Capacity Enhancement For 5G Wireless Networks

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Abstract: Rapid industrial sector growth looks forward to the upcoming communication technology of the fifth generation (5G). The technology of Massive Multiple Input and Multiple Output (MIMO) has attained importance in the field of studies. This is one of the inevitable major components of the 5G wireless tool. Due to the prospective benefit and its ability to send/receive information from various antennas at the same moment, the MIMO scheme is gradually being implemented in the field of communication. In 5G wireless communication systems, antenna arrays consisting of various elements became part of the normal setup. And such wireless communication systems are referred to as the MIMO scheme. By exploring redundancy across various transmissions and receiving channels, these array antennas can assist enhance the SNR. They also enable the spatial data in the scheme to be reused to enhance coverage. Multiple antennas, together with moment and frequency, use the spatial dimension without influencing system bandwidth demands. While the communication in general focuses on transmission multiplicity instead of traditional receiving multiplicity. Using the flat fading Rayleigh channel, which can be applied when various transmitter antennas are used, the notion of orthogonal spacetime block coding is demonstrated. Here it is presumed that channel between various pairs of transmitter receiver antenna undergoes independent fading. 5G can simultaneously serve multiple customers with high gain by providing different degrees of freedom (DOF). Increasing the system's Spectrum Efficiency (SE), Channel Capacity (CC), Reliability, and Signal-to-Noise Ratio (SNR).

Keywords: Massive MIMO (Multiple-Input and Multiple-Output), Orthogonal Space Time Block Coding, SNR, SE, CC.

I INTRODUCTION
Web technology and IOT uprising fields are the biggest market for 5G communication. For example, 5G communication has infringed various technology fields for instance, “cloud computing, eHealth services, automotive driving, tactile Internet, Augmented Reality (AR)/Virtual Reality (VR), Cyber-Physical System (CPS) etc. The above application regions can be classified into three distinct categories: Enhanced Mobile Broadband (eMBB), Massive Machine Type Communications (mMTC), Ultra-Reliable Low Latency Communications (URLLC). From the point of view of system capacity, there are three key strategies for 5G communication. First, massive MIMO method is introduced to enhance spectrum effectiveness: system bandwidth is extended using mm-wave spectral resource; multi layer and ultra dense network are adopted to enhance geographic spectra reuse. Massive MIMO communication systems are the massive array antennas created to serve various users as shown in Figure 1. This scheme can withstand the serious fading of mm-wave signals in multi layer and thick networks through wireless backhaul and suppression of interference. Consequently, the monograph focuses on massive MIMO technology and its fields of implementation to provide fundamental theory and patterns for practical systems design.

II TRANSMIT DIVERGENCE VS RECEIVE DIVERGENCE
The method of divergence reception is well established to decrease the impacts of fading overcommunication links, although it is mostly linked to the receiving end. Similarly, Alamouti recommends a transmitting divergence system that uses various antennas at the transmitting end to provide comparable divergence benefits. This method sounds more practical and appropriate as it is quite substantial to have numerous antennas at base station transmission rather than numerous antennas for each cellular communication system. The comparison of transmission and receiving divergence is simulated by means of consistent quadrature phase-shift keying (QPSK) modulation over the method of flat fading Rayleigh channels as shown in Figure 2. Two transmitting antennas and one receiving antenna (2x1) are used to develop the transmitting divergence, while one transmitting antenna and two receiving antenna (1x2) are used to receive divergence. Assuming the channels are completely known to the receiving end of all devices, simulation is performed. It involves a full encoded / transmitted signal scheme, channel model reception, demodulation of received signal with no divergence link (single transmit and receiver antenna) and theoretical efficiency of second order divergence link for comparison. The findings of the BER were produced by considering a variety of Eb / No points that enables us to compare the various schemes.

