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Design and Implementation of MIMO-NOMA Using STBC, Power Level Separation and ZF-Equalization for Wireless Networks

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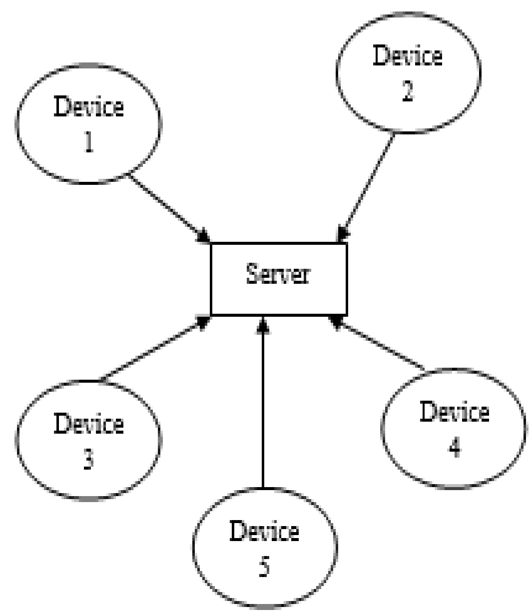
Abstract- *Generally, Cloud or IoT applications need to share common resources such as bandwidth. Moreover for higher data rates, MIMO has become a very popular technique Bandwidth is a vital resource shared by wireless networks. Non-Orthogonal Multiple access is a technique in which multiple users data is separated in the power domain. The problems addressed by NOMA are low overall bandwidth for multiple users. In the proposed approach MIMO-NOMA for enhanced Spectral efficiency and high data rates has been implemented. The proposed system also uses the Zero Forcing (ZF) Equalization to invert the negative effects of the channel. It is shown that the proposed approach attains lower BER compared to previously existing systems. Moreover, it is shown that the proposed system attains lesser SNR requirement compared to previously existing systems.*

Keywords- Multiple Input Multiple Output, Non orthogonal multiple access (NOMA) Bit Error Rate (BER), Signal to Noise Ratio, ZF Equalization.

I. INTRODUCTION

In multiple-input multiple-output (MIMO) communications, the system is equipped with multiple antennas at both the transmitter and the receiver technique. The multiple antenna scheme gives a more reliable performance through array gain, diversity and spatial multiplexing. These concepts are briefly discussed below.

The growing demand of multimedia services and the progress of Internet related contents lead to increasing interest to high speed communications network. The requirement for flexibility and wide bandwidth imposes the use of efficient transmission systems that would fit to the characteristics of wideband channels especially in wireless environment where the channel is very challenging process. In wireless environment the signal is propagating since the transmitter to the receiver along number of different paths, collectively referred as multipath communication. While propagating the signal power drops of due to the following effects: a path loss, macroscopic fading and microscopic fading. The fading of the signal can be mitigated by different diversity methods.



.**Fig.1 Physical representation of Networks**

To combat the effect of frequency selective fading, multiple input multiple output is generally combined with NOMA. To obtain diversity, in signal is transmitted through multiple independent fading paths in time, frequency or space and combined constructively at the receiver. Wireless Networks and Mobile Ad-hoc Networks are facing the following challenges:

- increasing number of users
- increased bandwidth requirement for multimedia applications
- overall limited bandwidth availability.

Hence Multiple Input-Multiple Output (MIMO) and Massive MIMO based networks are being used to face the challenge especially in IoT applications.MIMO systems enhance the channel capacity even at same bandwidth.OFDM increases the spectral efficiency and is widely used in LANs and WANs.

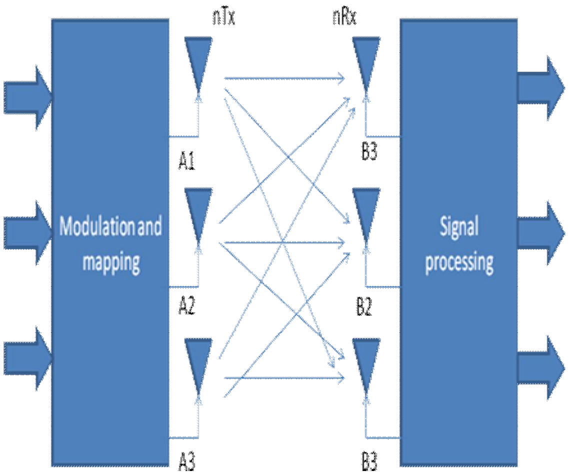


Fig.2 Block Diagram of a generic MIMO system

II. SPACE TIME BLOCK CODING (STBC)

STBC stands for space time block coding.

