# Performance Analysis of Multiuser NOMA using Non Orthogonal Spreading Sequence

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***Abstract* - The design of an efficient multiple access scheme for the 5G mobile system is a key technique to boost the system capacity. Non-Orthogonal Multiple Access (NOMA) scheme being presented to accompany existing Orthogonal Multiple Access (OMA). NOMA facilitate allocation of similar resource to multiple users simultaneously. NOMA permits allocation of frequency and time in the similar spatial layer using super positioning of signals or code domain multiplexing. NOMA permits a significant improvement in system throughput and capacity of connecting devices. When super position codes are utilized, over the similar subcarrier multiple user's signals will be superimposed with distinct received power at the base station. Here we propose, non-orthogonal spreading sequence known as Zadoff Chu sequence for NOMA scheme to improve the bit error rate performance of the multiuser NOMA system.**

***Keywords - NOMA, OMA, Zadoff Chu Sequence, Precoding, SIC***

## I. INTRODUCTION

Fifth generation (5G) wireless network is developed to improve the service provided by mobile communication system. 5G networks provide more spectral proficiency, reliable communication, low latency and massive connectivity. The major challenges to emphasis on 1000 time's prominence traffic volume and 100 times prominence data rate. This sudden growth in traffic and the user data rate can be managed by various methods but we can emphasize on the Physical layer methods which involves the massive Multiple Input and Multiple Output, Filter Bank Multi-Carrier, Non-Orthogonal Multiple Access, etc[]. It majorly emphases on the enhancement of spectrum proficiency to improve the network capacity.

OFDM supports various favorable features required for the fourth generation wireless communication system. In multipath fading scenario OFDM needs to add cyclic prefix to the transmitting symbol at the expense of bandwidth to conflict effect of multipath fading. OFDM is extremely delicate to the carrier offset. To enhance the spectral proficiency, Non-Orthogonal Multiple Access has been considered for the 5G networks [2]. NOMA differs from usual the OMA, where multiple user are allocated with narrow bandwidth achieving good sum rate capacity but OMA systems suffer to deal with a number of active connections.

NOMA employ the principles of superposition coding where several users are arranged in the power domain so that they share the similar time/frequency resource simultaneously. Hence, SC is effectively increasing the capacity of the NOMA system without expanding the bandwidth. The composite signal is detected at the receiver by utilizing Successive Interference Cancellation (SIC) which intrinsically needs more power level distinguish among the users for efficient detection. Employing SIC or Maximum likelihood detection interference for the NOMA system is supervised utilizing non-orthogonal resource assignment at the expense of receiver complication.

## II. RELATED WORK

OFDM is multicarrier modulation scheme preserves orthogonality among subcarriers. OFDM is widely employed for a 4G system and also utilized as multiple access scheme for 5G wireless communications. The OFDM system restricts the allocation of the number of users in each resource block to deal with this use and serve number of users in single resource block. NOMA scheme has been recommended for the future generation wireless radio access due to enrich spectral proficiency [4].

NOMA permits fairness among the user by allocating largest power to the far user, far user channel capacity will be improved because the channel capacity depends on SNR which results in significant improvement in the net throughput of NOMA. NOMA facilitate for connecting an enormous number of users and various classes of users by allocating them in same resource block which permits massive connectivity for 5G networks. NOMA can be integrated with existing wireless communication methods such as TDMA, OFDM, MIMO or mmWave [12] to enhance their proficiency further. In NOMA-TDMA multiple users can be served in one time slot. In case of mmWave NOMA base station can form multiple narrow beams to scan multiple users of NOMA at the same time. OFDM based NOMA provides significant improvement in the spectral proficiency by allocating more user in single subcarrier. NOMA can be efficiently incorporated with the cognitive radio system.

Therefore NOMA is backward compatible existing wireless communication system.

