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Investigation of The Linear Dispersion Coding Scheme and Non-Orthogonal Multiple Access Technology for the 5g Communication Network

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Abstract –The 5G and beyond networks requires high data transmission speed, low latency, massive IoT connectivity, increase in base station capacity, and perceived QoS. Nonorthogonal multiple access (NOMA) and the linear dispersion coding (LDC) technique are the contenders to attain the requirements of 5G and beyond networks. This paper discusses the technical view and presents the behavior of the NOMA and LDC in the multiple antenna communication systems. Presenting the basic principles of power-domain NOMA, reviewing the various objectives of NOMA, discuss uplink and downlink NOMA and then, realizing the behavior of the NOMA system. This work realizes the LDC scheme using a linear algebraic coding strategy. Furthermore, the simulation result shows that the NOMA can achieve high outage probability, high system capacity at high SNR. Result also shows that the LDC outperforms the basic alamouti STBC and also the optimal coefficient LDC can improve the BER performance at high SNR with the several order PSK modulation techniques for the multiple antenna wireless communication systems.

Keywords: LDC, NOMA, Massive MIMO, STC, 5G Communications, Wireless Networks

1. Introduction

The next generations of the wireless communication network are termed “5G and beyond networks” to attain tremendous and intellectual advancement in wireless technologies. These technological advancements require the very high data speed (in mbps and tbps), massive IoT connectivity (Ubiquitous Connection), very low latency (in decimal ms), augmented and virtual reality with fully artificial intelligence user experience, and ultra-high spectral and network efficiency [2]. There are three primary scenarios for future networks as detailed by ITU and ETSI are enhanced mobile broadband, ultra-reliable low-latency communications, and massive machine-type communications. The Massive MIMO (mMIMO) is the key enabling technology for the 5G and future networks to increment the wireless area throughput and to attain the growing requirements of the wireless carriers.

The mMIMO is an advancement and expansion of MIMO (Multiple Input Multiple Output) technology, which exploits an immense number of antennas (~100’s) at the BS and simultaneously assist the large number of users to tremendously enhance the data rate, SE, EE, and throughput of the communication system together with simplifying the signal processing needed. It can assist a huge number of users, thus directing to an enormous increment in the network capacity. The word “massive” indicates an immense number of antennas, utilized to simultaneously assist many UTs in the same time-frequency, these antennas utilize the radiated narrow beams to concentrate energy towards the UT that grants large array gain, high SE, and throughput. The mMIMO system is the main initiator in 5G, since it not just makes the provision of large directivity and multiplexing gain with massive connectivity but also decreases the interference through beam shaping. Economical signal processing techniques i.e., acceptable precoding and equalization technique have to be compelled to be used at every end exploiting multiple antennas to beat the signaling overhead quality for higher reliability to enhance the performance of wireless systems. The mMIMO systems will function an important role in smart real-time applications like autonomous vehicles, remote healthcare, smart antennas, smart highways, and smart environmental monitoring [3-6].There are a few active research area in the mMIMO system that needs to be investigated like pilot contamination, hardware impairments, channel estimation, efficient coding strategy, multiple access technique, signal detection, user scheduling. This paper analyzes the efficient coding strategy and multiple access technique like LDC and NOMA respectively, which increases the performance of the multiple antenna system. The objectives and the different approaches of this paper are listed in table 1.

Table 1. Objectives and different approaches used in the multiple antenna system

Objective	Approach	Solution
To attain low BER at high SNR, improve the reliable detection, and reduce the system complexity in the multiple antenna system.	The coding approach that satisfies the information optimality criteria with minimum BER	Appropriate space-time coding (STC) technique
To achieve the outage probability and tradeoffs between SE and interference mitigation in the multiple antenna system.	Use the multiple access scheme that presents energy efficiency with Successive/parallel interference cancellation (SIC/PIC) with MMSE low complexity algorithm	NOMA

According to the design aspect, the 1G to 4G technologies depends on the orthogonal multiple access (OMA), but for future networks, the OMA is not suitable because of the disadvantages of fewer user pairs, low receiver complexness, low system throughput with high latency. The 5G network requires an innovative multiple access strategy to overcome all these difficulties. The newly introduced, NOMA technology is acceptable as a 5G multiple access schemes. NOMA is important multiple access facilitating technology for the modeling of RAT for the 5G wireless networks to fulfill the requirements of large user access, high-speed connectivity, improved reliability, huge throughput, and decreased latency. The primary concept of NOMA is that several users share the same radio resources like subcarrier, time, spreading code simultaneously in a non-orthogonal fashion to increase the SE at the cost of incremented receiver complexness. One of the objectives of this paper is to survey the various objectives of NOMA, present the basic principles of the power-domain NOMA, and analyze the NOMA for the mMIMO system [7-8].