![Fig. 1. Massive MIMO System](image1)

![Fig. 2. Transmit Vs. Receive Diversity](image2)
The transmitting divergence computational complexity is comparable to that of the receiving divergence scheme. It can be inferred from the simulation outcomes shown in Figure 2 that the order variety of the maximal ratio combined (MRC) scheme for two transmitters and one receiver antenna is the same as one transmitter and two receiver antennas. It can also be observed that there is a 3dB decrease in the transmit divergence relative to the divergence received by the MRC. This is because, while modeling, the total transmitted power is the same for both cases. The performance will be the same when calculating / calibrating the transmitted power to obtain the same final receiving power for both cases. It can also be noted that the theoretical performance of the second order divergence connection coincides with the scheme of transmit divergence as it normalizes the complete power across all divergent branches.

III EXPLORATION OF ORTHOGONAL SPACE-TIME BLOCK CODING

This chapter discusses orthogonal space-time block coding efficiency using four transmitting antennas (4x1 system) and G4 half rate code. The anticipated order of divergence is 4, compared to the regime of 1x4 and 2x2, which is also the same order of divergence. For a rational comparison, which is shown in figure 3, Quaternary PSK with the half-rate G4 code is used to achieve the transmission rate of 1 bit / sec / Hz.

From the graph shown in Figure 3, it can be observed that the slopes of the BER curves for the 4x1, 2x2 and 1x4 system have the same order of divergence. It can also be noticed that the 4x1 system has a 3dB drop as all the system has been modelled assuming the same total transmitted power. The output of all three structures would appear to be the same if transmitted energy were calculated to achieve the same receiving capacity for each of these structures. The theoretical output also coincides with 4x1 system simulation outcomes as complete energy is standardized across branches of divergence. Use antenna array to improve SNR and 5 g wireless communication capability. The objective of a wireless communication scheme is to serve as many customers as possible due to limitations such as radiation energy limit and working budget with the largest data rate possible. Improving the signal- to- noise ratio (SNR) plays a key part in raising the data rate. The key to serving more customers is the reuse of funds. Numerous algorithms have been adopted over the past several decades to improve the SNR and reuse resources in time, frequency and space coding. This demonstrates how antenna array implementation can help enhance the SNR and a wireless link’s ability.

IV IMPROVE SNR BY ARRAY GAIN FOR LINE OF SIGHT PROPAGATION (LOS)

A LOS propagation is the easiest wireless channel. Although simple, in rural regions such a medium can often be discovered. Under such circumstances, adopting an antenna array can enhance the receiver’s SNR and thus enhance the bit error rate of the communication link (BER).

A. SISO LOS Channel

It is worth developing a baseline with a single input single output (SISO) communication scheme before jumping into the performance debate of a MIMO scheme. In a SISO LOS channel, there is a direct route from transmitter to receiver. As a unique case of multipath channel, such channel can be modelled.

Fig. 4. SISO LOS Channel – BER Vs. Eb/N0(dB)

B. SIMO LOS Channel

This chapter focuses on the single input multiple output (SIMO) scheme with the basis set for a SISO scheme. This scheme comprises of a single transmitting antenna and receiving multiple antenna. The design is created on the basis of a direct transmitter receiver route. The BER curve shown in Figure 5 shows a 6dB gain from the receiving array.

Fig. 5. SIMO LOS Channel – BER Vs. Eb/N0(dB)
C. MISO LOS Channel
The scheme of various single output inputs (MISO) operates similarly. The transmitter in this case is a 4-element ULA with a spacing of half-wavelength.

![MISO LOS Channel](image)

Fig. 6. MISO LOS Channel – BER Vs. Eb/N0(dB)

Note that MISO’s output matches the efficiency of a SIMO scheme with the pre-steering, which gains 6 dB in SNR. Compared to the SIMO situation, it may not be as intuitive as the overall transmit energy does not boost. However, a 6 dB gain is obtained by replacing a single isotropic antenna with a 4-element transmission array.

