple antennas in transmitter section and the same number of antennas in the receiver section, here transmitter end still have only one transmitter module and receiver end also have only one receiver module however only the count of antennas is rising at both ends. Therefore a MIMO system may define as a transmission system, having two or more than two antennas with single transmitter module at the data transmitter end and the equivalent number of antennas with single receiver section at data receiver end. Figure 2 represents a MIMO system.

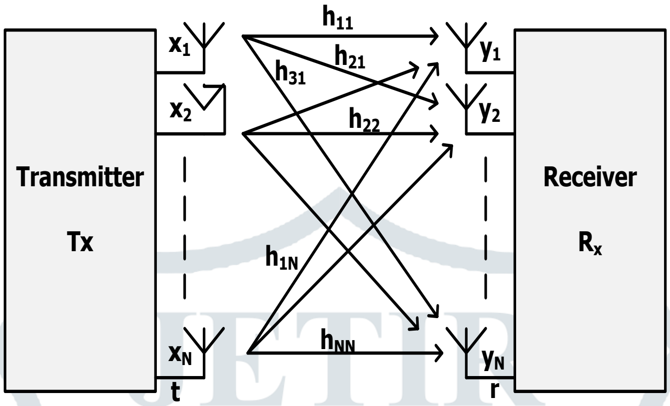

Figure 2: MIMO System

As there are multiple antennas in the MIMO system it provides more robustness against fading therefore it can be use to improved diversity gain. Another advantage of the MIMO system is that it can also be applied to achieve increased rate of data transmission if it is used with same power and bit streams transmitted in parallel. This scheme is termed as spatial multiplexing. MIMO system is constructed by three components mainly multiple antenna systems at transmitter section, channel, and multiple receiver antennas. Data stream such as p_1, p_2, ... p_N say p_i are used to transmitted by transmitter from multiple antennas through the channel and these data streams are received by multiple antennas simultaneously in terms of y_1, y_2, ... y_N say y_j. The MIMO signal model can be express in terms of vector.

$$\bar{\square} = \square\bar{\square} + \bar{\square}$$

Here $\bar{\square}$ is r dimensional received symbol vector, $\bar{\square}$ is t dimensional transmitted symbol vector, H is *rxt* channel matrix and $\bar{\square}$ is r dimensional Gaussian noise vector.

Features of MIMO

- → Diversity: MIMO transmits the same data through multiple antennas to enhance data reliability.
- → Capacity: MIMO transmits large data in parallel so that it provides enormous data rate.
- → The elemental tradeoff between multiplexing and diversity is feasible.
- → Minimized Interference can be achieved by utilizing spatial dimension to raise the space among consumer.[1]

B. Multi-Carrier System

The preliminary improvement of a multi-carrier system was done in the decade of 1950 and 1960 by military systems. These type of communication systems were called as classical Multicarrier Modulation (MCM) scheme. The total available bandwidth in the multi-carrier system is divided among several small multiple subcarriers which reduces narrowband interference. In this system each subcarrier transmits message information symbol at a lesser rate therefore period of symbol becomes longer, consequently, the system becomes comparatively more resistant against noise Figure 3 is the schematic of a multi-carrier transmission and reception system[1].

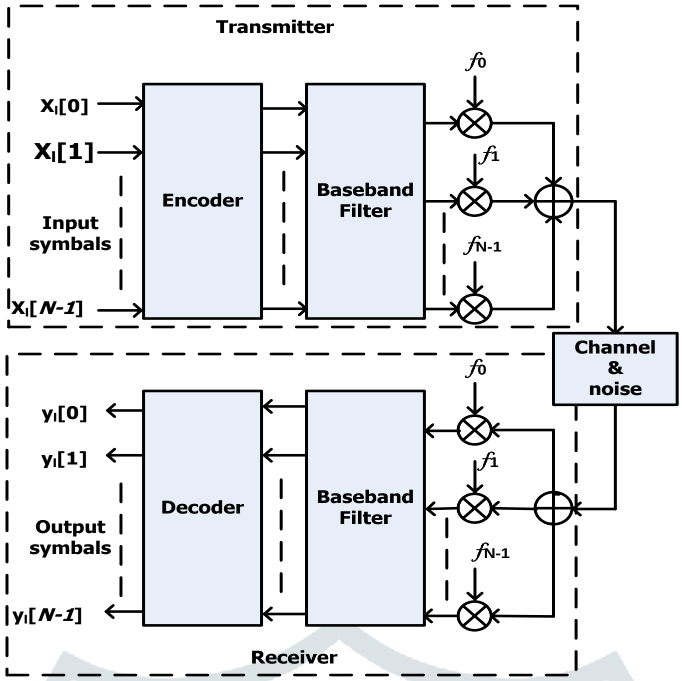

Figure 3: Schematic of the multicarrier system

In a multicarrier system, symbols are transmitted with orthogonal sub-channels in parallel form. This transmission system can be considered as a class of frequency division multiple access (FDMA) scheme.