The orthogonal space time-based block coding (O-STBC) is designed to maximize the diversity benefits at the cost of less channel capacity in the MIMO channels, thus new revolutionary ST coding is proposed, known as linear dispersion codes (LDC). LDC utilizes a linear matrix modulation scheme, in which the transmitted codeword is a linear combination of the dispersion matrices with the weights evaluated by the Tx symbols, the coefficients of these matrices are selected in such a way that it increases the ergodic capacity of the multiple antenna system [4]. This code is a special case of the STBC. LDC is a complex STC model. The LDC attains the high coding rate by satisfying the information-theory optimality criteria i.e., the codes are structured to increase the mutual data amid the Tx and Rx signals in a communication system. LDC optimizes the MI amid the Tx and Rx signals and can be utilized for any order of multiple antennas at Tx and Rx ends. LDC is very easy to encode and can be decoded in several methods like V-BLAST and sphere decoding. This coding system performs well when strong channel codes are usually employed in practical communication systems [9]. This work analyzed the LDC scheme based on the elementary matrix operations and coefficient mapping strategy. Mapped coefficients are linearly solved for optimum value estimation. Another objective of this paper is to survey the LDC scheme and evaluate the results of the BER for MIMO coded LDC system with the different higher-order PSK modulation techniques. Outlining the offerings of this paper:

- Review the LDC scheme for the multiple antenna system and implement the linear algebraic coding strategy in the multiple antenna system for the effective provisioning of the Communications networks;
- Presenting the basic principles of power-domain NOMA, reviewing the various objectives of NOMA, discuss uplink and downlink NOMA, and realize the behavior of the NOMA system.
- Evaluating the simulation results concerning error probabilities and comparing the BER Vs SNR for the LDC codes for the NRD distribution and the performance graph are plotted sequentially for MIMO system with the different order PSK modulation techniques. Eventually, compares the STBC with the optimum-coefficient-based LDC.
- Behavioral analysis of the NOMA system
- Finally, presents the conclusion of this work.

2. LDC System

Practically, the maximum diversity gain with improved reliable transmission and detection can be accomplished using the appropriate coding system in the multiple antenna system. STC is a popularly used coding system in multiple antenna systems. The previously used O-STBCs technique enhances the throughput and minimizes the interference but at the same time enhances the computational complexness of the system, which increments with a large number of antennas. Therefore, practically utilizing the low complex and efficient coders in mMIMO is an active area of research. LDC is a complex spatial-time block coding model. The term Linear Dispersion Codes is introduced in the year 2002, this term is a new case of STBC to improve the MI among the Tx and Rx signals. LDC split the data stream into sub-streams that are dispersed in linear combinations over space and time. The transmitted LD coded signal is a linear merger of dispersion matrices. As a result of linearity, LDC retains the ease decoder capability of V-BLAST. With the information-theoretic optimality property, LDC acquires several coding benefits like simple to encode and decode. It is a high-rate coding method that can deal with several numbers of Tx-Rx antennas and that subsumes several special cases of STBC. The LDC can be decoded easily by each of two ML or nulling and canceling. LDC performs superiorly at immense spectral efficiencies with low complexity [9].

2.1. Literature Review

Following concept boosting, articles are presented here to focus research in the field of LDC. Many researchers explained the criterion, in consideration of design in support of theory in-depth for the LDC concepts. Few noteworthy works in the field of LDC are given in table 2:

Table 2. Different techniques and approaches in the LDC

Ref No	Technique	Approach	Result and Performance Metrics
11	LDC structure for MIMO Rayleigh fading channels	Appropriately reorganized the LDC dispersion matrices, provide a tight frame	Enhances the performance of the LDC in details of E-SC, Pe, and full channel capacity.
10	Linear dispersion STFC design under frequency selective fading channels in the MIMO-OFDM systems	DLD-STFC requires double LDC encoding 3-stage LDC decoding, and LD-STFC, uses a single LDC encoding and decoding algorithm over multiple subcarriers, antennas, and OFDM blocks.	Tradeoffs amid the performance and complexity
12	LDC-OFDM, that linearly disperses data over both time (multiple subcarriers) and frequency (OFDM blocks)	Computation of optimized LDC matrices through a stochastic gradient descent scheme considering either ML or ZF decoder	BW efficient with reduced BER without enhancing the PAPR and maximize the ergodic mutual information
13	Dispersive Covariance Codes	uses the linear structure of LDC to acquire the channel covariance information at the Tx end	maximum capacity reduced Pe with low feedback overhead

14	SF-LDC in SCFDE systems	An appropriate linear precoding method and derived ST dispersion matrix	Tradeoffs between Tx diversity- spatial multiplexing.
15	Unitary-LDC	converting the $M \times M$ LDC into $T \times M$ non-square LDC, where M is the code rate	Symbol wise full diversity with low BER
16	GA aided optimization algorithm-based LDC design approach,	incorporate the various efficient optimization algorithms to solve the complex non-linear optimization problems.	large data rates and high diversity with a high degree of freedom.
17	LD-STBC for decode-and-forward synchronous relays	Haar-distributed unitary matrices are used to generate the random coding matrices for this system	decreases the ISI within relays.
18	SF-LDC is applied to SC-FDMA	The LDC is practiced to SC-FDMA to obtain the formulation of soft decision values in closed form, which is evaluated based on LLR.	increased sum-rate and high diversity order

