A Resource Allocation in Non-Orthogonal Multiple Access System with Proportional Rate Constraint

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Abstract : Non-orthogonal multiple access (NOMA) is a promising applicant innovation for 5G cell systems. Non-orthogonal multiple access (NOMA) has attracted a lot of attention recently due to its superior spectral efficiency and could play a vital role in improving the capacity of future networks. This paper presents resource allocation in terms of number of user, sum rate and transmission power. Simulation is done in MATLAB software and results shows that proposed resource allocation is better than OFDM and existing NOMA.

***IndexTerms* - OMA, NOMA, OFDM, MATLAB, 5G.**

I. INTRODUCTION

Conventional mobile communications systems are moving towards faster digital wireless technologies based on advances in semiconductor devices as described below. The first generation (1G) used Frequency Division Multiple Access (FDMA), the second generation (2G) used Time Division Multiple Access (TDMA), the third generation (3G) is using Code Division Multiple Access (CDMA), and the 3.9G and fourth (4G) generations are using Orthogonal Frequency Division Multiple Access (OFDMA) supporting efficient frequency usage and good resistance to fading. The proposals for 5G systems aim to increase spectrum efficiency even further by speeding-up existing technologies, using newly opened frequency bands, and increasing network density, and support for the expected required conditions is being examined. The non-orthogonal multiple-access (NOMA) and higher-order multiple-input and multiple-output (MIMO) technologies described in this work require huge processing power to implement these functions, which will be difficult to achieve using the performance of conventional semiconductor devices. Rapid developments in CPU processing power are expected to be a key element in deployment of 5G services.

Multiple accesses is a basic function of cellular systems, which are usually divided into two types: orthogonal and non-orthogonal. In orthogonal access systems such as TDMA, FDMA, and OFDMA, signals for different users are orthogonal to each other. On the other hand, in non-orthogonal access systems, such as CDMA, TCMA (Trellis Coded Multiple Access), IDMA (Interleave Division Multiple Access), the cross-correlation of signals for different users is not 0. The commonly used NOMA incorporates the above-described non-orthogonal multiple access but this section discusses a specified NOMA implementation for 5G systems. NOMA under discussion for 5G systems has a new extension of the user multiplex domain to improve the spectrum efficiency. Intentionally introducing non-orthogonality aims to increase the spectrum efficiency further. As a result, technologies such as new encodings and an interference canceller are required to correct the non-orthogonality, which has been considered difficult to implement until now. However, development is pushing forward with the expectation of introduction as key 5G technology following recent remarkable improvements in CPU performance. NOMA can be classified into three different user multiplex domains: NOMA with SIC (Successive Interference Canceler)/SOMA (Semi-orthogonal Multiple Access), SCMA (Sparse Code Multiple Access), and IDMA (Interleave Division Multiple Access).

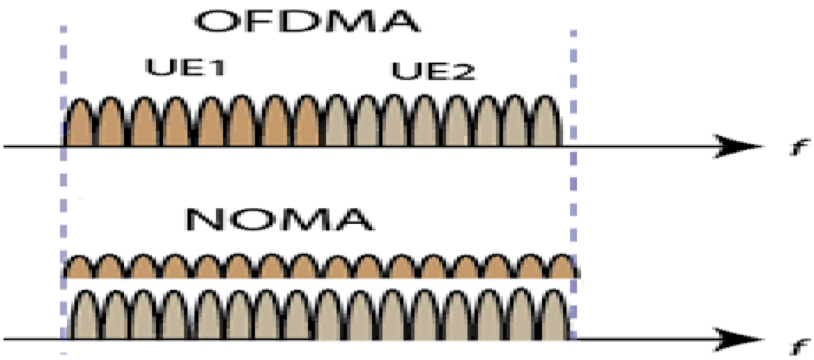

Figure 1: Non orthogonal multiple access

In addition to the conventional frequency and time domains, these schemes aim to increase the spectrum efficiency by multiplexing the user in the power domain for NOMA with SIC/SOMA, in the power and code domains for SCMA, and in the code domain for IDMA. The follow sections explain the characteristics and principles of each of these schemes.

II. OFDM-MIMO IN WIRELESS COMMUNICATION

MIMO innovation has as of late risen as another worldview to accomplish exceptionally high transmission capacity efficiencies and enormous information rates in present day remote interchanges. Traditional MIMO is a cell remote innovation which empowers the utilization of multiple transmitting and getting recieving wires to move more information in less time. A MIMO direct is executed in a remote connection between M transmits and N get recieving wires. It comprises of M x N components that speak to the MIMO channel coefficients. NOMA is to utilize the power space for multiple accesses, though the past generations of mobile systems have been depending on the time/frequency/code area. Take the traditional orthogonal frequency-division multiple access (OFDMA) utilized by 3GPP-LTE for instance. A primary issue with this orthogonal multiple access (OMA) strategy is that its spectral efficiency is low when some transmission capacity assets, for example, subcarrier channels, are dispensed to clients with poor channel state data (CSI).