C. OFDM

Orthogonal frequency division multiplexing (OFDM) transmission scheme is a type of a multichannel system, OFDM is a variety of MCM with compactly placed narrowband subcarriers. These subcarriers have overlapping spectra. Thus the system provides multiple access of carriers. In the field of telecommunication OFDM is a method of modulation of a signal. In OFDM scheme a information stream is split among numerous narrowband carriers.

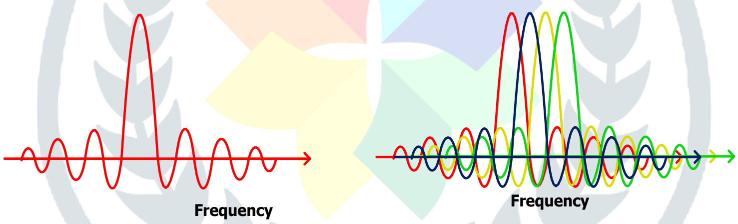

Figure 4: (a) an OFDM subcarrier spectra (b) Overlapped OFDM subcrriers

Narrowband frequency channels overlap one another in OFDM scheme in such a way that any of the sub carriers can be easily retrieved from combined signal. Figure [4] exhibits an OFDM single narrowband sub carrier and overlapped OFDM subcarriers. An advantage of OFDM scheme is that overlapping of subcarrier results in efficient use of the total available bandwidth. In this scheme information is blended into symbols. These symbols are disseminated and transmitted over the narrowband sub channels in such a way that one symbol is sent over the one channel only. While using this scheme one must ensure to meet minimum interference chance among narrowband sub channels and therefore frequency channels must be chosen cautiously. In the spectrum of frequency carrier in frequency domain, distance among the channel is specified by first null of the spectra of channel.

Concept of OFDM took arise in the decade of 1960 but it was not feasible without FFT. With the introduction of FFT in telecommunication OFDM became practicable. Inverse Fast Fourier Transform (IFFT) is an intelligent choice to generate OFDM signal. OFDM demodulation can also be achieved by using Fast Fourier Transform (FFT).Therefore OFDM scheme can be performed simply by using IFFT and FFT algorithm at transmitter and receiver end respectively. The benefits of using OFDM are decreased inter carrier interference (ICI), lessened inter symbol interference. spectral efficiency provided by OFDM is high. In OFDM without necessitate of equalization in time domain, it is possible to accept enormous changeable channel conditions with no trouble. Another advantage of OFDM is that tuned filters are not required at receiver end for subcarriers and also there is less sensitivity to synchronization errors. OFDM uses IFFT and FFT algorithm at transmitter and receiver end respectively so the complexity of hardware is reduced. The general transceiver structure of OFDM is presented in Figure5. Inter symbol Interference (ISI) in OFDM can be reduce by using cyclic prefix. In the present generation of wireless communication OFDM transmission scheme is being broadly used in IEEE 802.11 (Wi-Fi) Digital Audio Broadcasting (DAB), High Performance Wireless Local Area Network (HIPERLAN), Digital Video Broadcasting (DVB), and LTE (Long Term Evolution). [1]