2.2 LDC Encoding

Consider the LD encoded data is transmitted through the channel which is consistent for the time spam of T symbols in the $N_t \times N_r$antenna system and CSIR is known. The transmission matrix (s) of size $T \times N_t$ instructs the transmitted data signal onto the Rx antennas all over T. The LDC encoder generates the Q encoded data symbols that are transmitted from N_tTx antennas and these transmitted codeword are symbol as C_{LDC}. Assume that the input data stream has to be partitioned into Q sub-streams, typically Q = min (N_r,N_t).T and s_1,s_2,….$s_Q$are the complex data symbols chosen from m-PSK or m-QAM, constellation diagram. The LD coded data (C_{LDC}) is given as:-

$$C_{LDC} = s = \sum_{q=1}^{Q}(\alpha_q A_q + j\beta_q B_q) \tag{1}$$

where $C_{LDC} \in C_{T \times N_t}$and $A_q \in C_{T \times N_t}$, $B_q \in C_{T \times N_t}$, for q = 1, ...,Q. A_q and B_q are known as dispersion matrices. The complex data symbols are conveyed by real scalars (α_q, β_q) as:

$$S_q = \alpha_q + j\beta_q \tag{2}$$

Selection of the optimum value of {A_q, B_q} is essential for the high channel capacity at high SNR. The optimum {A_q, B_q} should sensitive to one of the subsequent constraints:

- The power constraint E[trSS*]=N_tT concerning A_q and B_q

$$\sum_{q=1}^{Q}(trA_q^* A_q + trB_q^* B_q) = 2N_tT \tag{3}$$

- Each term of S_q maintains the analogous average power in *T* time slots from each Tx antennas:

$$A_q^* A_q = trB_q^* B_q = TN_t/Q\ ,\ q=1,2,..Q \tag{4}$$

- Each term of S_q maintains the analogous power in particular channel usage from each Tx antenna:

$$A_q^* A_q = B_q^* B_q = (\mathrm{T/Q}).I_{N_t} \tag{5}$$

The optimum value of {A_q, B_q} Tx definite combination of each symbol from each Tx antenna in every channel usage to accomplish the demand of efficient coding techniques [9].

2.3 LDC Decoding

The transmitted LD coded data over the channel matrix of dimension $2N_rT\times2Q$ gets received by the Rx antenna. The received codeword can be decoded easily by the linear mathematical algebraic equation solver because of the linearity property in LDC, which comes from the linear dispersion matrices. The linearity property in LDC can be analyzed by the received data equation as:

$$\begin{aligned} \mathrm{r} &= \sqrt{\frac{\rho}{N_t}}\mathrm{sH} + \mathrm{v} \\ &= \sqrt{\frac{\rho}{N_t}}\sum_{q=1}^{Q}(\alpha_q A_q + j\beta_q B_q)\mathrm{H} + \mathrm{v} \end{aligned} \tag{6}$$

The above equation shows the linearity amid s, r, and H. The theoretical part shows that the LDC converges faster and performs well with a low complexity decoding algorithm to support future high data rate MU wireless communication systems [9].

2.4. LDC Implementation

The basic LDC is defined in the eq (7) buy the orthonormal matrix. In order to derive the optimal coefficients values of α_1 to α_4 and $\beta_1$to β_4.

$$S = \begin{bmatrix} \left[\alpha_1+\alpha_3+\mathrm{j}\left[\frac{\beta_2+\beta_3}{\sqrt{2}}+\beta_4\right]\right] & \left[\frac{\alpha_2-\alpha_4}{\sqrt{2}}-\mathrm{j}\left[\frac{\beta_1}{\sqrt{2}}+\frac{\beta_2-\beta_3}{2}\right]\right] & 0 \\ \left[\frac{-\alpha_2+\alpha_4}{\sqrt{2}}-\mathrm{j}\left[\frac{\beta_1}{\sqrt{2}}+\frac{\beta_2-\beta_3}{2}\right]\right] & \alpha_1-\mathrm{j}\frac{\beta_2+\beta_3}{\sqrt{2}} & -\frac{\alpha_2+\alpha_4}{\sqrt{2}}+\mathrm{j}\left[\frac{\beta_1}{\sqrt{2}}+\frac{\beta_2-\beta_3}{2}\right] \\ 0 & \left[\frac{\alpha_2+\alpha_4}{\sqrt{2}}+\mathrm{j}\left[\frac{\beta_1}{\sqrt{2}}-\frac{\beta_2-\beta_3}{2}\right]\right] & \left[\alpha_1-\alpha_3+\mathrm{j}\left[\frac{\beta_2+\beta_3}{\sqrt{2}}-\beta_4\right]\right] \\ \left[\frac{\alpha_2-\alpha_4}{\sqrt{2}}+\mathrm{j}\left[\frac{\beta_1}{\sqrt{2}}+\frac{\beta_2-\beta_3}{2}\right]\right] & -\alpha_3+\mathrm{j}\beta_4 & \left[-\frac{\alpha_2+\alpha_4}{\sqrt{2}}+\mathrm{j}\left[\frac{\beta_1}{\sqrt{2}}-\frac{\beta_2-\beta_3}{2}\right]\right] \end{bmatrix} \tag{7}$$

where, $s_j = \alpha_j + i\beta_j$, for j = 1,. . . ,4 are the transmitted symbols as a function of time taken from the QAM constellation. The system performance depends on the efficient channel realization and also using the efficient precoding design that can add the improvement. The LSD-based optimum precoding is proposed to design in this paper. The LDC is special coding methods that are expected to improve the diversity of modeled MIMO channels. An example of LDC for three antennas was acquired as [9].

