Non-Orthogonal and Hybrid Multiple Access System for Resource Allocation in 5G Visible Light Communication

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Abstract : The demands of the forthcoming fifth-generation (5G) communication system are expected to achieve 1,000 times the system capacity and 10 times the spectral efficiency of fourth-generation (4G) networks. 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. For an efficient use of the available spectrum, several Non-Orthogonal Multiple Access (NOMA) schemes are under evaluation for 5th Generation (5G) of visible light communication systems requirements. This paper presents NOMA, hybrid and various techniques to resource allocation in terms of transmission power, number of user, and sum rate. Simulation is done in MATLAB 8.3 software.

***IndexTerms* - NOMA, VLC, 5G, Resource, Spectrum, Power, MATLAB.**

I. Introduction

Wireless communication, or sometimes simply wireless, is the transfer of information or power between two or more points that are not connected by an electrical conductor. The most common wireless technologies use radio waves. With radio waves distances can be short, such as a few meters for Bluetooth or as far as millions of kilometers for deep-space radio communications. Visible light communication (VLC) is a data communications variant which uses visible light between 400 and 800 THz (780–375 nm). VLC is a subset of optical wireless communications technologies.The technology uses fluorescent lamps (ordinary lamps, not special communications devices) to transmit signals at 10 kbit/s, or LEDs for up to 500 Mbit/s over short distances. Systems such as RONJA can transmit at full Ethernet speed (10 Mbit/s) over distances of 1–2 kilometres (0.6–1.2 mi).

This paper investigates the resource allocation problem for downlink multi-user NOMA system. An optimization problem is formulated to maximize the sum rate under the total transmit power and proportional minimum user rate constraints. Considering the proportional rate constraint is a key contribution of our work and differentiates us from existing resource allocation methods for NOMA. Not only does this constraint ensure fairness between users, it is crucial in NOMA. Firstly for NOMA, the weaker users will have to detect their signals by treating the stronger users as interferers.

The stronger users will also need to detect the weaker users' signals first and remove them before they detect their own signals. In practice, this requires sufficient power allocated to the weaker users for such detection to be successful. This can be achieved by a proportional rate constraint. Secondly, ac-cording to the rate boundary of NOMA, NOMA achieves the highest performance gain over orthogonal multiple access (OMA) when the weaker users achieve a good rate. Therefore, simply achieving a high rate for the stronger users as in conventional minimum rate constraints will not fully utilize the potential of NOMA and may also be impractical. Thus, we considered proportional fairness constraint in our work. We first derive two closed-form sub-optimal solutions for a two-user case as obtaining the optimal solution for NOMA requires high complexity numerical operations. The closed-form solution is shown to achieve performance that is close to the optimal one and better performance than all existing techniques. However, the solution is restricted to two users only.

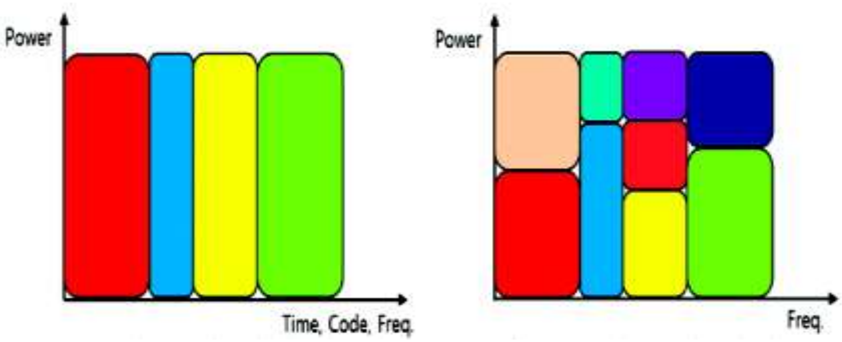

Figure 1: (a) Orthogonal multiple access (b) Non-orthogonal multiple access

II. Background

Z. Tahira, et al., [1] In visible light communication (VLC), the data is transmitted by modulating the light emitting diode (LED). The data-rate is throttled by the narrow modulation bandwidth of LEDs, which becomes a barrier for attaining high transmission rates. Non-orthogonal multiple access (NOMA) is a new scheme envisioned to improve the system capacity. In addition to multiple access schemes, optimization techniques are applied to further improve the data rate. In this letter, convex optimization is applied to

NOMA-based VLC system for downlink. The proposed optimization system is analyzed in terms of the bit error rate (BER) and the sum-rate.