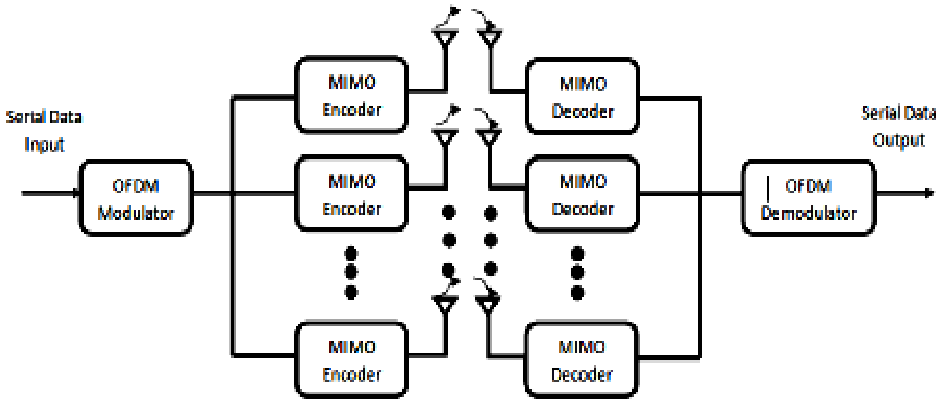

Figure 2: MIMO- OFDM in 4G LTE

Then again, the utilization of NOMA empowers every client to approach all the subcarrier channels, and thus the data transfer capacity assets allotted to the clients with poor CSI can in any case be accessed by the clients with solid CSI, which fundamentally improves the spectral efficiency. non-orthogonal multiple access (NOMA) has been as of late proposed for 3GPP Long Term Evolution (LTE) and imagined to be a fundamental segment of fifth generation (5G) mobile systems. The key component of NOMA is to serve multiple clients simultaneously/frequency/code, yet with various power levels, which yields a critical spectral efficiency increase over customary orthogonal Mama. This article gives a systematic treatment of this recently rising innovation, from its mix with multiple-input multiple-output (MIMO) advances, to helpful NOMA, just as the exchange among NOMA and subjective radio.

Presently the idea of non-orthogonal multiple access (NOMA) technique for the up and coming 5G systems. The majority of the current cell systems actualize orthogonal multiple access (OMA) methods, for example, time division multiple access (TDMA), frequency division multiple access (FDMA) or code division multiple access (CDMA) together. Be that as it may, none of these methods can fulfill the high needs of future radio access systems.

A. NOMA IN 5G COMMUNICATIONS

The qualities of the OMA plans can be abridged as pursues. In TDMA, the data for every client is sent in non-covering availabilities, so that TDMA-based systems require exact planning synchronization, which can be testing, especially in the uplink. In FDMA usage, for example, orthogonal frequency division multiple accesses (OFDMA), data for every client is doled out to a subset of subcarriers. CDMA uses codes so as to isolate the clients over a similar channel. NOMA is on a very basic level not the same as these multiple access plans which give orthogonal access to the clients either in time, frequency, code or space. In NOMA, every client works in a similar band and simultaneously where they are recognized by their capacity levels. NOMA utilizes superposition coding at the transmitter with the end goal that the progressive obstruction crossing out (SIC) recipient can isolate the clients both in the uplink and in the downlink channels.

NOMA was proposed as an applicant radio access innovation for 5G cell systems. Reasonable usage of NOMA in cell systems requires high computational capacity to execute constant power assignment and progressive impedance retraction calculations. By 2020, the time that 5G systems are focused to be conveyed, the computational limit of the two handsets and access focuses is required to high enough to run NOMA algorithms.

