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Throughput Enhancement and BER Reduction in LTE/NR Using NOMA Aided OFDM with Self-Interference

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Abstract— ***Wireless Technology is the most demanding and fastest growing technology in the field of communication. NOMA (Non Orthogonal Multiple Access) has emerged as most popular radio access technology which can be used to serve multiple users in same time and frequency resource. In this work a novel self-interference technique using NOMA aided OFDM is proposed to increase throughput performance of LTE/NR network. It is shown that the proposed system is very useful in the scenario where users' channel condition is very bad and higher order modulation cannot be used. It is inferred from simulation results that proposed system will give benefit in terms of throughput and resource utilization. Further it is shown that BER (Bit Error Rate) performance can also be improved by employing a special coding technique.***

Keywords— ***NOMA, OFDM, Self-Interference, SIC (Successive Interference Cancellation), coding.***

I. INTRODUCTION

As the name suggest in NOMA users are no longer differentiated based on some kind of orthogonally in time or frequency or code. So the concept of orthogonally is no longer there in NOMA. Here multiple users are allowed to use non-orthogonal resources concurrently. As a result NOMA achieves higher spectral efficiency and lower latency than OMA but it allows some degree of multi user interference at receiver. The concept of NOMA is based on superposition coding at transmitter at SIC at receiver. In power domain NOMA all users are given different power based on their channel conditions. If any user has a good channel condition then it is given lower power than the user with bad channel condition. At the receiver side any user with good channel condition can eliminate the interference by the users whose channel conditions are poorer than that user.

We know in LTE and NR in physical layer we use OFDM for transmission.

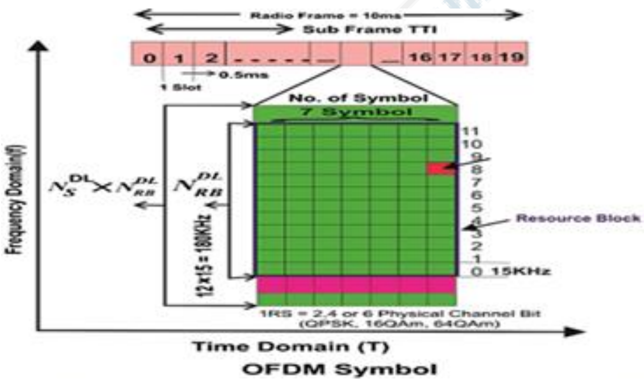

Figure 1. OFDM Resource Grid

If we consider one OFDM resource block then it will contain 7 symbols (for normal CP) (figure1) in time domain and 12 subcarrier in frequency domain. So overall we will have 12*7=84 REs (Resource elements). Each RE is a modulated symbol. Now suppose one condition that user is allocated only one Resource Block (RB) and we want to send more information using one RB, but its channel condition is not good, so cannot do higher order modulation.

This paper has shown, how users' throughput can be increased using self-interfered superimposed symbols using NOMA aided OFDM. As a result more information can be sent without using more Resource Blocks (RBs). This model is useful for those conditions where users' channel condition are poor and higher order modulation is not possible. This model is also useful where we have less number of RBs. Later it is also shown that using a coding technique the BER performance can also be improved.

II. PROPOSED SYSTEM MODEL

One frame size in LTE/NR is 10ms. Each frame will be composed of many slots. The number of slots in one frame is fixed in LTE but it will vary according to different numerology in NR. Each slot will carry OFDM symbols (7 symbols for normal CP and 6 symbols for extended CP).

A. Self-interfered symbol generation

Here in figure 1 it is shown that we can take one user's some modulated symbols and using super-imposed coding we can generate one super imposed symbol.