The research problem in this paper is to find out the optimal values of coefficients α_1 to α_4 and β_1 to β_4. The validation of STBC is done for 4x3 complex orthogonal matrix respectively to ¾ rate system. For the validation part the complex orthogonal metros O is considered as work designed by the V. Tarokh et al [19] were set to as;

$$O = \begin{bmatrix} 1 & -2 & -3 \\ 2+j & 1+j & 0 \\ 3+j & 0 & 2 \\ 0 & -3+j & 2+j \end{bmatrix} \quad (8)$$

In favor of deriving the optimal coefficients values of α_1 to α_4 and $\beta_1$to β_4.The real and imaginary terms of the $S_{i,j}$ term in eq (7) is compared respectively with the eq (8). Based on the relative comparison, the following linear equation combinations have been derived for finding the coefficients. Let the initial estimate be taken a

$$-\alpha_3 + j\beta_4 = -3 + j \rightarrow \alpha_3 = 3 \; and \; \beta_4 = 1 \quad (9)$$

$$\frac{\beta_2 - \beta_3}{2} = 0 \qquad \rightarrow \beta_2 = \beta_3 = \frac{1}{\sqrt{2}} \quad (10)$$

Set the $\alpha_1 = 1 \; and$ try to set the α coefficients to eliminate the $\sqrt{2}$ factor as;

$$\alpha_2 + \alpha_4 = 6\sqrt{2} \rightarrow \alpha_2 = 2\sqrt{2} \;, \quad \alpha_4 = 4\sqrt{2} \quad (11)$$

These linear equations lead to coefficient vectors as

α_1=1, α_2= $2\sqrt{2}$, α_3=3, α_4= $4\sqrt{2}$ and

$\beta_1 = \sqrt{2}, \beta_2 = \frac{1}{\sqrt{2}} . \beta_3 = \frac{1}{\sqrt{2}} . \beta_4 = 4$

3. NOMA: An Introduction

NOMA is important multiple access facilitating technology for the modeling of RAT for the 5G networks to fulfill the requirements of large user access, high-speed connectivity, improved reliability, huge throughput, and decreased latency. The primary concept of NOMA is that the several users share the same radio resources like subcarrier, time, spreading code simultaneously i.e., the multiple users access the communication channel in a non-orthogonal fashion to increase the SE at the cost of incremented receiver complexness (to partitioned the non-orthogonal user's message signal). As opposed to OMA, which depends on the sharing of radio resources in an orthogonal fashion, NOMA supports multiple UTs by multiplexing several users in the same resources in a non-orthogonal fashion as shown in figure 1.

Based on concepts and implementation prospects, the NOMA technology can be divided into two categories termly Code-domain NOMA and Power-domain NOMA. The CD-NOMA includes SCMA, LDS-CDMA, LDS-OFDM, MUSA, and SAMA. The key concept behind CD-NOMA is that it uses non-orthogonal sparse spreading to multiplex the multiple users that share the same resources. Whereas the PD-NOMA applies the SC principle and superimposes the several users using the same radio resources by allocating distinctive power levels to each user. The applications of the PD-NOMA system are CNs, WSNs, and D2D communications. The features, benefits, and challenges of PD-NOMA are given in table 3.3. The PD-NOMA uses the SIC or DPC schemes at the Rx end to decode the data signals [5-7]. The PD-NOMA is considered in this research work.

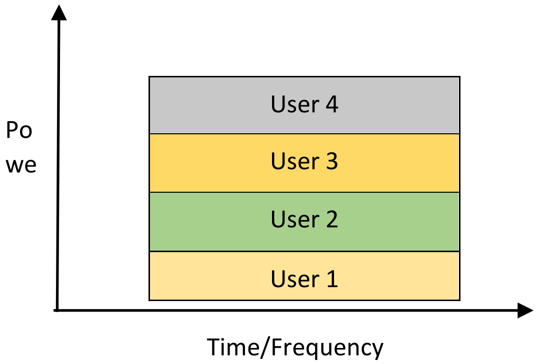

Fig 1. NOMA System

Table 3. Features, advantages, and disadvantages of PD-NOMA

Features	Advantages	Disadvantages
• User multiplexing is achieved in the power domain • SIC receiver is utilized to decode the superimposed signals • Take benefits of the several channel conditions	• Increases the SE • Increases the throughput of the system • Improved coverage gain • Not deteriorates the performance due to the near-far effect.	• Difficult to optimize and design codes • SIC increments the system signaling Overhead • Receiver complexness requires advancement in chip technology

3.1 The principle of SIC Receiver and Superposition Coding (SC)

The NOMA technology uses the SC at the Tx end and the SIC at the Rx end so that multiple users can utilize the same resources. SC is the physical layer modulation technique to Tx individual message signals of multiple users simultaneously by performing superimposition i.e., the addition of these message signals to create a composite signal before transmission. The SC superimposes all the independent message signals into a single wave as shown in figure 2.

The SIC performs the decoding of the received signals one after another till it searches for the desired signal as shown in figure 3. The figure illustrates that all the message signals indicated are superimposed at the Tx end. At the Rx end, the SIC decoder receives all the transmitted signals. The SIC firstly decodes the strongest signal and refers to all other signals as interference. After then subtracting the strongest decoded signal from the Rx signal and in case of perfect decoding, another transmitted signal from the leftover signals are perfectly attained. SIC portrays the decode and subtract method as far as it searches for its own desired signal. The achievement of SIC relies on the accurate cancellation of the signals in the repetition process, whereas the SC precisely superimposes the transmitted signals and divides the power amid the user information waveforms.