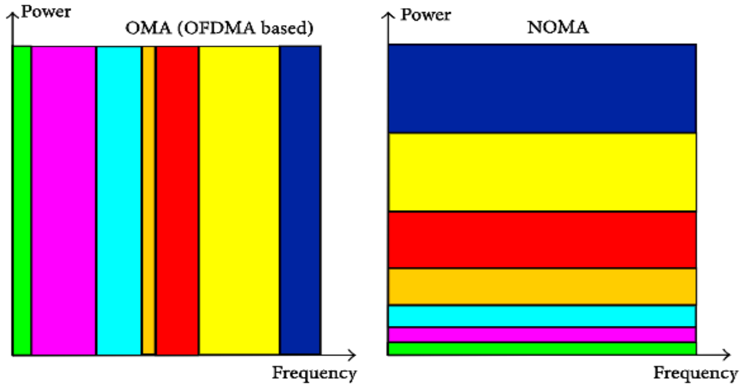

Figure 3: A pictorial comparison of OMA and NOMA

In other words, the insufficient performance of OMA makes it inapplicable and unsuitable to provide the features needed to be met by the future generations of wireless communication systems. Consequently, researchers suggest NOMA as a strong candidate as an MA technique for next generations [32]. Although NOMA has many features that may support next generations, it has some limitations that should be addressed in order to exploit its full advantage set. Those limitations can be pointed out as follows. In NOMA, since each user requires decoding the signals of some users before decoding its own signal, the receiver computational complexity will be increased when compared to OMA, leading to a longer delay. Moreover, information of channel gains of all users should be fed back to the base station (BS), but these results in significant channel state information (CSI) feedback overhead. Furthermore, if any errors occur during SIC processes at any user, then the error probability of successive decoding will be increased. As a result, the number of users should be reduced to avoid such error propagation. Another reason for restricting the number of users is that considerable channel gain differences among users with different channel conditions are needed to have a better network performance.

III. PROPOSED APPROACH

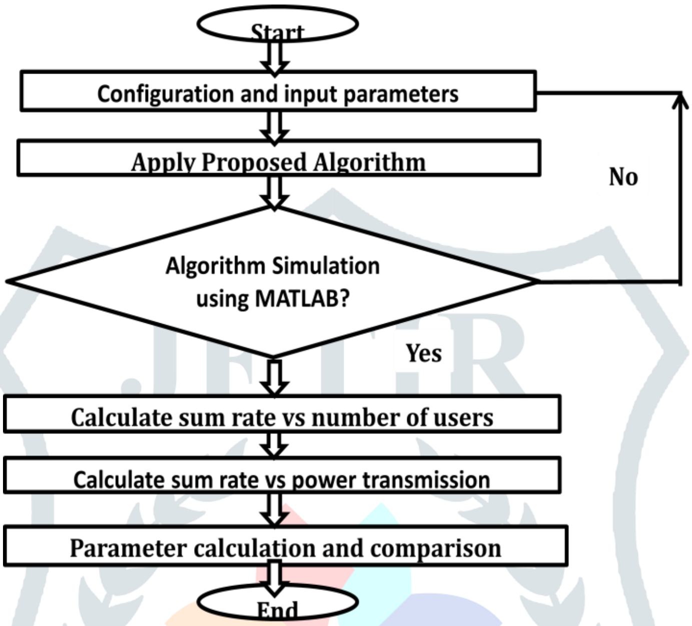

Figure 4: Flow Chart

Figure 4 is showing flow chart of proposed work. In which after applying proposed algorithm calculate sum rate vs power and sum rate vs number of users. The optimization problem is first formulated to maximize the sum rate of the two-user NOMA system, and the solution is then generalized to the multi-user case. In order to guarantee that each user is able to achieve its target data rate, the optimization will include nonlinear constraints of proportional fairness. It is important to point out that by using the proportional fairness constraint, once the minimum rates for all users are satisfied, the remaining resources will also be allocated in a proportional manner. Such approach is important to maintain fairness in distributing the radio resources among these users and to ensure that the weak users have enough power to decode their own data from the received signal while treating the stronger users as noise, and to ensure that the stronger users have enough power to apply SIC and cancel the effect of the weak users and detect their own data.

$$P_{RB} = P_s^{(L)} + P_s^{(H)} = \frac{P_t}{S}.$$

Without this constraint, the maximum sum rate could simply be achieved by allocating all the bandwidth and power to one user or a few users who have the best channel conditions and not all users will be allowed to transmit. In addition, another important property of this constraint is that it can utilize the potential advantage of NOMA over OMA. The minimum rate requirement is assigned to each user based on the large scale fading factor (the distance based path loss and the Log-normal shadowing factor) experienced by that user in addition to the small scale fading effects. Since path loss and shadowing is more dominant and vary slowly, the proportionality constraint is therefore effectively more long term rather than short term.

$$P_s^{(H)} = -\frac{\left(|h_s^{(H)}|^2 + |h_s^{(L)}|^2\right) B_s N_0}{2|h_s^{(H)}|^2 |h_s^{(L)}|^2} + \frac{\psi_3 \sqrt{B_s N_0}}{2|h_s^{(H)}|^2 |h_s^{(L)}|^2 \sqrt{\Gamma_1}}$$

Solving the formulated problem in to requires a numerical solution or some iterative algorithm for suboptimal solution. Therefore, we first propose a low complexity sub-optimal approach that allocates the power equally among all the RBs. In other words, the total transmission power in each RB is set to be Using this assumption along with the optimization steps that are depicted in Appendix A, the sub-optimal power for the strong user is found to be

$$P_s^{(L)} = \frac{2|h_s^{(H)}|^2 |h_s^{(L)}|^2 P_{RB} + \left(|h_s^{(H)}|^2 + |h_s^{(L)}|^2\right) B_s N_0}{2|h_s^{(H)}|^2 |h_s^{(L)}|^2} - \frac{\psi_3 \sqrt{B_s N_0}}{2|h_s^{(H)}|^2 |h_s^{(L)}|^2 \sqrt{\Gamma_1}}$$

It is worth mentioning that the superscripts and are included just to distinguish the parameters of the users with the better channel gain from those with weaker channel gains at the selected RB and not over all RBs. It also does not necessarily mean that is higher than, where it could be less than or equal to depending on the final values from the proposed closed form solutions.