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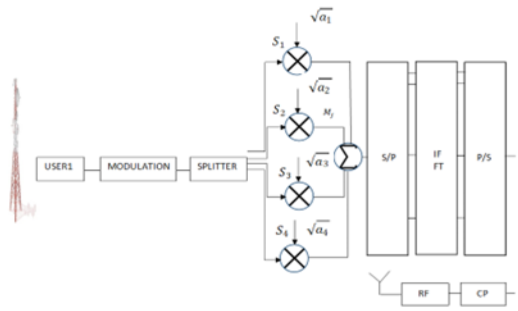


Figure 2. NOMA aided OFDM block without coding.

From figure 2, at first users' information will be modulated. Then we will take four symbols and do superimposed coding to get one self-interfered modulated symbol M_j. If each s_i is QPSK modulated then each M_j will be composed of 8 bits. M_j is one of the modulated symbols for one OFDM symbol block. If we consider 64 FFT then j will vary from 1 to 64.

$$M_j = \sum_{i=1}^{4} \sqrt{a_i} * s_i$$

$a1<a2 < a3<a4$ and $a1 + a2 + a3 + a4 = 1$

At the receiver side after doing IFFT while decoding symbols from M_j we need to eliminate the interference effect. Here we will use SIC for that and will get all four symbols back. According to our model symbol s4 will be decoded first, then s3 and so on.

B. Theoretical Throughput Calculation

Traditional LTE User theoretical throughput:

TP = $\frac{(12*14*n*RB*R)*10^3}{10^6}$ Mbps (1)

NOTE n: modulation order. RB: number of resource block R: Code Rate. 14 is the number of OFDM symbols in one SB (Scheduling Block).

LTE User Throughput through Proposed Model:

TP = $\frac{(12*14*N*RB*R)*10^3}{10^6}$ Mbps (2)

N = bits per modulated symbols* number of symbols grouped.

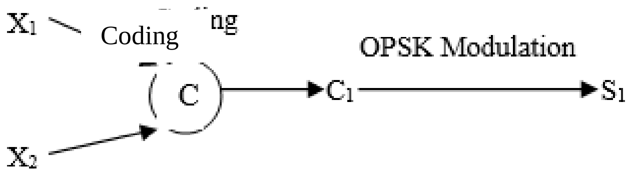
C. Coding to decrease BER

If a special coding technique is used then BER performance can also be improved. Here we will combine binary symbols to generate a special coded symbol which will be modulated. In figure 3, the block diagram for this is shown.

X_1:	0	1	1	0	1
X_2:	1	0	1	1	0
Coded symbol:	2	3	1	2	3

- If data of X_1 is greater than data of X_2, then coded symbol output will be 3.
- If data of X_1 is smaller than of X_2, then coded symbol output will be 2.
- If both data of X_1 and X_2 are same then the same bit will be generated, so it will be either 1 of 0.

This Coding technique is also very useful to decrease BER in multi user NOMA grouping.



Xi: Unmodulated binary data

S_j: modulated symbol

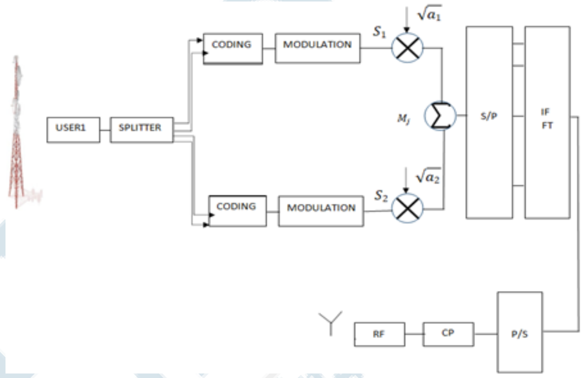


Figure 3. NOMA aided OFDM block with coding.

III. SIMULATION RESULTS

In this section all simulation results for above models are discussed. For modeling we have used Rayleigh Fading channel coefficients with mean 0 and variance 0.5.

