Comparative Analysis of Non Orthogonal Multiple Access Scheme and OMA

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Abstract—In this paper I compared the spectrum efficiency of OFDM and NOMA for both BPSK and QPSK modulation. On the basis of our simulation results we described the merits and demerits of NOMA scheme over OFDM scheme. In this l compared the BPSK and QPSK modulation schemes and on the basis of results of simulation described the advantages and disadvantages of BPSK over QPSK.

Keywords—LTE; OFDM; fading; bandwidth; radio frame

I. INTRODUCTION

In NOMA scheme a SIC receiver is used for robust multiple access. The SIC receiver may increase the complexity of the receiver because SIC decodes all other users signal along with its own signal which may result in increasing processing delay. Thus, the feasibility of NOMA is depends on the expected evolution of device processing capabilities in the future.

Based on the system-level evaluations, the downlink NOMA with SIC helps to improve the capacity and cell-edge user throughput both irrespective of the frequency-selective CQI availability at the BS. By using basic NOMA using SIC we can improve 30-40% more spectral efficiency than OMA [1]. Error propagation has almost no impact on NOMA performance because NOMA scheduler pairs a UE have high channel gain with a UE have low channel gain. NOMA relies mainly on receiver side CSI and signal processing so that it can provide a good robustness to mobility.

The another approach to improve the capacity and throughput gain of NOMA is to combine the NOMA with MIMO system by applying random beam forming to transform the MIMO channel to a SIMO channel. In this system multiple beams are generated by BS and multiple users are superposed in each beam. At SIC receiver two interference cancellation processes is done. First one is Interference Rejection Combining (IRC) used for inter-beam interference cancellation (i.e., interference cancellation among the UEs with different beam) and another one is SIC used for intra-beam interference cancellation (i.e., interference cancellation among the UEs within the same beam). In this case because of IRC we have no need to decode different channel gains [2].

NOMA is a multiplexing scheme that utilizes an additional new domain, i.e., the power domain, which is not sufficiently utilized in previous systems like FDMA, TDMA, CDMA, OFDMA etc. Non-orthogonality is intentionally introduced in terms of power-domain user multiplexing. The UE (User Equipment) has high channel gain is allocated less power and the UE has low channel gain is allocated more power. These large power differences play very important role in successful decoding and thus successful cancellation of the interference at the user with high channel gain. So the NOMA technology is a promising choice to tackle the future challenges towards currently being increase in mobile traffic & also in the next decade for 5G wireless network.

II COMPARISON BETWEEN OMA AND NOMA

We are comparing here OFDMA as the OMA scheme and NOMA scheme. In OFDMA there are different subcarriers used for the data transmission of different users while in NOMA all the subcarriers are used by each user because of all users have different power levels of the signals which is the basis of differentiating the signals in the system. We can see the difference between both schemes in fig. below.

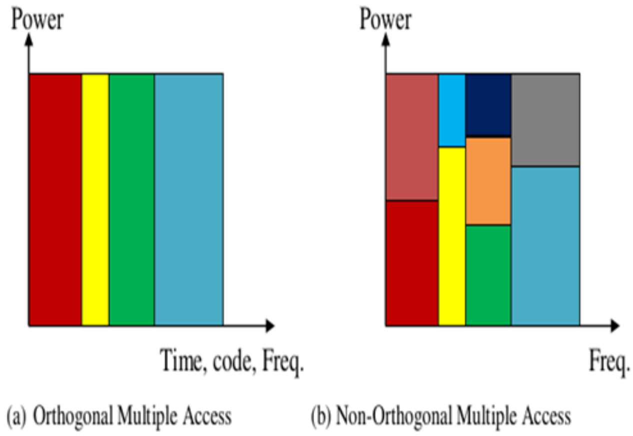


Fig.1 Difference between OMA and NOMA

In the NOMA scheme we use the power domain for differentiating the data of users while the differentiation of data in previous generations relying on the time/frequency/code domain. Spectral efficiency of this OMA scheme is low when some bandwidth resources i.e. subcarriers channel are allocated to the users have poor channel condition while in NONA each user uses the all subcarrier channels and hence the users have strong channel conditions will also access the bandwidth resources allocated to the users with poor channel conditions, which significantly improves the spectral efficiency [6]. Compared to the traditional orthogonal multiple access (OMA), non-orthogonal multiple access (NOMA) technology can achieve higher spectrum efficiency and support more massive connectivity [11].