In power domain NOMA multiple users are arranged using superposition coding so as all users share the similar frequency and time resources at the same time. Each user is distinguished with distinct power level and allocation of power depends on the channel condition of each user. Therefore superposition coding improves the NOMA system capacity with no expansion in the bandwidth. To estimate the received signal, the SIC estimation method is employed at the receiver structure. In SIC users are estimated in the descending order of their power allocation factor. User with more power level is decoded first, then it will be subtracted from composite signal. Because it simple to decode the larger power level signal from the composite signal which maximizes the sum rate of channel capacity. Hence NOMA accredits fairness among all users, enhances system capacity and enormous connectivity of devices this leads to the application of the NOMA system in 5G wireless communication.

## III. METHODOLOGY

NOMA serves multiple users by allocating higher power variation among the paired users while transmitting. NOMA users are multiplexed using superposition coding at the transmitter and estimation of signal is done at the reception using SIC decoding. The SIC estimation is one of the MUD scheme which is combination of an iterative signal estimation and modulation [11]. It can be utilized to estimate signal where user signals are ordered corresponding to their SINR.

### *A. System model*

Let $s_1, s_2$ ….. $s_N$ represents the transmitting users signal. The base station accomplishes the superposition of transmitting signal and represented as

$$S = \sqrt{Pa_1}\, s_1 + \sqrt{Pa_2}\, s_2 + \cdots + \sqrt{Pa_N}\, s_N \qquad (1)$$

Where P is the total transmit power $a_1, a_2, \ldots . a_N$ represent the power allocation coefficients and ordered as
$a_1 > a_2 > \cdots > a_N$
. The received signal at $i^{th}$ user is

$$R = \left(\sqrt{Pa_1}\, s_1 + \sqrt{Pa_2}\, s_2 + \cdots + \sqrt{Pa_N}\, s_N\right)h_i + W_i \qquad (2)$$

Where $h_i$ and $W_i$ are channel coefficient and noise with variance$\sigma^2$.

At receiver SIC is applied to extract each user signal, the mechanism behind SIC is weaker user is decoded first, then subtracted it from received composite signal and estimates its own signal. Hence NOMA is observed as other techniques for interference cancellation.

The SINR for $i^{th}$ user is presented by

$$SINR_i = \frac{a_i P|h_i|^2}{a_{i+1}P|h_{i+1}|^2 + \cdots + a_n P|h_n|^2 + \sigma^2} \qquad (3)$$

### *B. Zadoff Chu sequences*

Zadoff Chu sequences are a class of complex exponential polyphase sequences with constant amplitude [3]. The auto-correlation of Zadoff Chu sequence having a prime length with a cyclically shifted form of itself has zero auto-correlation [7]. Here we consider Zadoff Chu sequences with length L is given by

$$z_r(n) = \begin{cases} e^{-j\frac{2\pi}{L}\cdot\frac{rn(n+2q)}{2}} & for\ L\ even \\ e^{-j\cdot\frac{2\pi}{L}\cdot\frac{rn(n+1+2q)}{2}} & for\ L\ odd \end{cases} \qquad (4)$$

Zadoff Chu sequence length L, having root index $r = 1 \ldots L-1$ , it is possible to have L-1 different sequences with different root index. This sequence has superior correlation properties [8], are necessary in a distinct engineering application such as channel estimation, timing synchronization [9].

### *C. Precoding of NOMA using Zadoff Chu Sequence*

Zadoff Chu sequence precoded NOMA system is shown in the figure .Precoding is the simple linear method which enhances the system performance. During transmission, signals are precoded after the power allocation using the Zadoff Chu sequence. At the receiver side prior to SIC decoding the received signal is inverse precoded using Zadoff Chu sequence which improves the bit error rate performance of the NOMA system.