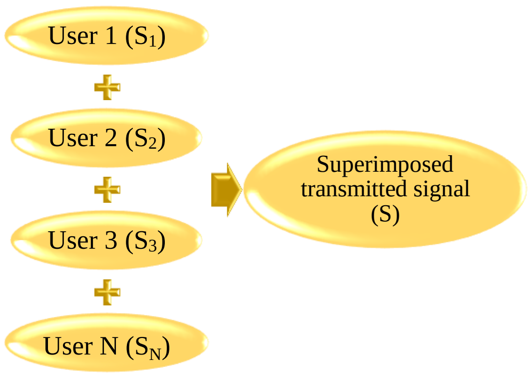

Fig 2. The Superposition Coding

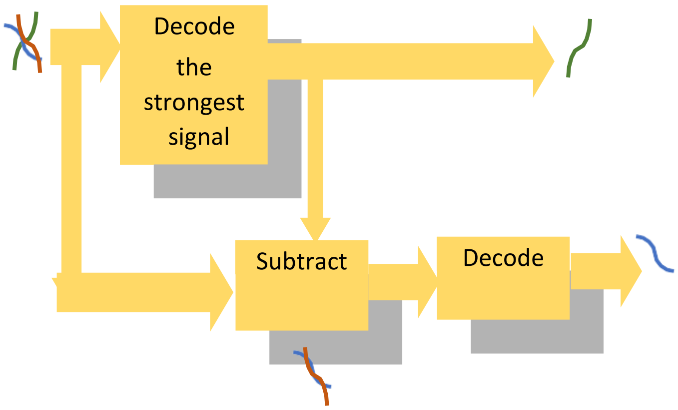

Fig 3. The SIC Receiver

3.1 Downlink NOMA

In NOMA DL, the BS performs the SC scheme for its multiple users. Each UT exploits the SIC method for detection of their message signal as shown in figure 4, which represents a BS and K number of UTs with SIC detectors. Assume that the UT_1 is nearest to the BS, and UT_K is the farthest to the BS. The BS should perform the power allocation between the individualistic message signals. In NOMA DL, generally, BS allocates high power to the farther UE and least power to the closest UT. At the receiver side, all UTs Rx the same transmitted signal that comprises all user's information. Each UT firstly decodes the strongest signal and then subtracts the decoded signal from the received signal. SIC repeats the decode and subtract method as far as it searches for its own desired signal. UT positioned nearest to the BS cancels the signals of the farthest UTs to decode its own desired signal first.

3.2 Uplink NOMA

The UL-NOMA realization is distinctive from the DL-NOMA. At the transmitter side, the UL-NOMA network multiplexes K different UTs using SC. And the BS exploits the SIC with the view to differentiate the user signals. The BS decodes the first signal from the nearest UT. The received signal y(t) at the BS is expressed as:

$$y(t) = \sum_{k=1}^{K} x_k(t) g_k + w(t)$$

where, $x_k(t)$ is k^{th} user information

g_k is the channel attenuation gain in the middle of BS and UT_k

w(t) is the AWGN with zero mean and density N_0

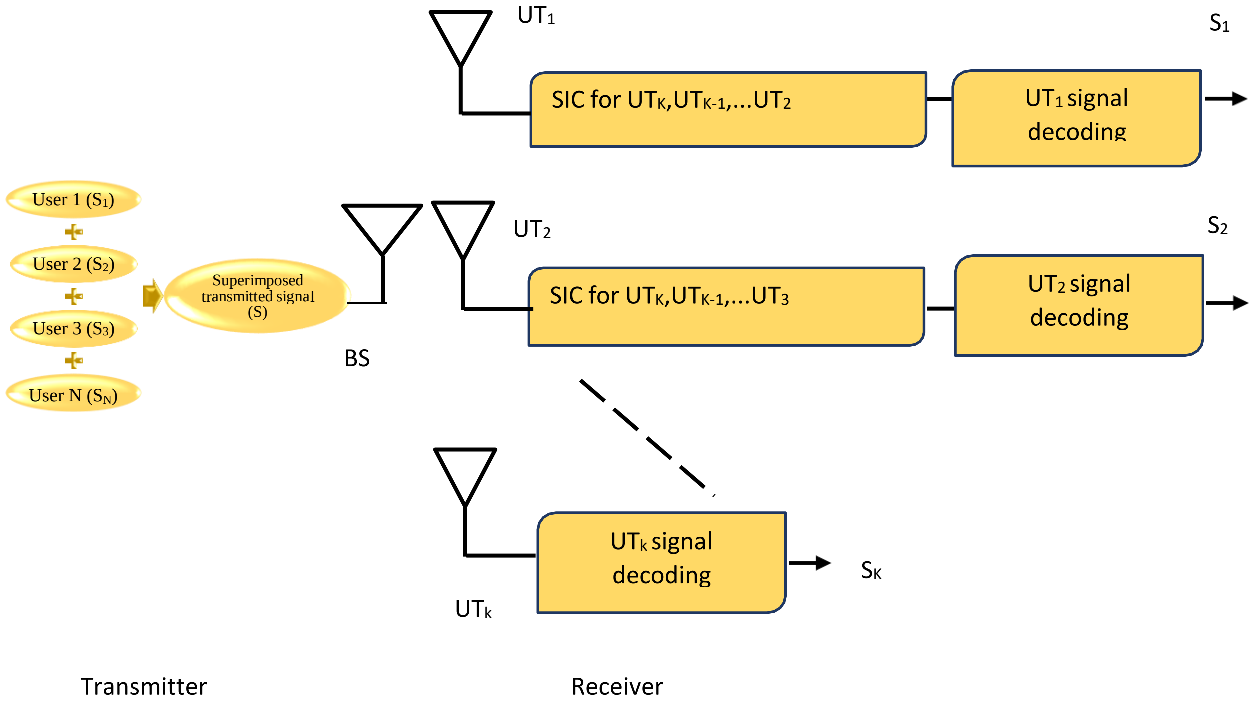

Fig 4. NOMA-DL system for K users

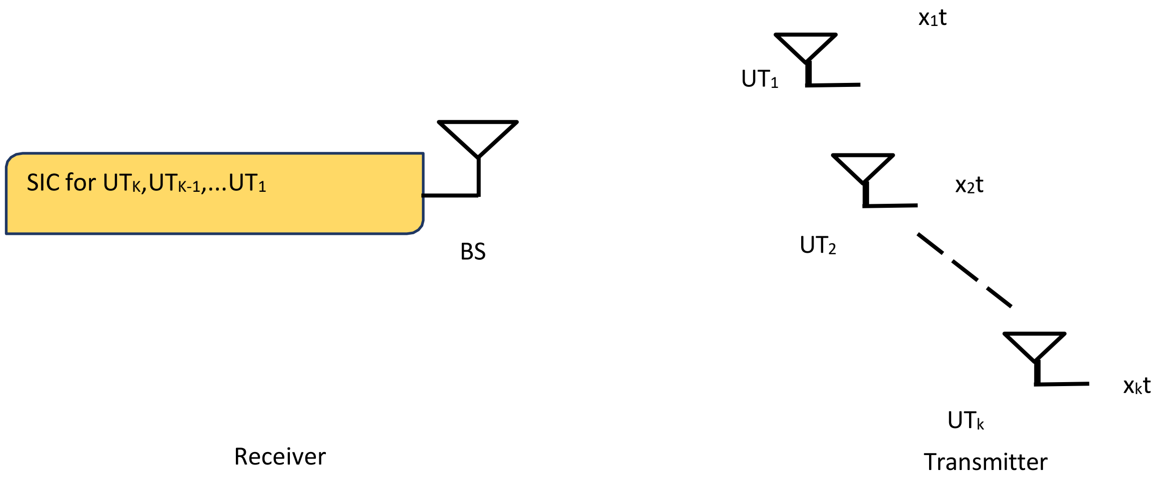

Fig 5. NOMA-UL system for K users

3.4 Literature Review

Following concept boosting, articles are presented here to focus research in the field of NOMA. Many researchers explained the criterion, in consideration of design in support of theory in-depth for the NOMA concepts. Few noteworthy works in the field of NOMA are given below:

Table 4. Noteworthy achievements of NOMA

Ref No.	Objective	Approach	Technique
20	To attain the fairness performance under perfect CSI	Optimized power allocation scheme that formulates the research problems	PD-NOMA
21	To increase the energy efficiency of the DL-NOMA	A low complex optimal subchannel algorithm for the subchannel multiplexed users	PD-NOMA
22	To reduce the difficulty of the message passing algorithm (MPA) scheme	Shuffled-MPA (S-MPA) strategy depends on serial message update approach	Multi-carrier code domain (S-MPA)
23	To attain high overloading that provides the grant-free transmission	Special blind MU detection approach	MUSA
24	To lessen the error propagation.	SIC iterative processing strategy	SIC-MMSE
25	To increment user overloading and reduce the MU interference	Expand the length of the non-orthogonal spreading sequences	MUSA
26	To maximize diversity gain, easy detection with low receiver complexness	Appropriate user pairing to lessen system complexness and cooperative PD-NOMA to attain maximum diversity gain	PD-NOMA
27	To increase the MI in SCMA	An iterative codebook optimization approach	SCMA
28	To reduce the difficulty of the SCMA decoding.	MCMC based SCMA decoder	MCMC
29	To increase the transmission reliability.	With forward relay and half-duplex decode	Co-PDMA
30	To allow a simple MU interference cancellation	MMSE-SIC/PIC	MMSE-SIC/PIC
31	To boost the outage performance of MIMO-NOMA	By designing appropriate precoding and decoding matrices for MIMO-NOMA.	MIMO-NOMA
32	To progress the link-level performance of SCMA	MU-SCMA receiver	SCMA

4. Simulation Result

4.1 LDC Realization

The SER comparison of the presented optimal coefficient LDC with the STBC technique is given in figure 6, which presents that the LDC outperforms STBC. It can be observed that optimal coefficient LDC (O- LDC) improves the BER pattern and the BER continuously degrades with the increment in the SNR value of the system. The results are evaluated for the ¾ rate code for the 3 transmitting antenna systems. The error probabilities comparison for the several order of the PSK modulation techniques for the using the optimal coefficient LDC method is presented in figure 7.