It is the process of re-arranging data bits/ data packets in the form of a matrix in which:

Number of Columns = No. of MIMO transmitters

No. of Rows = No. of time slots needed to transmit the entire data

The STBC matrix is unique and is available only sending and receiving ends. Its like the S-Box design in cryptography.

In recent years, fifth generation (5G) wireless networks have attracted extensive research interest. According to the 3rd generation partnership project (3GPP) [1], 5G networks should support three major families of applications, including enhanced mobile broadband (eMBB) [1] massive machine type communications (mMTC) [1], [2]; and ultra-reliable and low-latency communications (URLLC) [1], [2]. On top of this, enhanced vehicle-to-everything (eV2X) communications are also considered as an important service that should be supported by

5G networks [1]. These scenarios require massive connectivity with high system throughput and improved spectral efficiency. In NOMA, the signals are separated in the power domain which is depicted in figure 1.

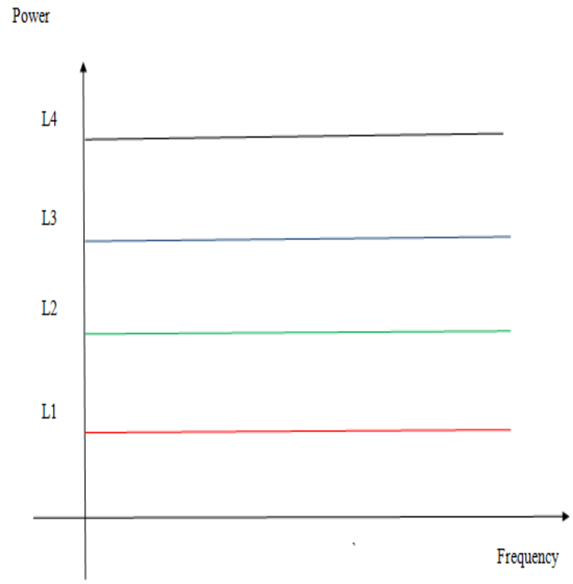


Fig.3 Separation of signals in Power Domain using NOMA

III. MATHEMATICAL MODELLING OF POWER LEVEL SEPARATION

In light of the explained approach, it is necessary to derive its mathematical formulation which is given below:

a) Individual signal strength of each MPC be given by:

$$S_i = g_i\sqrt{P_i} \qquad (1)$$

Where S represents i^{th} MPC power,
'g' represents gain of the i^{th} path
P represents the power of the i^{th} MPC

b) The cross correlation of the spreading function applied on the data stream:

$$\text{Spreading Function} = R_i,j(k)$$

(c) The noise statistics for the k^{th}sample i.e. $n_i(k)$

Thus the different MPCscorresponding to paths can be mathematically written as:

$$r_k = R_k.D.S_k + n_k \qquad (2)$$

Where D represents the signal strength matrix corresponding to different MPCs given by:

$$S_i = g_i\sqrt{P_i} \qquad (3)$$

The proposed algorithm can be explained as: Let the various MPC strengths be:

$$S_1.G_1, S_2.G_2, S_3.G_3 .... S_n.G_n$$

It can be observed that the signal power of transmitter is multiplied with the corresponding channel gain where the channel gain for different MPCs varies due to frequency selectivity of the channel.Considering that we have the information about the signal strengths given by equation :

$$P_1 g_1{}^2 > P_2 g_2{}^2 > \ldots\ldots\ldots\ldots\ldots\ldots\ldots P_M g_M{}^2 \qquad (4)$$

We decide the strongest among all the received user MPCs.

2. Detect the k^{th}strongest MPC among all the signals using the following equation:

$$S_k=dec(P_iG_i)^M$$

3. Cancel the first strongest MPC interference at the receiver end according to the equation:

$$y_{e+1}^{(i)} = y_e^{(i)} - g_e\sqrt{P_e}R_{i,}e(k)\hat{S}_k^{(e)} \qquad (5)$$

Here we subtract the interference from the strongest interfering signal from each signal received at the receiver using the Decision Feedback actuating Signal $e(k)S_k^{(e)}$

4. let k=1, and repeat the above process for all the received signals up to k=M

Plot the BER performance for the proposed system for the following cases:

a) When there is only one signal travelling from transmitter to receiver
b) When multiple signals with multiple run lengths are travelling from transmitter to receiver.
c) MPC governed BER without proposed system
d) MPC governed BER with proposed system.