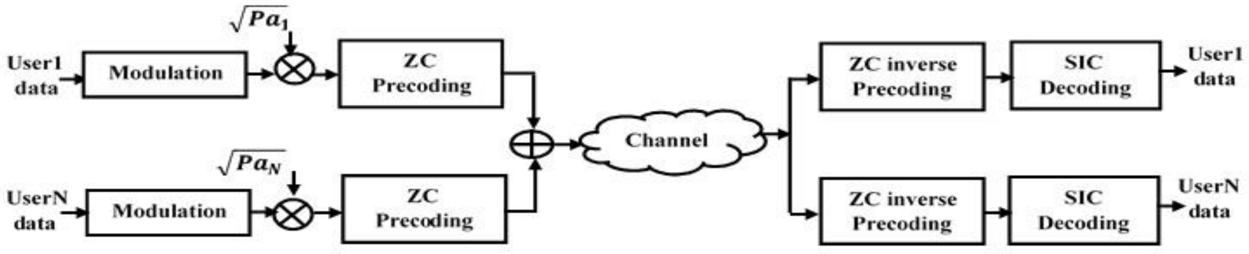


Fig.1. Precoding of NOMA using Zadoff Chu Sequence

## IV. RESULTS AND DISCUSSION

### *A. Zadoff Chu Sequence*

Fig. 2 shows the Zadoff Chu sequence of length $L = 257$ with root index $r = 1$ . The figure shows the Zadoff Chu sequence and its shifted version. Sequence will be repeated after L shifts

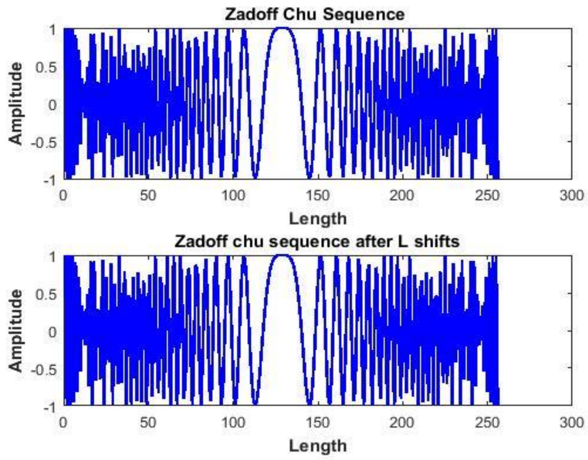


Fig. 2. Zadoff Chu sequence of length L

### *B. Zadoff Chu precoded NOMA*

Fig. 3. Shows the BER performance of Zadoff Chu (ZC) sequenced precoded NOMA using BPSK modulation technique in AWGN channel. We can observe that far user has the more BER because near user cause interference for far user. There is no interference for near user and has less BER. Simulation results shows that, the BER performance of ZC precoded NOMA in AWGN channel using BPSK modulation. For near user at a clip rate of $10^{-4}$ BER is 40dB for ZC precoded NOMA and 45dB for non precoded NOMA. BER of NOMA system is improved by precoding using Zadoff Chu sequence.