The conventional OMA system serves the users only have strong channel conditions while the NOMA system serves the users with different channel conditions in a timely manner, hence NOMA strikes a good balance between system throughput and user fairness which satisfy the demands of 5G system in terms of ultra-low latency and ultra-high connectivity.

User fairness in terms of SIC in the NOMA system is that the user have high channel gain allocated lowest power while the user have low channel gain allocated highest power, the user with strong channel condition decodes all the signal, consider all other user's signal as an interference and subtract it from the total signal to get the desired signal. The users with channel gains between high & low have no need to decode and suppress the signals who have high channel gain, they will decode the its own signal along with all user's signal who have channel gain below its own channel gain and consider the signal of other users as the interference and subtract it from the total received signal, in this way the user have lowest channel gain has no interference signal from any of the users and hence no need to suppress the signal and it will automatically get its own signal via the process of SIC. The fig. below shows the process of SIC at the receiver site.

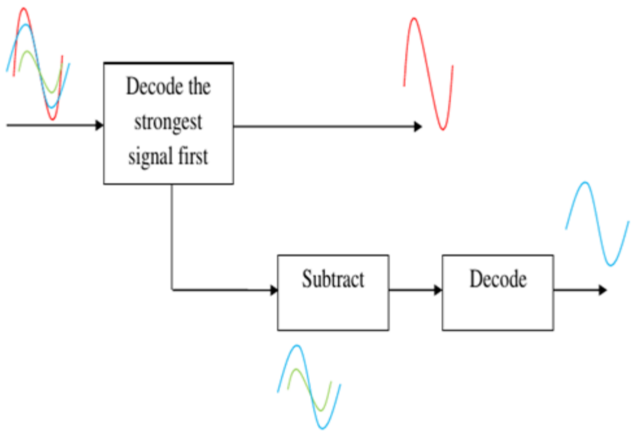


Fig. 2 SIC Process at the Receiver Side

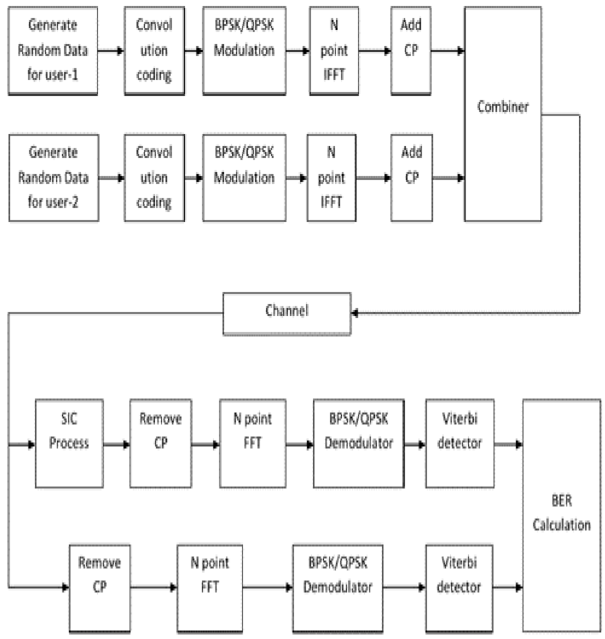


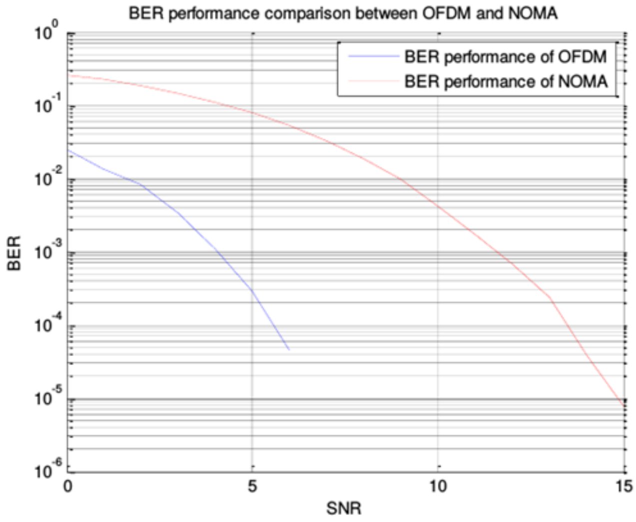
Fig.3