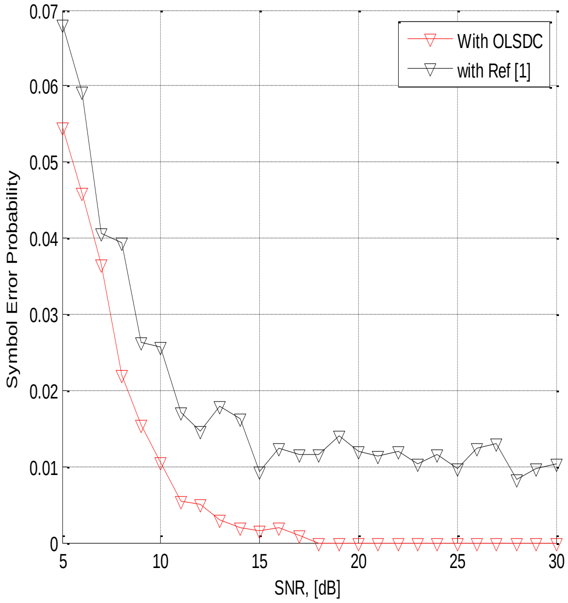

Fig 6. Comparison of optimal coefficient LDC with the STBC

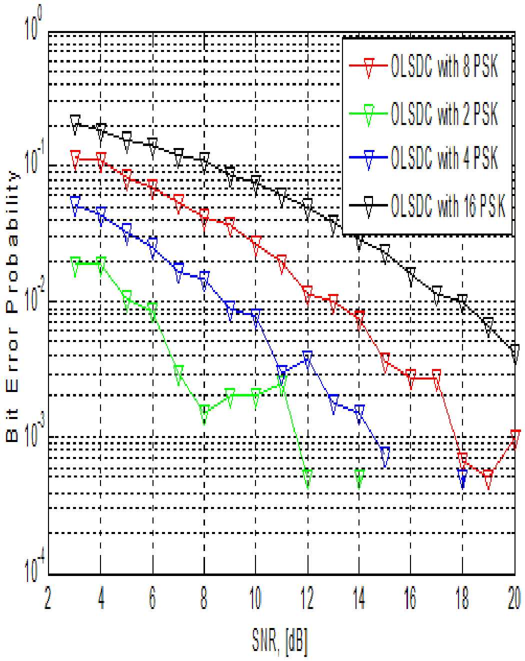

Fig 7. BER Comparison for the PSK techniques using optimal coefficient LDC

4.2 Realization of NOMA:

In this period, more emphasis is given to realize the behavior of the NOMA technique in the multi-node cooperative communication system in the MATLAB R2014a software tool. NOMA has immense potential in future networks for enhancing spectral efficiency, supporting massive connectivity, and reducing latency. The main work done in this tenure are :

- Analyzed the behavior of UL and DL Fixed NOMA concerning outage probability and SNR in the MATLAB tool and compared the simulation and theoretical results for 2 users. In Fixed NOMA, the decoding order of the users is fixed and the outage appears when the maximum possible data rate is lower than the desired rate. Outage probability characterizes the performance of NOMA + SIC. The MATLAB results are given in fig 8 and fig 9.
- Realized the ordered NOMA in detail of outage probability and SNR in the MATLAB tool and compared the simulation and theoretical results for 2 users. In the ordered NOMA, the weaker user (minimum channel gain) is decoded first then the stronger user (maximum channel gain) is decoded. The MATLAB result is shown in figure 10.
- Analyzed the NOMA Optimal power allocation technique in terms of capacity and SNR in the MATLAB tool. The optimal power factor (that minimizes the error probability)

can be obtained via Signal Error Rate Minimization. The water-filling optimal power allocation technique is used to allocate the power to every user and compare the result with the sub-optimal power allocation technique. The MATLAB result is shown in figure 11.