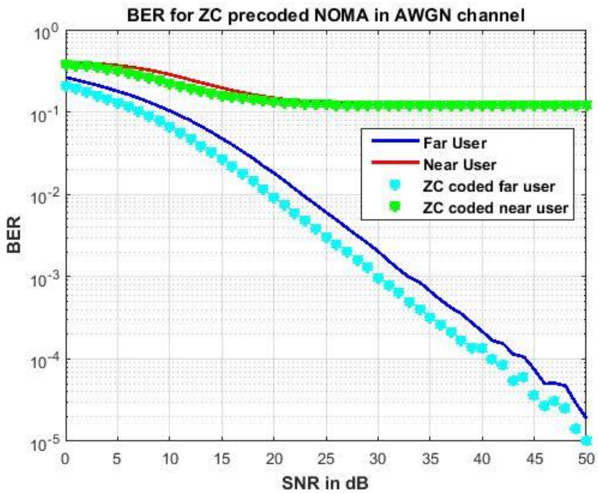


Fig.3. BER performance of ZC precoded NOMA in AWGN Channel

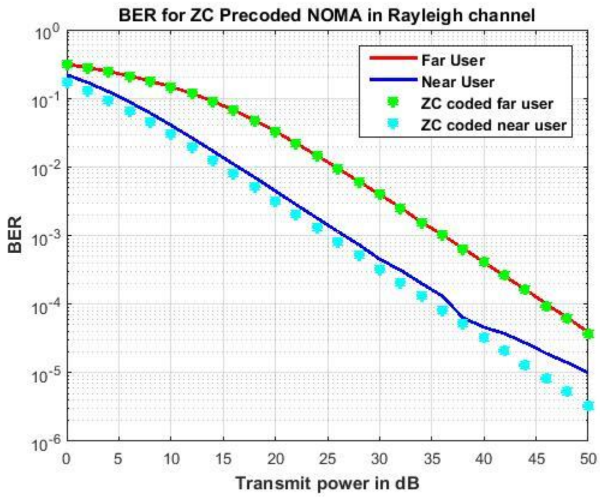


Fig.4. BER performance of ZC precoded NOMA in Rayleigh Channel

Fig. 4. Simulation results show that, the BER performance of ZC precoded NOMA is improved in Rayleigh channel using BPSK modulation. BER for near user at a clip rate of $10^{-4}$ is 34dB for ZC precoded NOMA and 37dB for non precoded NOMA.

## V. CONCLUSION

This paper presents performance analysis of NOMA system using Zadoff Chu sequence precoding. We consider two user scenario, at the transmitter the use of super imposed signal improve the spectral proficiency over the orthogonal multiple access. The super imposed signal is precoded with Zadoff Chu sequence to improve the BER performance. At the receiver inverse precoding is done before SIC decoding. SIC decodes the received signal depending on the order of power allocation. Simulation results show that Zadoff Chu sequence precoded NOMA system and out performance over the conventional NOMA system.

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## REFERENCES

[1] Zhiguo Ding, Yuanwei Liu, Jinho Choi, Qi Sun, Maged Elkashlan, Chih-Lin Iand H. Vincent Poor “Application of non-orthogonal Multiple access in LTE and 5G networks ,“ a manuscript submitted to the IEEE communications magazine , 2015.

[2] SteliosTimotheou, Member, IEEE, and IoannisKrikidis, Senior Member, IEEE,”Fairness for non-orthogonal multiple access in 5G systems,”. IEEE , 2015.

[3] Zhuyan Zhao1, Deshan Miao1, “Uplink contention based transmission with non-orthogonal spreading,” IEEE , 2016.

[4] AlessioZappone, Luca Sanguinetti, GiacomoBacci, Eduard Jorswieck: Energy-Efficient Power Control, ”A look at 5G wireless technologies,” IEEE International Conference on Communications (ICC15), London, UK, 2014.

[5] Yejian Chen, Frank Schaich, and Thorsten Wild Bell Laboratories, Alcatel-Lucent, “Multiple access and waveforms for 5G: IDMA and universal filtered multi-carrier,” IEEE , 2014.

[6] Soheila V. Bana, PravinVaraiya ,“Space Division Multiple Access (SDMA) for robust Ad hoc vehicle communication networks ,“ The IEEE fourth international conference on intelligent transportation systems , 2003.

[7] Mohammad M.Mansour, “Optimized architecture for computing zadoff chu sequences with application to LTE,” Lebanon, 2009.

[8] D. C. Chu, “Polyphase codes with good periodic correlation properties”, IEEE Trans. on Inf. Theory, 1972 vol. IT-18, pp. 531–532.

[9] Srdjan Budisin,”Decimation Generator of Zadoff Chu Sequences,” , Sequences and their application –SETA , 2010.

[10] Pekka Pirinen centre for wireless communications Finland,”A brief overview of 5G activities,”1st International conference on 5G for Ubiquitous Connectivity ,2014 .

[11] Imran Baig, Member IEEE, “A precoding-based multicarrier non-orthogonal multiple access scheme for 5G cellular networks,” IEEE ,2017

[12] Lili Wei, Rose Qingyang Hu, Yi Qian, and Geng Wu,” Key elements to enable millimeter wave communications for 5G wireless systems,” IEEE Wireless Communications 2014.