Z. Yang et al., [2] This letter investigates joint power control and user clustering for downlink nonorthogonal multiple access systems. Our aim is to minimize the total power consumption by taking into account not only the conventional transmission power but also the decoding power of the users. To solve this optimization problem, it is firstly transformed into an equivalent problem with tractable constraints. Then, an efficient algorithm is proposed to tackle the equivalent problem by using the techniques of reweighted ℓ_1-norm minimization and majorization-minimization. Numerical results validate the superiority of the proposed algorithm over the conventional algorithms including the popular matching-based algorithm.

J. Cui et al., [3] This work investigates the application of non-orthogonal multiple access (NOMA) in millimeter wave (mm-Wave) communications by exploiting beamforming, user scheduling, and power allocation. Random beamforming is invoked for reducing the feedback overhead of the considered system. A non-convex optimization problem for maximizing the sum rate is formulated, which is proved to be NP-hard. The branch and bound approach is invoked to obtain the ϵ-optimal power allocation policy, which is proved to converge to a global optimal solution.

Z. Q. Al-Abbasi et al., [4] Non-orthogonal multiple access (NOMA), which has attracted a lot of attention recently due to its superior spectral efficiency, could play a vital role in improving the capacity of future networks. In this work,a resource allocation scheme is developed for a downlink multi-user NOMA system. An optimization problem is formulated to maximize the sum rate under the total power and proportional rate constraints. Due to the complexity of computing the optimal solution, it is develop a low complexity sub-optimal solution for a two-user scenario and then extend it to the multi-user case by proposing a user-pairing approach as well as a number of power allocation techniques that facilitate dealing with a large number of users in NOMA system. Simulation results support the effectiveness of the proposed approaches and show the close performance to the optimal one.

S. K. Zaidi et al., [5] In a conventional Cooperative Non Orthogonal Multiple Access (NOMA) scheme, only one user from the NOMA pair acts as a relay and forwards information to the other user. In this work,we aim to introduce NOMA-based relaying to extend the coverage of the source and serve the remote devices in out-of-coverage area. This extension in coverage is supported by powering the relays wirelessly with the help of simultaneous energy transfer so that the relays can self-sustain within the network without utilising their individual power. The proposed results confirm that this scheme successfully utilises wireless-powered NOMA relays in delivering the information of the source to remotely located users.

T. A. Zewde et al., [6] In this work, study the performance of non-orthogonal multiple access (NOMA) scheme in wireless-powered communication networks (WPCN) focusing on the system energy efficiency. it is consider multiple energy-harvesting user equipments (UEs) that operate based on harvest-then-transmit protocol. The uplink information transfer is carried out by using power-domain multiplexing, and the receiver decodes each UE's data in such a way that the UE with the best channel gain is decoded without interference. In order to determine optimal resource allocation strategies, it is formulate optimization problems considering two models, namely half-duplex operation and asynchronous transmission, based on how downlink and uplink operations are coordinated.

J. Dommel et al., [7] Sparse-spreading based non-orthogonal multiple access is considered to be a key component to support massive connectivity and increased capacity for future wireless communication systems. Since multiple users are co-scheduled on the same physical resources, power allocation cannot be optimized independently per user but also has to consider the assignment of resources between different users. This accounts specifically in the downlink, where the sum power constraint holds. In this work,we propose a heuristic approach for power allocation in a downlink system using multi-user sparse coded multiple access.

Q. Li, et al., [8] In this work,a two-user multiple-input multiple-output non-orthogonal multiple access (MIMO-NOMA) network is analyzed. A joint antenna selection (JAS) scheme, which determines the best transmit antenna at the source node and the optimal antenna at the two users is proposed to minimize the outage probability. The exact expression for the outage probability is derived in closed-form. Meanwhile, the asymptotic outage expression in high signal-to-noise ratio (SNR) regime is also obtained to illustrate the diversity order of the proposed JAS scheme.

M. S. Ali et al., [9] propose a low-complexity sub-optimal user grouping scheme. The proposed scheme exploits the channel gain differences among users in an NOMA cluster and groups them into a single cluster or multiple clusters in order to enhance the sum-throughput of the system. For a given set of NOMA clusters, it is then derive the optimal power allocation policy that maximizes the sum-throughput per NOMA cluster and in turn maximizes the overall system throughput. Using Karush-Kuhn-Tucker optimality conditions, closed-form solutions for optimal power allocations are derived for any cluster size, considering both uplink and downlink NOMA systems. Numerical results compare the performances of NOMA and OMA and illustrate the significance of NOMA in various network scenarios.

G. Ansari et al., [10] shows the combination of MIMO technology with OFDM system, there is enhancement of wireless digital communication which is quite beneficial for future communicating system. MIMO-OFDM improves the efficiency and quality of the wireless scenario. With efficient channel estimation technique especially non-blind under MIMO-OFDM scenario present an enhanced performance with low complexity.