D. MIMO LOS Channel
Since a SIMO scheme offers an array gain from the received array and a MISO system offers an array gain from the transmission set, the combination of transmitter and receiver array gains advantages the MIMO scheme with a LOS propagation.

![MIMO LOS Channel](image)

Fig. 7. MIMO LOS Channel – BER Vs. Eb/N0(dB)

As anticipated, the BER curve indicates the transmitter and receiver contribution 6-db array gain, leading in a complete 12 dB gain over the SISO situation. All channels are line-of-sight channels in the earlier sections. While such channels are discovered in some wireless communication systems, wireless communications generally occurring multipath fading settings. The remainder of this explores how arrays in a multipath setting can be used to assist.

A. SISO Multipath Channel
Assume that the channel contains 10 randomly positioned scatters, then there will be 10 routes from the transmitter to the receiver as demonstrated in Figure 8.

![SISO Multipath Channel](image)

Fig. 8. SISO Multipath Channel graph.

For simplicity, suppose that signals traveling across all routes arrive within the same span of symbols, so the channel is flat frequency.

![SISO Multipath Channel](image)

Fig. 9. SISO Multipath Channel - BER Vs. Eb/N0(dB)

The figure 9 depicts the plot of BER versus energy per bit to noise power spectral density ratio (Eb/N0) for SISO multipath channel. From the graph it can be observed that compared to the BER curve derived from a LOS channel, the BER drops very slowly due to fading caused by multipath propagation, as energy per bit to noise power spectral density ratio (Eb/N0) increases.

B. SIMO Multipath Channel
As more receiving antennas are used in the receiving array, the receiver has more copies of the receiving signals. Again, suppose that the receiver has a 4-element ULA. By matching the channel response, The optimal combining weights can be obtained. Such a combining scheme is often termed as maximum ratio combining (MRC). Although such a system needs channel understanding in theory, it is possible to predict practically channel responses at the receive array.

![SIMO Multipath Channel](image)

Fig. 10. SIMO Multipath Channel - BER Vs. Eb/N0(dB)
Note that a steering vector no longer weighs the received signal in a particular direction. In this case, the receiving array weights are given by the channel response's complex conjugate. Otherwise, the received signal may be made out of phase with the transmitted signal by multipath. The receiver is presumed to be acquainted with the response of the channel. If not, the pilot signal can be used to predict the channel response. From the BER curve it can be seen that not only does the SIMO scheme provide some SNR gains over the SISO scheme, but the slope of the SIMO system's BER curve is also steeper compared to the SISO system's BER curve. The gain from the shift in slope is often referred to as the increase in diversity.

C. MISO Multipath Channel
Things get more interesting when there is multipath propagation in a MISO system. First, if the channel is known to the transmitter, then the strategy to improve the SNR is similar to maximum ratio combining. It is necessary to weigh the signal radiated from each element of the transmit array so that the propagated signal can be added to the receiver coherently.

Fig. 11. MISO Multipath Channel - BER Vs. Eb/N0(dB)

Note the increase in transmission diversity shown in figure 11 of the BER curve. The performance of a MISO multipath scheme is not as great as that of the SIMO multipath channel situation. This is because only one copy of the received signal is available yet the transmit energy is distributed across various routes. To obtain an equal profit, it is definitely feasible to amplify the signal on the transmit side, but this introduces extra costs. If the transmitter does not know the channel, there are still ways to explore the diversity through space time coding. Alamouti code, for example, is a well-known coding scheme that can be used if the channel is not known to achieve diversity gain.

D. MIMO Multipath Channel
The remainder of this is focused on a MIMO channel multipath. This section illustrates in particular the case where the number of scatters in the environment is greater than the quantity of elements in the transmitter and receiver array. Such environment is often termed as a rich scattering environment.

There are two ways to take advantage of a MIMO channel. The first way is to explore the diversity gain offered by a MIMO channel. Assuming the channel is known, the following figure 13 shows the diversity gain with the BER curve.

Fig. 12. MIMO Multipath Channel graph.