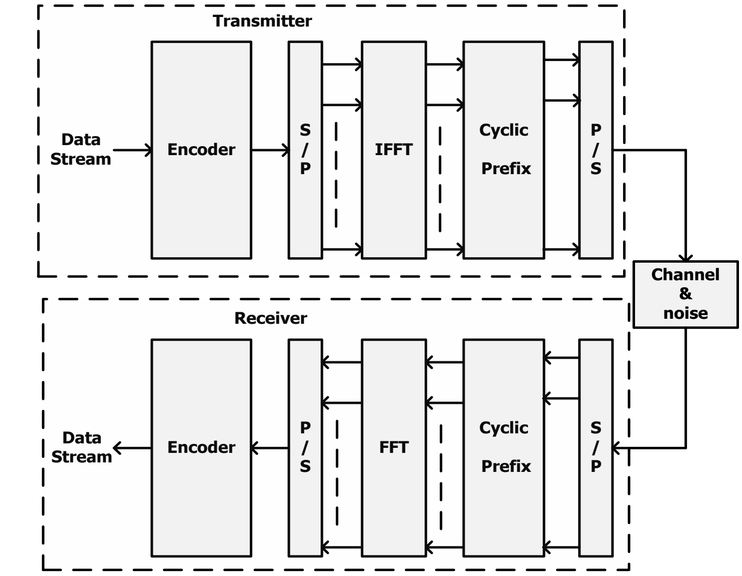

Figure 5: Schematic of OFDM transmission scheme

D. MIMO-OFDM

Originally the quality of a wireless system depends on three parameters; data rate, range of transmission, and reliability of data received. Prior to 4th generation, improvement in any of the parameters was achievable at the cost of reduction in the other two parameters. However with the advent of MIMO-OFDM system it became possible to improve all three parameters simultaneously. MIMO-OFDM became a key technology for currently deployed Transmission system with large data rate such as Long Term Evolution (LTE), and some IEEE standards [3]. MIMO-OFDM is the combination of MIMO systems with OFDM technology to achieve high throughput and easier receive processing at the receiver. In MIMO-OFDM scheme, single channel is converted into a set of flat fading MIMO channels. These channels are then transmitted in parallel. Hence MIMO-OFDM significantly simplifies baseband receiver processing, by eliminating the need for a complex MIMO equalizer.

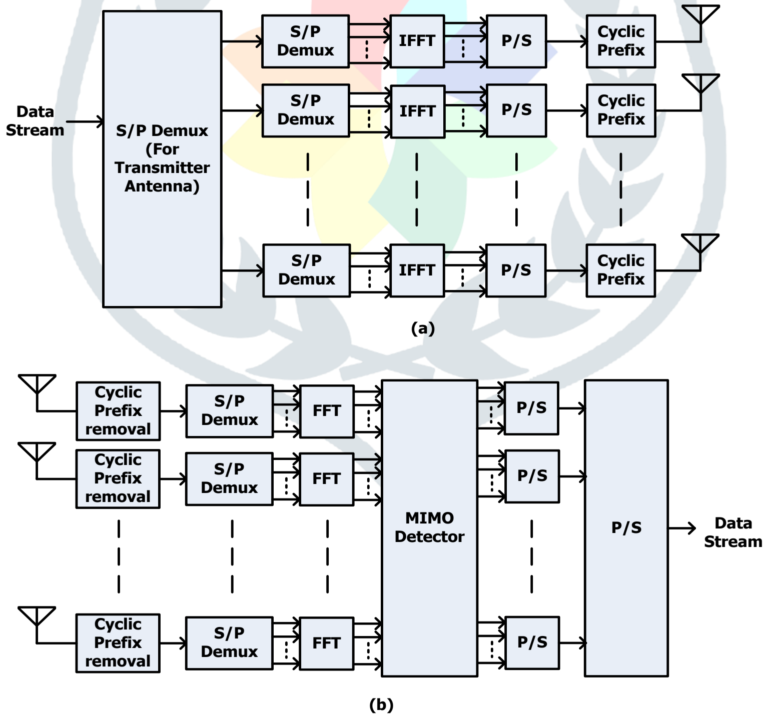

Figure 6: Schematic diagram of MIMO-OFDM

MIMO-OFDM has been emerged as a key technology for 4th gen, as the demand of high quality, and data rate has increased with the advent of new better quality multimedia services. Besides this, MIMO-OFDM has some drawbacks such as inter cell interference (ICI), and high Peak to Average Power Ratio (PAPR), etc. For the improvement of this system several researches have been made by researchers. In Paper [4] it was suggested to use Partial Transmit Sequence (PTS) to reduce PAPR. Figure 6 shows a Transceiver system of MIMO-OFDM technology. Paper [5] briefs that if we add BCH coding on AWGN channel communication system shows a consistent improvement in BER performance. Research paper [6] proposed Selective Codeword Shift (SCS) technique and modified Selective Mapping (SLM) technique to minimize PAPR and improve BER performance in MIMO-OFDM system. To minimize Inter cell Interference (ICI), ICI avoidance technique is the most suitable technique [7].