Channel Equalization for MIMO-NOMA

The concept of equalization is fundamentally very important to mitigate the effects of noise and distortions induced by a channel. The equalizer tries to mitigate the effects of the wireless channels that cause distortions at the receiver. It can be seen that the equalizer acts just prior to the receiver after sensing what the channel has done to a signal. . In mobile radio channels always changes and multipath causes time dispersion of the digital information is known as inter-symbol-interference, it makes too difficult to detect the actual information at the receiver. Moreover it cannot be rectified even by increasing the signal power at the transmitting end. Therefore such errors are called **irreversible errors.** The only way out is to reverse the detrimental effects using equalizers so as to improve the reliability of communication through wireless and broadcast modes.

Let the channel have an impulse response h(t). Since any practical system can sense the channel in the discrete time domain, therefore the channel impulse response can be re-considered as h(n). Let the channel in the frequency domain be H(z). Then the output of the channel is:

$$y(n) = x(n) * h(n) \qquad (6)$$
$$Y(z) = X(z).H(z) \qquad (7)$$

Where, * stands for convolution
x(n) is the input to the channel
y(n) is the output of the channel
The aim at design of an equalizer is the design of a system with a transfer function

$$E(z) = \frac{1}{H(z)} \qquad (8)$$

There are several ways in which the system with the transfer function E(z) can be practically implemented.

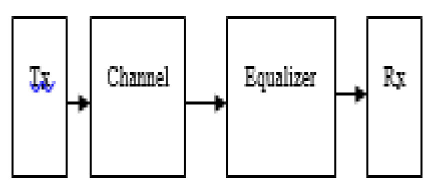


Fig.4 Use of Equalizer in Data Network

The different techniques result in different equalizer structures. Different equalizer structures can be Linear Equalizers, MLSE Equalizers, Zero Forcing Equalizers, Adaptive Equalizers, and Decision Feedback Equalizers etc.

Flowchart of Proposed System

The figure depicts the flowchart of the proposed system.

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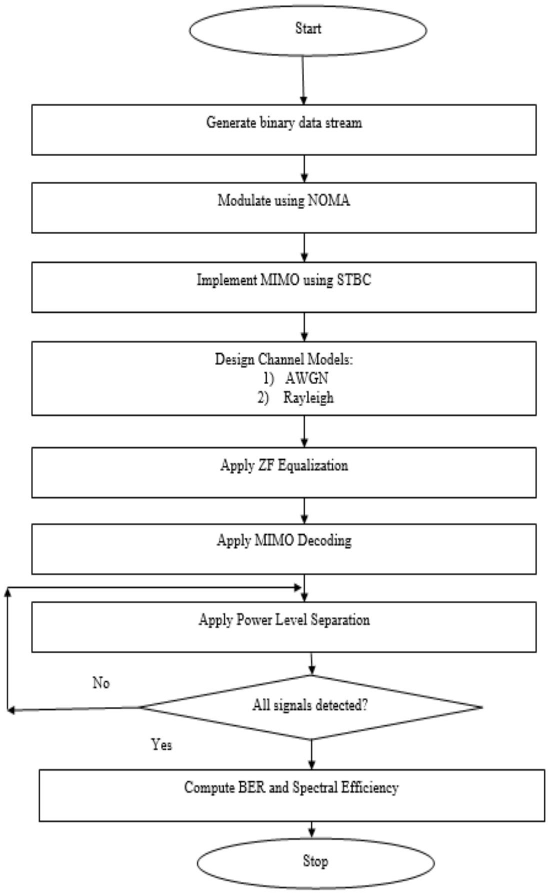

Fig.5 Flowchart of Proposed System

IV. RESULTS

The results obtained are shown below.