VI. RESULTS AND THEIR ANALYSIS

Parameters	Values
Size of FFT (nFFT)	64
Number of Channels	52
Number of Pilot	12
Number of Symbols	1000
Coding rate	1/2
Number of Samples in CP	16
OFDM Symbol Size	80

Here I compare the NOMA and OFDM scheme as in terms of their performance and spectral efficiency.

Fig. 4 Performance Comparison between OFDM and NOMA with BPSK



In fig.4 The performance comparison of OFDM and NOMA is shown with BPSK. The performance is weak in NOMA as compared to OFDM because in NOMA technique there are two users which are simultaneously using the same frequency resource so that there are effect of interference also from the another user to each user in addition to noise so that the performance of NOMA is poor as compared to OFDM.

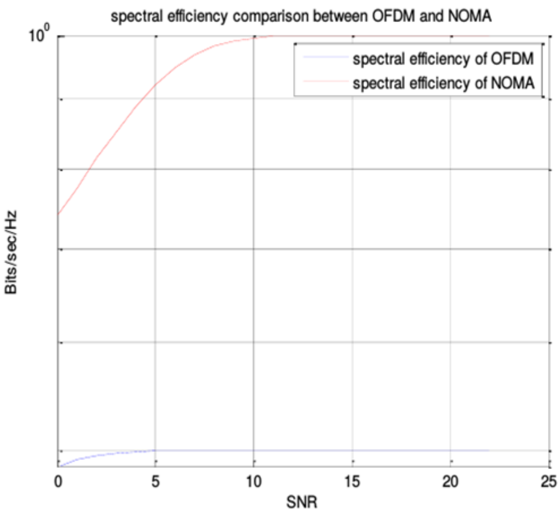


Fig.5 Spectral Efficiency Comparison between OFDM and NOMA with BPSK

If we see the spectral efficiencies of these two systems, the number of users in NOMA is double at the same frequency but only single user is served in the OFDM, so that the spectral efficiency is double in NOMA as compared to OFDM which we can see in the fig. that is the spectral efficiency of OFDM system with BPSK is 0.5 bits/sec/Hz while the spectral efficiency of NOMA system is 1 bits/sec/Hz which is twice of OFDM system.

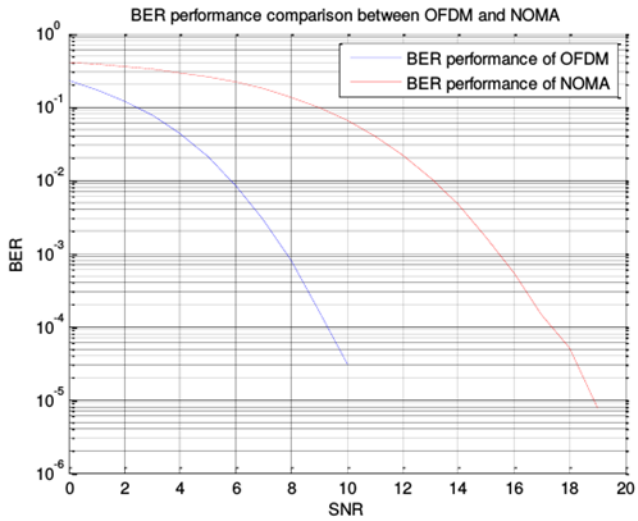


Fig.6 Performance Comparison between OFDM and NOMA with QPSK

Now, we are comparing the performance of OFDM and NOMA system with QPSK modulation.