IV. SIMULATION RESULT

Proposed work is simulated using MATLAB environment. Input parameter which is taken to implementation is following.

Table 1: Input Parameters

Sr. No.	Parameter	Value
1	Cell Diameter (D)	300
2	Path loss Exponent (v)	3
3	Noise Power Density (N0)	-174
4	Total Bandwidth (WT)	5
5	No. of RBs (S)	25
6	Bandwidth per RB (Bs)	200
7	No. of subcarriers per RB(Nc)	12

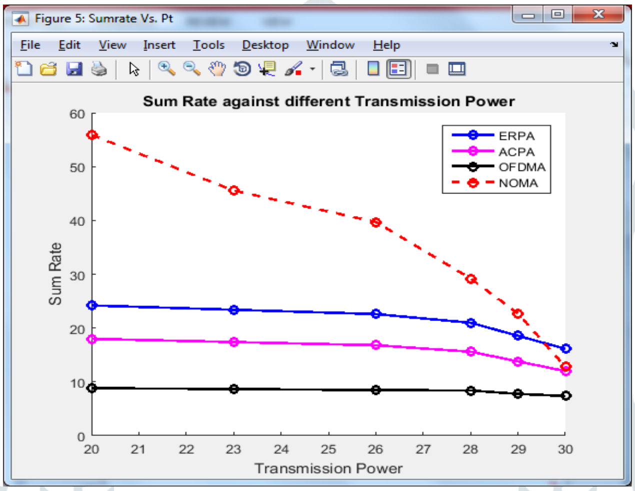

Figure 5: Transmission power vs sum rate

Figure 5 presenting transmission power and sum rate of existing approaches and NOMA. It is clear that NOMA gives significant better performance than previous.

Table 2: Simulation Parameter-I

Sr. No	Approach	Transmission Power	Sum Rate
1	ERPA	30	10
2	ACPA	30	18
3	OFDMA	30	25
4	Proposed NOMA	30	58

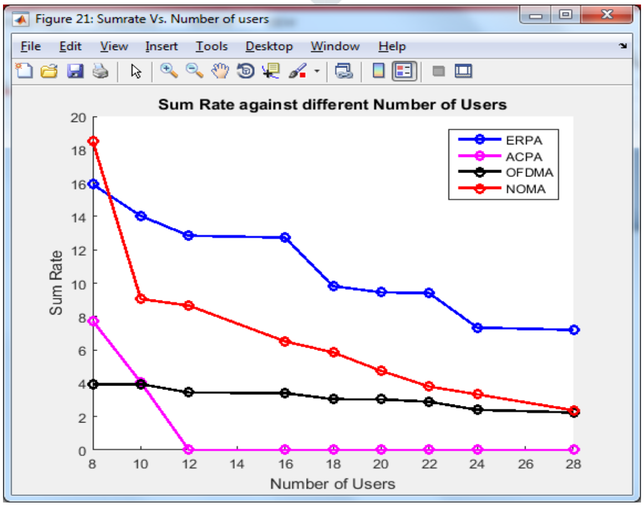

Figure 6: Number of users vs sum rate

Figure 6 presenting number of users and sum rate of existing approaches and NOMA. It is clear that NOMA gives significant better performance than previous.

Table 3: Simulation Parameter-II

Sr. No	Approach	No of users	Sum Rate
1	ERPA	28	4
2	ACPA	28	8
3	OFDMA	28	16
4	Proposed NOMA	28	19

V. CONCLUSION

Thus the Resource Block was allocated using the NOMA algorithm of RBs allocation and classification algorithm. Due to this algorithm the power consumption gets reduced and the sum rate against the Transmission Power was increased. Two sub-optimal power allocation methods have been proposed to allocate the transmission power to each user in a two-user scenario. In addition, to optimize the sum rate for a large number of users, the proposed techniques are extended to a multi-user scenario by the vertical pairing concept. Simulation results show that NOMA provides better performance than OFDMA. In future this process will be extended to analysis of real time value with reduction of Signal to Noise Ratio with the Resource Block algorithm and Classification algorithm.

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