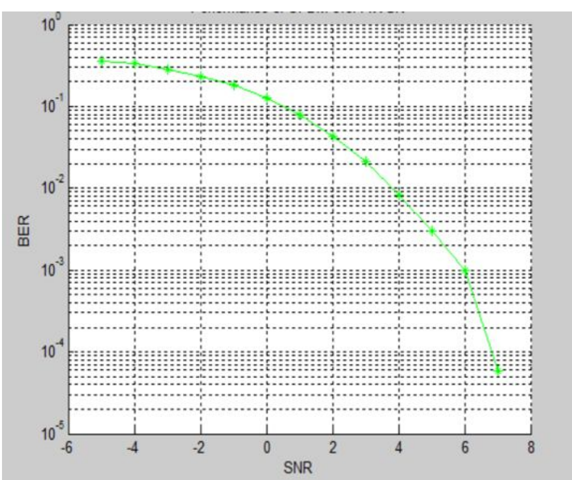

Fig.6 Performance of NOMA over AWGN

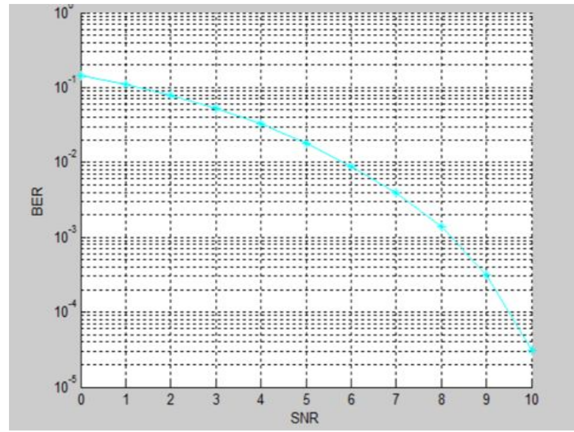

Fig.7 Performance of MIMO-NOMA over AWGN

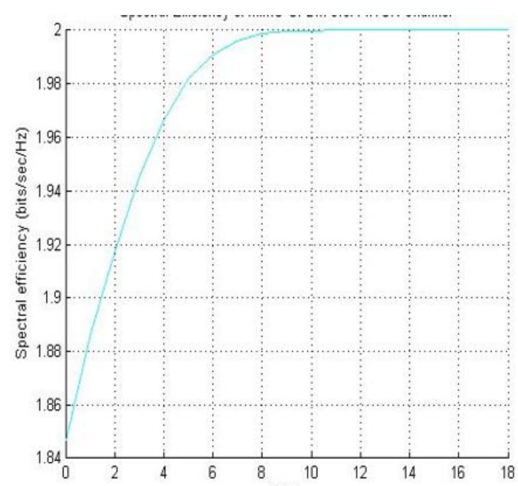

Fig.8Spectral Efficiency over AWGN

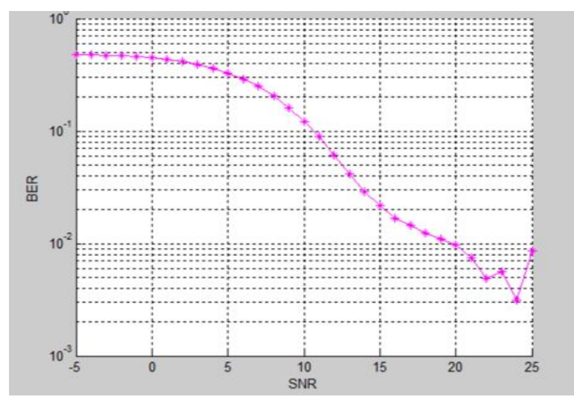

Fig.9Performance of NOMA over Rayleigh Channel

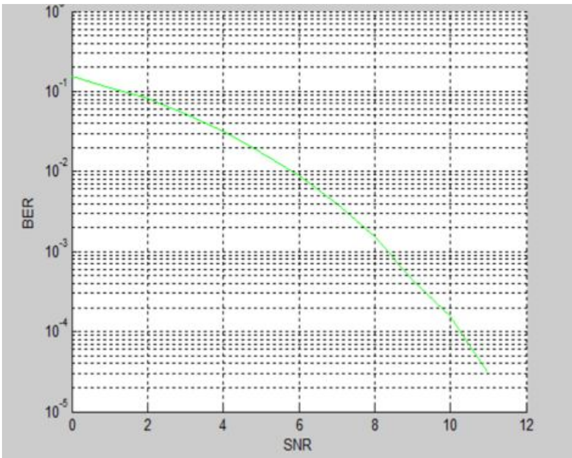

Fig.10 Performance of MIMO-NOMA over AWGN

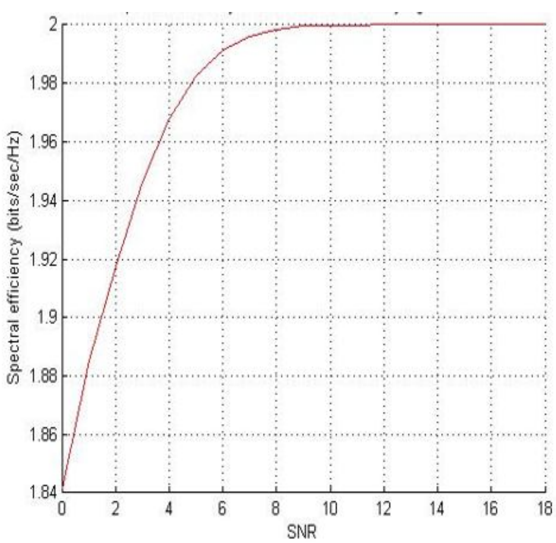

Fig.11 Spectral Efficiency over Rayleigh Channel

V. CONCLUSION

It can be concluded that Cloud or IoT applications need to share common resources such as bandwidth. Moreover for higher data rates, MIMO has become a very popular technique Bandwidth is a vital resource shared by wireless networks. Non-Orthogonal Multiple access is a technique in which multiple users data is separated in the power domain. It has applications in Cloud, IoT and 5G systems. Bandwidth is a vital resource shared by wireless networks. NOMA is more effective in terms of bandwidth efficiency compared to FDM or OFDM. Hence NOMA is turning out to be the future multiplexing technique. Channel equalization is also used to revert the effects of noise and disturbance in channels. The problems addressed by NOMA are low overall bandwidth for multiple users.

REFERENCES

[1] Xiaojuan Zhao, Shouyi Yang, Aihua Zhang, Xiaoyu Li, “A Compressive Sensing Based Multi-user Detection Algorithm for SIMO-NOMA Systems”, IEEE 2018
[2] B Wang, L Dai, Y Zhang, T Mir, “Dynamic compressive sensing-based multi-user detection for uplink grant-free NOMA”, Vol-20, Issue-11, IEEE 2016