Fig. 13. MIMO Multipath Channel - BER Vs. Eb/N0(dB)

Compare a MIMO channel's BER curve with a SIMO system's BER curve. In the multipath case, a MIMO channel's diversity gain isn't necessarily better than a SIMO channel's diversity gain. This is because only the dominant mode in a MIMO channel is used to get the best diversity gain, yet there are other modes that are not used in the channel.

VI IMPROVE CAPACITY BY SPATIAL MULTIPLEXING FOR MIMO MULTIPATH CHANNEL
The concept behind spatial multiplexing is that various information streams can be sent concurrently across the channel by a MIMO multipath channel with a rich scatterer environment. For example, because of the scatterers, the channel matrix of a 4x4 MIMO channel becomes full rank. This implies that as many as 4 information streams can be sent at once. The aim of spatial multiplexing is less about increasing the SNR but more about increasing the information throughput. The concept of spatial multiplexing is to separate the channel matrix into multiple modes so that from the received signal the information stream sent from different components in the transmission array can be retrieved separately. To accomplish this, before the transmission, the data stream is pre-coded and then combined after the reception. The channel matrix is used for computing the precoding and combining weights as:
\[ [wp, wc] = \text{diagbfweights(mimompchan)}; \]
To see how the combination of the precoding and combining weights can help transmit various information simultaneously, examine the weights product and the channel matrix.
\[
wp \times \text{mimompchan} \times wc
\]
\[
\text{ans} =
\begin{bmatrix}
10.3543 & 0.0000i & 0.0000 & 0.0000i & 0.0000 & 0.0000i & 0.0000 & 0.0000i \\
-0.0000 & 0.0000i & 6.9563 & 0.0000i & 0.0000 & 0.0000i & 0.0000 & 0.0000i \\
-0.0000 & 0.0000 & -4.0000 & 0.0000i & 2.4446 & 0.0000i & -0.0000 & 0.0000i \\
0.0000 & 0.0000i & 8.0000 & 0.0000i & 0.0000 & 0.0000i & 1.0349 & 0.0000i \\
\end{bmatrix}
\]
Note that the product is a diagonal matrix, meaning that the data each receives from the array element is merely a scaled version of the array element transmitted. So, within the initial channel it acts like various orthogonal sub-channels. The first sub-channel leads to the route of the dominant transmitter-receiver to prevent losses in the gain of divergence. Moreover, other sub-channels can now also be used to carry information, as shown for the first two sub-channels in the BER curve.

Fig. 14. Improve Capacity by Spatial Multiplexing for MIMO Multipath Channel - Eb/N0(dB)

While the second stream can not provide a profit as large as the first stream as it utilizes a less dominant sub-channel, there is an improvement in the overall information throughput. Therefore, next section measures the performance by the channel capacity instead of the BER curve. In a MIMO scheme, the best way to transmit information is by dividing the power equally between the transmitting components. However, if the transmitter is acquainted with the medium, the channel’s capacity can be further enhanced. In such a situation, a transmitter can use the water fall algorithm to select sub-channels where sustainable SNR can be acquired for data transmission. The figure 15 describes the comparison of the system capacity between the two power distribution schemes.

Fig. 15. Improve Capacity by power distribution for MIMO Multipath Channel - SNR(dB)

The result shows that compared to the uniform power distribution, the water fill algorithm offers better system capacity. When the system level SNR increases, the distinction becomes lower.

VII CONCLUSION
To get acquainted with the 5G Wireless Communication Systems that can be used to communicate with these current techniques, the study experience took several directions at first. As described throughout this study, it is essential to use array processing to enhance MIMO's wireless communication system quality. The arrays can be used to improve the SNR by Array Gain for Line of Sight Propagation, Diversity Gain for Multipath Channel, Capacity by Spatial Multiplexing for MIMO Multipath Channel and shown as depictions in the form of waveforms, depending on the nature of the channel.

VIII REFERENCES


AUTHORS PROFILE

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