REVIEW OF MASSIVE MIMO, FILTER BANK MULTI CARRIER AND ORTHOGONAL FREQUENCY DIVISION MULTIPLEXING

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Abstract - *This paper introduces about the importance of Massive MIMO and Filter Bank Multi Carrier (FBMC). It also points out the differences between Orthogonal Frequency Division Multiplexing (OFDM) and Filter Bank Multi Carrier (FBMC). OFDM, which I introduced in the paper, require the use of "Cyclic Prefix" to avoid Inter Symbol Interference (ISI) and convert the channel to sub channel carriers. In Filter Bank Multi Carrier (FBMC), cyclic prefix is not used which helps in increases the bandwidth efficiency. It also explains about the short comings which are encountered in Orthogonal Frequency Division Multiplexing (OFDM). This paper gives the brief description about the MIMO technology and its types.*

Key words: MIMO, Massive MIMO, OFDM, FBMC, ISI and 5th Generation mobile technology.

1. INTRODUCTION

Massive MIMO is the new advanced technology in 5th Generation mobile network to achieve high data rates. It mainly focuses on advanced techniques for higher spectral efficiency. We know that the 4Th Generation mobile communication technology 4G, is still facing high energy consumption and spectrum crisis. So, in order to achieve that higher data rate, many researches were still being going on. We have OFDM (Orthogonal Frequency Division Multiplexing) and FBMC (Filter Bank Multi Carrier) techniques to achieve that higher data rate and spectral efficiency. But we have some major differences in both techniques. I discuss that part in the below paragraphs. Orthogonal Frequency Division Multiplexing is a method which is having high capacity and it is having the special property, i.e. Robustness. Both would fight against Interference. One more interesting fact in the damage of communication system are Fading and Multipath delay. These really damages the communication system. When the Fading and Multipath delays are occurring during communication we can see the extreme fading and Inter symbol Interference (ISI) occurs at the Receiver side. In order to rectify these, then came OFDM. In order to get rid of from the signal overlapping, we are using FFT (Fast Fourier Transform) and IFFT (Inverse Fast Fourier Transform).The use of FBMC (Filter Bank Multi Carrier) is to overcome some of the short comings in Orthogonal Frequency Division Multiplexing. That I discussed in differences between OFDM and FBMC section. Before discussing with the Massive MIMO, we should know about the MIMO and its use.

2. LITERATURE REVIEW

2.1 MIMO TECHNOLOGY

This is the key technology in 3G/4G/5G technologies. MIMO stands for Multiple Input Multiple Output. Multiple input means multiple transmitting antennas and Multiple output means Multiple Receiving antennas. The combination of these two is known as MIMO. In the forthcoming 5G technology, MIMO is used. Because of spectral efficiency improvisation factor, Spatial multiplexing and interference reduction. MIMO is having the special property that is high data rate transmission. In spatial multiplexing, a signal having high data rate is divided into many small signals to transmit from different antennas. MIMO can also be used as wired communication also. The best example is Power Line Communication. Single Input Single Output (SISO), Single Input Multiple Output (SIMO) and Multiple Input Single Output (MISO) are the types which were shown in the figure1. Multiple Input Single Output (MISO) are used to minimize errors and optimize data speed. Here, multiple antennas are used at the source or transmitter side, but at the receiver side only one antenna is used. In Single Input Single Output (SISO), only one antenna and one receiver antenna is used. However here the channel performance is limited. The best advantage in SISO is its simplicity. In Single Input Multiple Output (SIMO), only one antenna is used at the transmitter side and many receiving antennas at the receiving side. In wireless communication system SIMO is always used to reduce the effects of fading.

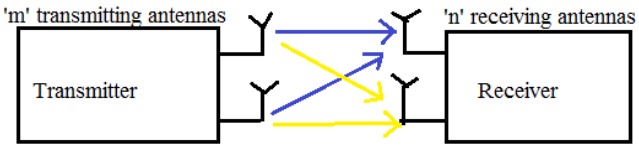

Fig-1: Multiple Input Multiple Output (MIMO)

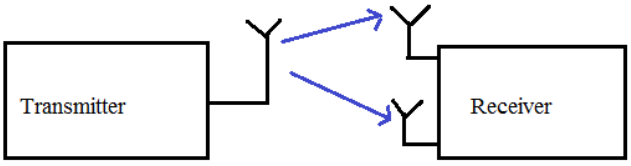

Fig-2: In Single Input Multiple Output (SIMO)

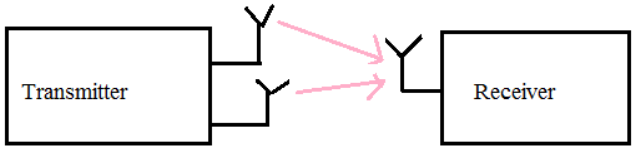

Fig-3: Multiple Input Single Output (MISO)