E. Massive-MIMO

Massive-MIMO (also known as Very Large MIMO and Hyper MIMO) is a multi user MIMO (MU-MIMO) technology that is capable to provide good quality of communication services to various wireless terminals uniformly in environments where mobility of terminals is very high. Figure [7] shows connectivity of various terminals with massive MIMO antenna array. The main concept behind this technology is to equip antennas in large quantity at the base station which will provide services to many terminals concurrently [8]. Although it is not described that how many numbers of the antenna should be attached with the base station in Massive- MIMO, yet it is considered to be tens or even hundreds of antennas, For example, Massive-MIMO system having 98 to 128 antennas has been demonstrated by Some major service providers like Huawei and ZTE. 64 transmit and 64 receive antennas have been used by Ericsson's AIR 6468. Massive-MIMO systems with the use of beamforming technology enables the use of available frequency spectrum in a very concentrated manner which results in a uniform and low latency and data rate throughout the coverage area[9]. Massive-MIMO is capable to manage very large traffic and by using linear processing it can improve spectral efficiency.

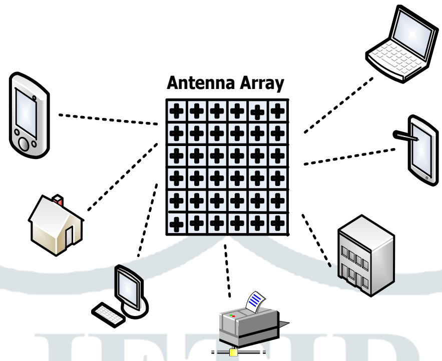

Figure 7: Connectivity of terminals with Massive MIMO System using large antenna arrays

In Massive-MIMO system by using multi-user MIMO (MU-MIMO) complexity of MAC layer design is reduced [10]. Some advantages of Massive-MIMO systems are as follows:

→ Massive-MIMO system provides excellent spectral efficiency.
→ Massive-MIMO system uses an array of antennas which significantly increases the gain of the overall system that allows a reduction in radiated power.
→ Spatial multiplexing increases the capacity of the system appreciably.
→ Massive-MIMO can deliver many good services uniformly to users as it is a scalable technology.
→ To diminish inter user interference, simple linear processing and detection methods can be used; and also effect due to fast fading and noise is diminished.

With several advantages, massive MIMO System still has some areas like pilot contamination, novel, Propagation models channel tracking algorithm, in which researchers have to work [8].

F. Ultra Massive-MIMO

With the passage of time data traffic has raised massively and to manage this traffic current wireless network requires more efficient technologies and systems. Fifth generation technology has been deployed at the initial phase in some countries like China, South Korea and it may come to India at the end of the year 2020 or in 2021. But if we follow coopers law then we come to know that 5G technology will not be sufficient for the current requirement of the communication system. So besides the implementation of 5G, we have to look for the next generation technology. i.e. 6G. 6^{th} generation mobile network is predictable to endow with high Bandwidth spectrum (Likely to be TeraHertz (THz) band), much higher data rate, energy-efficient transmission techniques, high reliability of data, and reduced latency. While using Thz band there are some hurdles related to losses in propagation and power limitation. A solution to overcome these hurdles may be ultra massive MIMO (UM-MIMO) system [11]. In UM-MIMO system antenna requirement on transmitter as well as receiver will be increased. For THz band UM-MIMO system may bear a hundred to thousand of antenna for transmission and reception. For THz transmission, Paper [12] has shown an example of a 1024 X 1024 transmitter and receiver antenna element of UM-MIMO design. Furthermore improving the UM-MIMO system several techniques like spatial multiplexing (SMX) and beamforming can be pooled. UM-MIMO can be a promising technology for the next generation up-gradation. Recently nano-antennas of small footprints based on graphene have been proposed to increase the capacity of the system These antennas can be easily controlled in UM-MIMO array of sub-array architecture (AoSA).

III. CONCLUSION

In this paper, we have explained some key technologies currently which are being used in fourth generation and some advancement in technology for upcoming generations. In future UM-MIMO with beamforming technology or with spatial multiplexing may become a game changer to achieve high data rate, (in terahertz band), lower latency, high reliability, and most importantly to increase system capacity.

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