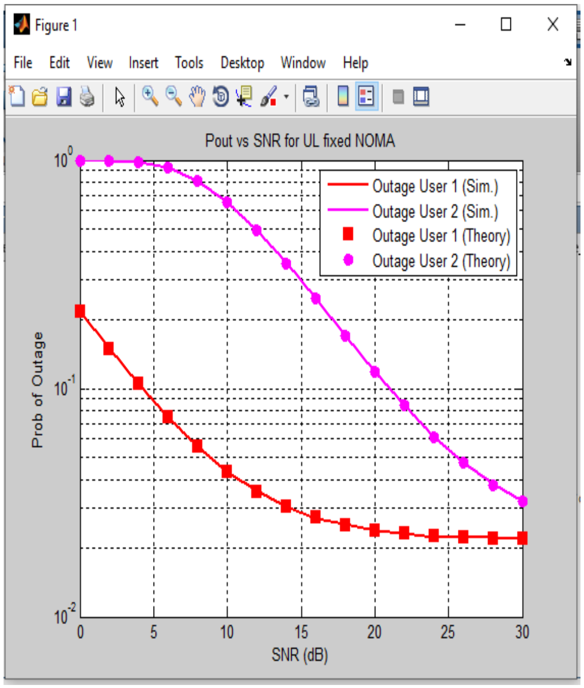

Fig 8. UL Fixed NOMA

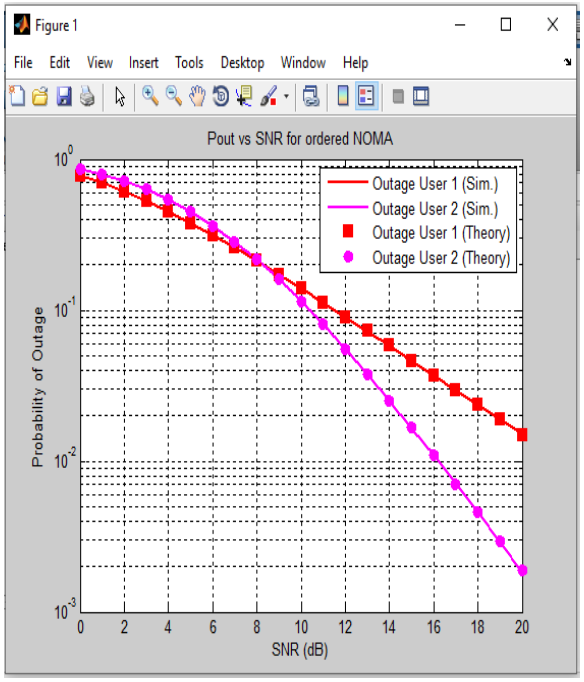

Fig 10. UL Ordered NOMA

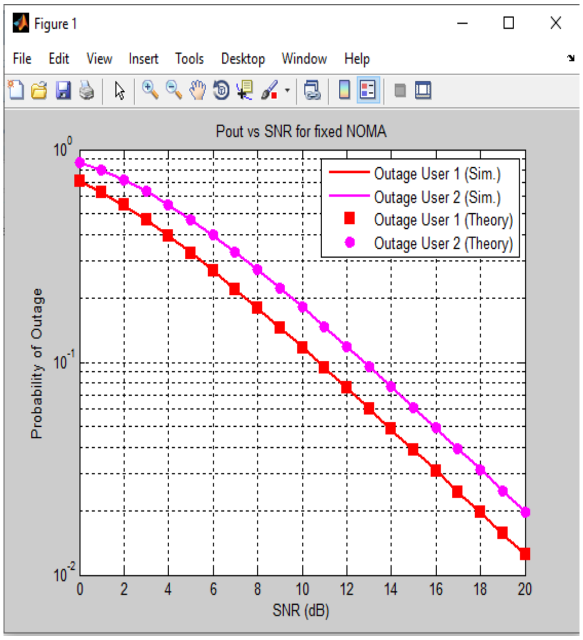

Fig 9. DL Fixed NOMA

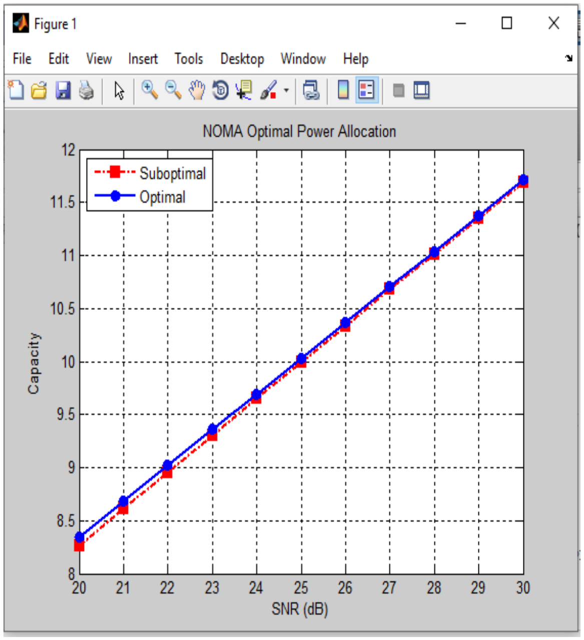

Fig 11. Optimum Power Allocation in NOMA

5. Conclusions:

The Multiple antenna system is the fundamental requirement for an efficient cellular spectrum to attain high spectral efficiency with low complex signal processing. The various research challenges are needed to accomplish this emerging wireless access system. This paper focuses on the multiple access technology and the coding system for the multiple antenna system. Nowadays NOMA is a popularly used 5G multiple access strategy because of the immense potential of spectral efficiency, low latency massive connectivity, and large net data throughput. This paper gives a technical view of NOMA and realized the behavior of the DL and UL-NOMA concerning outage probability Vs SNR. This work also discusses the LDC for multiple antennas system. This coding scheme depends on the linear algebraic coding strategy to boost the performance of the multiple antenna system concerning error probabilities and SNR. Simulation result presents that the LDC outperforms the basic alamouti STBC and improves the BER pattern at high SNR for the different M-PSK modulation, thereby increasing the performance of the communication system.

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Abbreviations

BER	Bit error rate
BS	Base station
BW	Bandwidth
CD-NOMA	Code-domain NOMA
CSI	Channel state information
CSIR	Channel state information at receiver
CNs	Cellular Networks
D2D	Device-to-device communication
DLD-STFC	Double linear dispersion space-time-frequency-coding
DL	Downlink
E-SC	Ergodic sum capacity
LDC	Linear dispersion codes
LD-STFC	linear dispersion space-time-frequency-coding
LDS-OFDM	LDS aided OFDM
LDS-CDMA	low-density spreading CDMA
MCMC	Monte carlomarkovchain
MED	Minimum euclidean distance (MED
MI	Mutual information
MIMO	Multiple-input Multiple-output
MU	Multi-user
MUSA	Multiuser shared access,
NOMA	Non-orthogonal multiple access
OMA	Orthogonal multiple access
PARP	Peak-to-average power ratio
PD-NOMA	Power-domain NOMA
RAT	Radio Access Technology
SCFDE	Single Carrier - Frequency Domain Equalization
SCDMA	Sparse code division multiple access
SC-FDMA	single-carrier frequency-division multiple access
SC	Superposition Coding
SCMA	Sparse code multiple access (SCMA)
SIC	Successive interference cancellation
SE	Spectral Efficiency
SNR	Signal-to-noise ratio
STC	Space-time Coding
SU	Single-user
UL	Uplink
UT	User-terminal
WSN	wireless sensor networks
5G	5th Generation