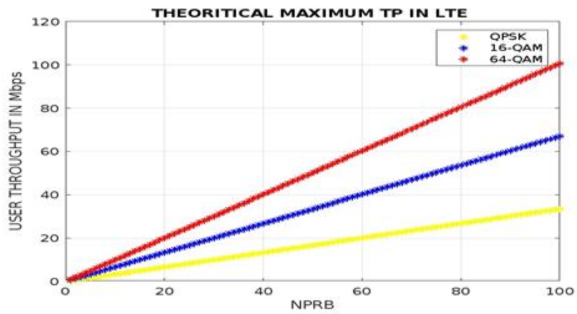


Figure 4. Conventional LTE Throughput

Figure 3 shows how LTE throughput will vary with number of RBs for different modulation order. It is obvious that if we increase modulation order then throughput will increase but the modulation order will depends on channel condition. If we have good channel condition then higher modulation can be done. But if the channel is not good then we have to go for lower order modulation, as a result throughput will decrease.

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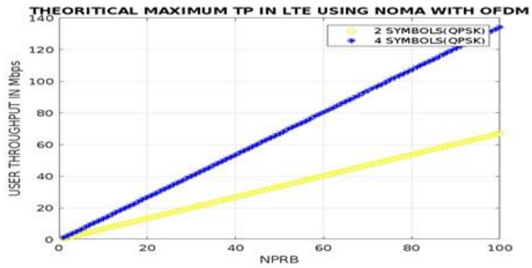

Figure 5. LTE Throughput using proposed model

Figure 4 shows how user Throughput will increase if we use NOMA-OFDM model. This is because in this model we are generating self-interfered superimposed symbol that will act as a RE in OFDM resource grid. Here many modulated symbols are grouped together to make one RE, as a result using one RE we are able to send more number of bits. So we will be able to send more information bits without using more resources.

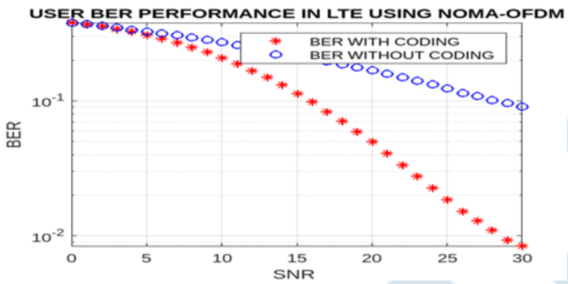

Figure 6. BER Performance with and without coding

From figure 5, it is seen that the proposed model using NOMA-OFDM (For increasing user throughput) will achieve lower BER when we will use coding. This is because of the fact that due to coding symbols are grouped together and for every 2 bits we are generating one symbol and this symbol will be modulated and superimposed with another symbol. Here the overall transmitted bits will remain same. Here we are creating self-interference of coded symbols and eliminating those at receiver end using SIC.

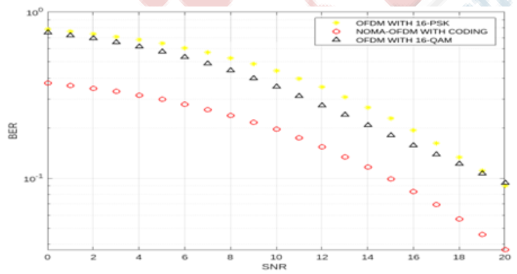

Figure 7. BER Performance with different modulation scheme

Figure 6 shows that our NOMA-OFDM system (for increasing users' throughput) will give lower BER performance when it will be compared with QAM or PSK with same order of modulation. Here in this plot we can see that although all three effectively carrying 4 bits, but our NOMA aided OFDM will show lower BER among those. This is possible only because of grouping of bits.

IV. CONCLUSION

So from simulation results it is clear that the proposed system will give better system performance in terms of throughput, resource utilization and BER. The main objective of this paper is, how users' throughput can be increased without using more resources. For this our work has shown a self-interference technique, using NOMA super imposed coding, of many symbols and those symbols are retrieved back at receiver end using SIC. Note that as it is self-interference, so interference symbols are useful. This model is very useful for poor channel conditions where higher order modulation is not possible but network wants to provide good throughput performance. Further, the BER performance can be also improved using a special coding technique.

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