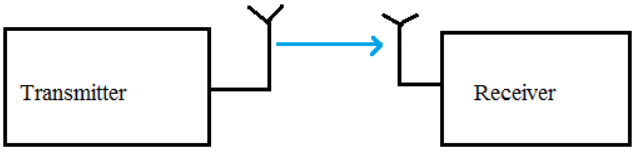

Fig-4: Single Input Single Output (SISO)

3. About Massive MIMO

Massive MIMO means installing very large antenna array at each base station, with this a large number of users are served simultaneously. Because of high frequency signal strength [6] capability we are using this Massive MIMO technique in 5G [1], [3]. When we are using mille metric waves, the value of lambda gets small, means very small wavelength. This leads to decrease in the power at the receiver side. So, it's a problem. This problem can be furnished by installing more number of transmitting or receiver antennas or by increasing the transmitting power.

$$P_{rx} = (P_{tx}/4*pi*R^2)*(Lambda\text{^}2/4*pi)\ (G_{rx}\ G_{tx}) \quad (1)$$

One more thing when we install all the 100 antennas at the base station, all the antennas will not work at the same time. Only some antennas will work at certain time and then other antennas [4], [5]. That is mainly due to acquire channel state information. With the help of OFDM, TDMA and FDMA, Massive MIMO technology is possible. Here the size of each antenna is very small and the area of receiving energy is also very small [10]. Massive MIMO somewhat equal to CDMA.

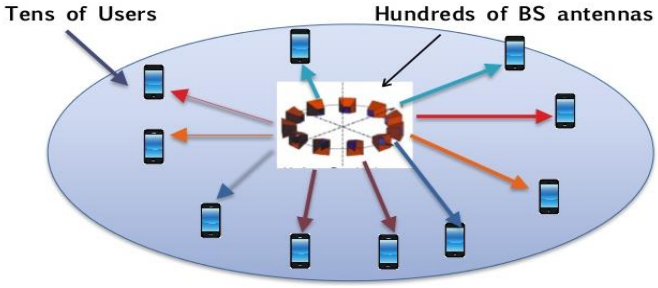

Fig-5: Massive MIMO

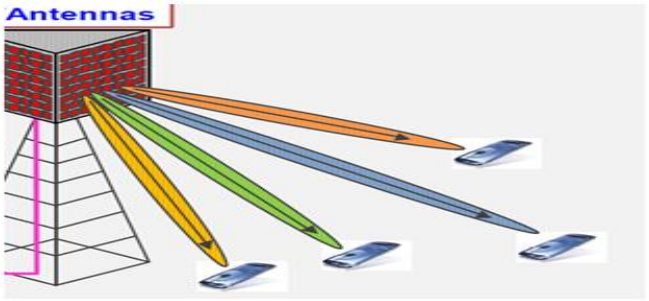

Fig-6: High order MU-MIMO transmission system

In conventional Massive MIMO, Ultra linear 50watt amplifiers were used. Now we are using mille watt range power amplifiers [2]. Those are low cost power amplifiers. In companies like Huawei, Motorola and Nokia they started research on using massive MIMO technology in 5th Generation mobile communication network. The antennas which they were used is shown in the figure 3. It don't need much space to install this equipment. But the problem is about security.

Table-1: Major research areas for the physical layer of Massive MIMO

Research Direction	Priority	Difference from Traditional Antennas
1. Base station antenna structure and Design	Medium	Antennas are arranged in 2D/3D arrays
2. Base station Precoding	Medium	New precoding algorithms are explored
3. Control Channel Performance	High	It is much lower than that of data channels.
4. Base station signal detection and channel estimation	Medium	FDD systems need feedback algorithm, while TDD systems are not affected.

4. Orthogonal Frequency Division Multiplexing (OFDM)

OFDM is required to achieve high capacity and Robustness (It fights with Interference).Fading, multipath delay are making the communication system damage. But the extreme fading and Inter Symbol Interference (ISI) occurs at the receiver side. So, because of these we are getting errors and also decreases the system performance. Even though we are having Adaptive equalisation, due to its high cost and delay in the coding make it's difficult. Then comes Orthogonal Frequency Division Multiplexing (OFDM) technique. In OFDM, it consists of several sub carriers block to transmit the data. Fast Fourier Transform and Inverse Fast Fourier Transform are using to get rid of from the ISI and signal overlapping. ISI will come the transmitted signal is distorted by other transmitted signals. In this process, the total signal frequency band is divided into N sub channel frequency. We are dividing this signal band because to avoid overlapping. In OFDM the main important function is maintaining orthogonality. It's is explained mathematically using mathematical expressions. First take a signal $\cos(2\pi n f_0 t)$ and another signal with $\cos(2\pi n f_0 t)$. The integration of these two signal gives zero.