III. PROPOSED METHODOLOGY

In this process, investigate the resource allocation problem for downlink multi-user NOMA system. An optimization problem is formulated to maximize the sum rate under the total transmit power and proportional minimum user rate constraints. Considering the proportional rate constraint is a key contribution of our work and differentiates us from existing resource allocation methods for NOMA. Not only does this constraint ensure fairness between users, it is crucial in NOMA. Firstly for NOMA, the weaker users will have to detect their signals by treating the stronger users as interferers. The stronger users will also need to detect the weaker users' signals first and remove them before they detect their own signals. In practice, this requires sufficient power allocated to the weaker users for such detection to be successful. This can be achieved by a proportional rate constraint. Secondly, ac-cording to the rate boundary of NOMA, NOMA achieves the highest performance gain over orthogonal multiple access (OMA).

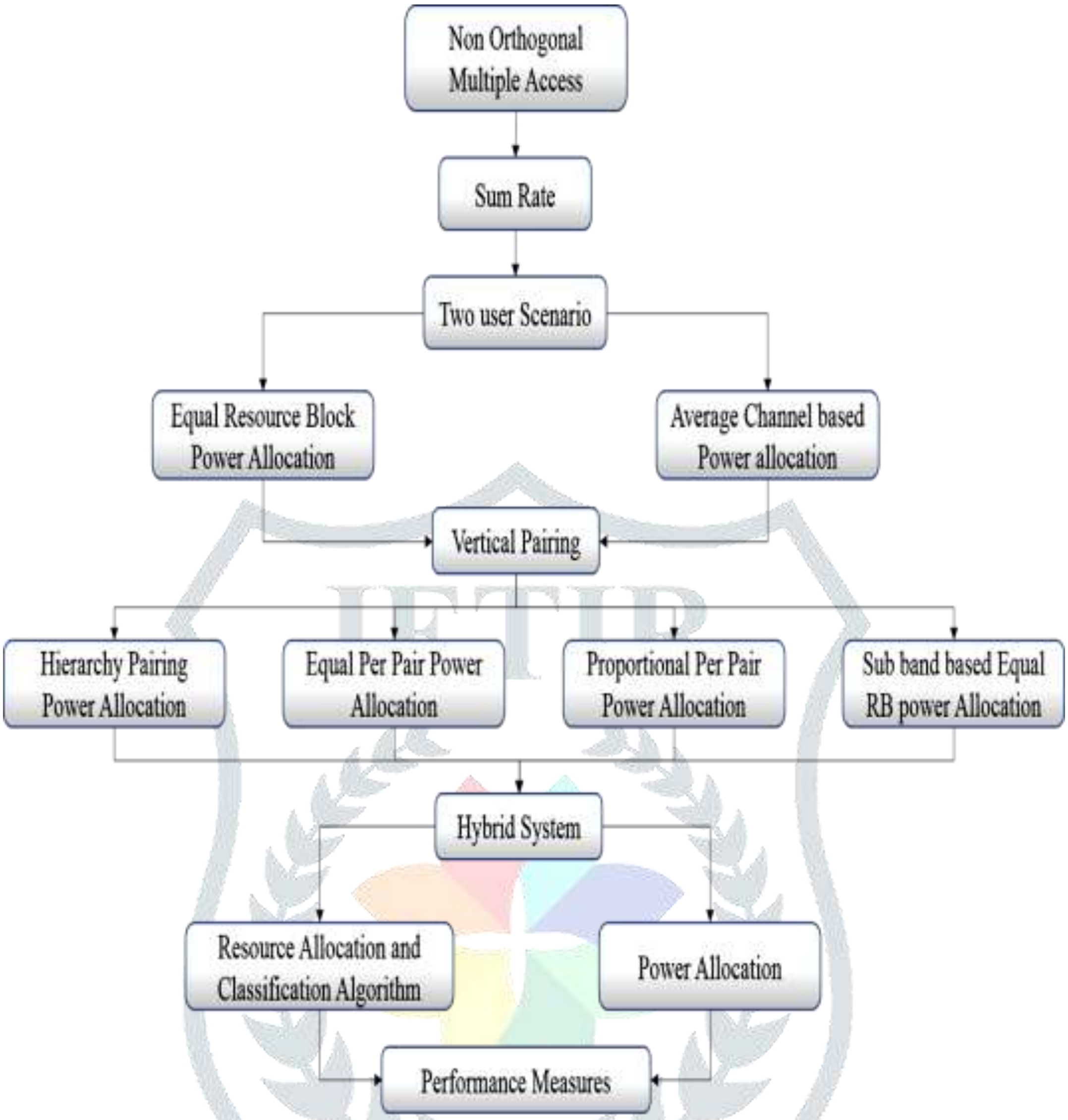

Figure 2: Flow Chart

When the weaker users achieve a good rate, therefore, simply achieving a high rate for the stronger users as in conventional minimum rate constraints will not fully utilize the potential of NOMA and may also be impractical. Thus, we considered proportional fairness constraint in our work. We first derive two closed-form sub-optimal solutions for a two-user case as obtaining the optimal solution for NOMA requires high complexity numerical operations. The closed-form solution is shown to achieve performance that is close to the optimal one and better performance than all existing techniques. However, the solution is restricted to two users only. We then extend the obtained solution for a larger number of users by proposing a sub band-based approach whereby two users are multiplexed into each sub band. However, splitting the whole bandwidth into sub bands cannot fully utilize the potential of NOMA, where the entire bandwidth can be occupied by all users.