As shown in fig. we can see that the performance of OFDM system is better than the performance of NOMA for QPSK also. The reason is same as the above which we discussed with BPSK scheme. However we can also see that in this fig that the performance is decreased in both OFDM and NOMA with QPSK as compared to BPSK because the QPSK has less phase margin so that BER of QPSK is greater than the BPSK which decrease the performance of both systems with QPSK modulation.

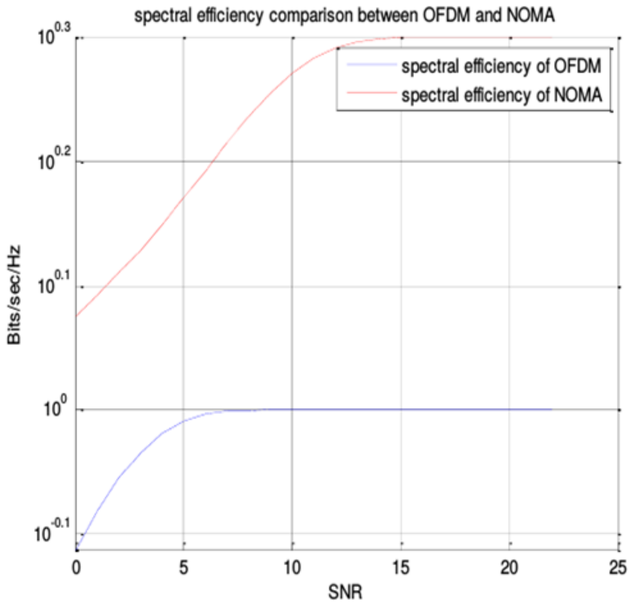


Fig.7 Spectral Efficiency Comparison between OFDM and NOMA with QPSK

Next, we are going to compare the spectral efficiencies of OFDM and NOMA systems with QPSK modulation. We can see in fig. that QPSK modulation the spectral efficiency of spectral efficiency of NOMA is twice the spectral efficiency of the OFDM. The spectral efficiency of OFDM system is 1 bits/sec/Hz while the spectral efficiency of NOMA system is 2 bits/sec/Hz. The reason is same as we discussed in comparison of OFDM and NOMA with BPSK system.

VII. C ONCLUSION

We also compared the performance of OFDM system with NOMA system in both modulation schemes BPSK and QPSK. We can see that performance wise the NOMA is poor than the OFDM because in OFDM we have only single user and the whole bandwidth is occupied by only that user that's why in OFDM system there is no effect of interference while in NOMA we are serving the two users in the same bandwidth resource so that there is interference also from other user to each user in addition to noise on both user so that the probability of error and BER is more in NOMA than the OFDM system. Hence the performance is poor in NOMA as compared to OFDM with both modulation schemes BPSK and QPSK. On comparing the spectral efficiency of OFDM and NOMA system with both modulations BPSK and QPSK, we can see in NOMA we are serving two users with same bandwidth resource while in OFDM we can serve only one user for a particular band of frequencies so that the spectrum efficiency is better in NOMA because we are using the band efficiently by introducing a new domain i.e. power domain to differentiate the signals of UEs. In my simulation results the spectrum efficiency of NOMA is double of that the BPSK in both case BPSK as well as QPSK because we are serving 2 users at the same frequencies of band, if we will serve 3 users in NOMA scheme then the spectrum efficiency will improve 3 times of OFDM system and so on.

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