$$\int \cos(2\pi n f0t)\ \cos(2\pi n f_0 t)\ dt = 0 \qquad (2)$$

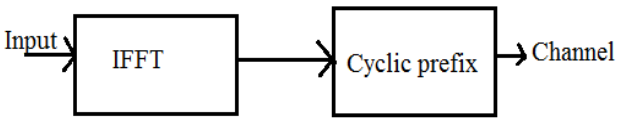

Fig-7: Orthogonal Frequency Division Multiplexing

5. Filter Bank Multi carrier (FBMC)

Chang and saltzberg introduced this multi carrier concept twenty years ago. That work really helped in Massive MIMO. OFDM require the use of "Cyclic Prefix" to avoid Inter Symbol Interference (ISI). But in FBMC no need of that cyclic prefix, FBMC has an ability to adopt large number of sub carriers. But slight negligible level of Interference might be there. Side lobes might spread out either side in OFDM [9], But with filter Banks we can get rid of from that spread out which we get much cleaner carrier results [7].Chang described the conditions of FBMC. The conditions relates to signalling a group of Phase amplitude Modulation (PAM) symbol sequences though the filter bank. But Saltberg explained the Quadrature Amplitude Modulation symbols which is better than the previous. Later Offset Quadrature Amplitude Modulation, simply OQAM, cosine Modulated Filter Bank and then blind equalisation method for cosine Modulated Filter Bank came into existence. After all Cosine Modulated Multi Tone and Staggered Multi Tone (SMT) were came. Advancement of Offset QAM OFDM is Staggered Multi Tone (SMT) [12], [13].

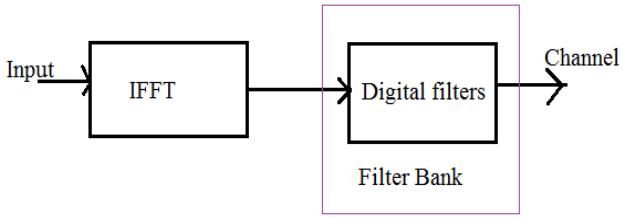

Fig 8: Filter Bank Multi Carrier

5.1 Difference between OFDM and FBMC

OFDM supports MIMO to remove interference but it has high PAPR and it needs High power. This is somewhat noisy and low spectrum density. But FBMC is a technique to overcome all the shortcomings that were encountered with OFDM

- OFDM require the use of "Cyclic Prefix" to avoid Inter Symbol Interference (ISI) and convert the channel to sub channel carriers.
- Weak Spectral localisation of the subcarrier results in Spectral edge and interference issues with unsynchronised issues.
- Side lobes might spread out either side, But with filter Banks we can get rid of from that spread out.

From the figure OFDMA, the main blocks IFFT and cyclic Prefix plays main role in OFDMA. And in the Filter Bank Multi Carrier figure (FBMC), there is no cyclic prefix and instead of that they used digital filters. Finally What I am saying is FBMC is the derivative of OFDM. This can be done with the help of digital signal processing technique.

6. PAPR reduction

PAPR means (Peak to Average Power Ratio) means the relationship between the maximum power of a sample in a transmit OFDM signal and its average power. PAPR will affect the system when large number of sub carriers are out of phase then PAPR effect the system [8, 11]. And even block coding, tone injection, partial transmit of sequence and selected mapping are all makes the transmit signal quality low or degrade the signal quality.

7. CONCLUSION

Finally my conclusion is Massive MIMO helps in increasing the channel capacity more than ten times and also mainly it helps in fighting with the Inter Symbol Interference (ISI), So that's why I am giving the name as 'Robustness' to the Massive MIMO technology. We can expect definitely this Massive MIMO systems in 5G, the upcoming generation. With this we can create wonders in terms of speed,

Performance and mainly Internet. OFDM supports MIMO to remove interference but it has high PAPR and it needs High power. This is somewhat noisy and low spectrum density. But FBMC is a technique to overcome all the shortcomings that were encountered with OFDM. Let's welcome this new technology in between the human world to create wonders in our livings. With the evolution of this 5th Generation technology, we can find many solutions to the questions. Whatever it may be it clears the ambiguity in the issues faced in the previous technology generations. So that's' why I am calling this technology as "Smart Technology" in the Mobile communication technology. With this we can create a creative world enriched with a lot of smart things. Education becomes very easier with the help of this technology. Finally, I conclude this is a gift to the people in this globalized world.

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