[3] J Choi, J Mo, RW Heath, “Near maximum-likelihood detector and channel estimator for uplink multiuser massive MIMO systems with one-bit ADCs”, Vol-64, Issue-5, IEEE Xplore- 2016
[4] Maha Alodeh ; Symeon Chatzinotas ; Björn Ottersten, “Energy-Efficient Symbol-Level Precoding in Multiuser MISO Based on Relaxed Detection Region”, Vol-15, Issue-5, IEEE Xplore- 2016
[5] Fabian Monsees ; Matthias Woltering ; Carsten Bockelmann ; Armin Dekorsy, “Compressive Sensing Multi-User Detection for Multicarrier Systems in Sporadic Machine Type Communication”, IEEE 2015
[6] Bichai Wang ; Linglong Dai ; Yifei Yuan ; Zhaocheng Wang, “Compressive Sensing Based Multi-User Detection for Uplink Grant-Free Non-Orthogonal Multiple Access”, IEEE-Xplore 2015
[7] S Wang, Y Li, J Wang, “Multiuser detection in massive spatial modulation MIMO with low-resolution ADCs”, IEEE Transactions on Wireless Communication, Vol-14, Issue-4,available at IEEE Xplore, IEEE 2015
[8] S Narayanan, MJ Chaudhry, A Stavridis, “Multi-user spatial modulation MIMO”, Proceedings of Wireless Communications and Networking Conference (WCNC), available at IEEE Xplore, IEEE 2014
[9] P Botsinis, D Alanis, SX Ng, LLCSO Hanzo, “Quantum-Assisted Multi-User Detection for Direct-Sequence Spreading and Slow Subcarrier-Hopping Aided SDMA-OFDM Systems”, IEEE 2014
[10] A Mukherjee, SAA Fakoorian, J Huang, “Principles of physical layer security in multiuser wireless networks: A survey”, Vol-16, Issue-3, IEEE 2014