Thus, we propose a vertical pairing concept where users are grouped in pairs and allowed to occupy the entire bandwidth. The pairs are then multiplexed in the power domain using a modified solution from the obtained two-user sub-optimal one. Moreover, a low complexity power allocation scheme is proposed that allocates power to each resource block (RB) in proportion to the sum of channel power of all multiplexed users. This facilitates the sum rate optimization of NOMA with a large number of users. In addition, this process discusses the idea of hybrid multiple access, which represents a combination between NOMA and OFDMA, as a good candidate for the next generation wireless networks. Simulation results are provided to confirm the superiority of the proposed NOMA-power allocation schemes over the existing ones, as well as the superiority of the proposed hybrid multiple access scheme over conventional NOMA.

IV. SIMULATION RESULTS

Proposed work is simulated using MATLAB environment. Communication tool box is using to make and design the proposed algorithm-

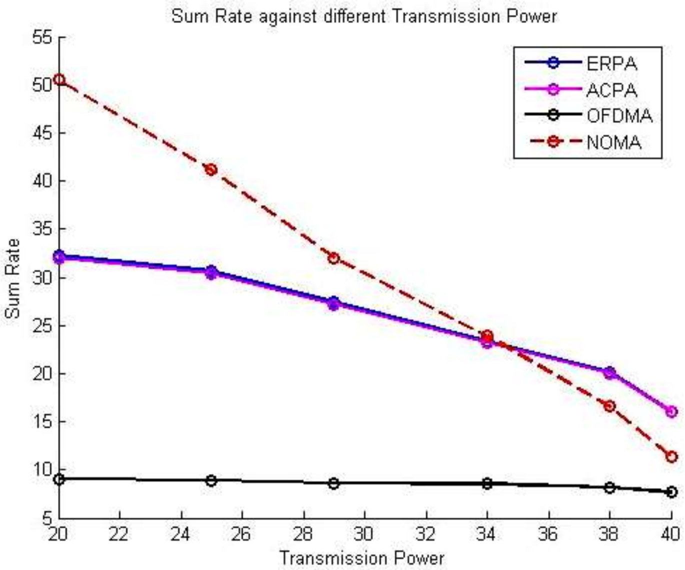

Figure 3: Sum rate against different transmission power

Figure 3 is showing the sum rate value against the transmission power. Here total 40 dbm power uses the service as primary and secondary users. Therefore maximum sum rate is 52 in case of NOMA technique.

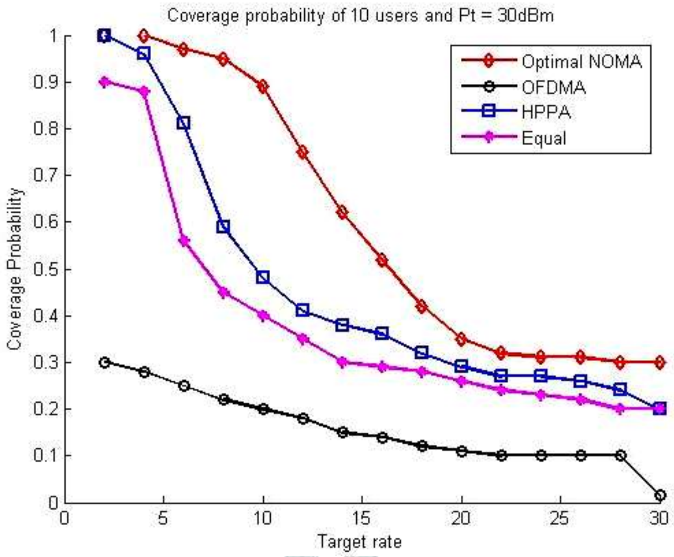

Figure 4: Coverage probability

Figure 4 is showing the coverage probability of all the techniques. So the optimal NOMA has the maximum coverage probability rather than other technique.

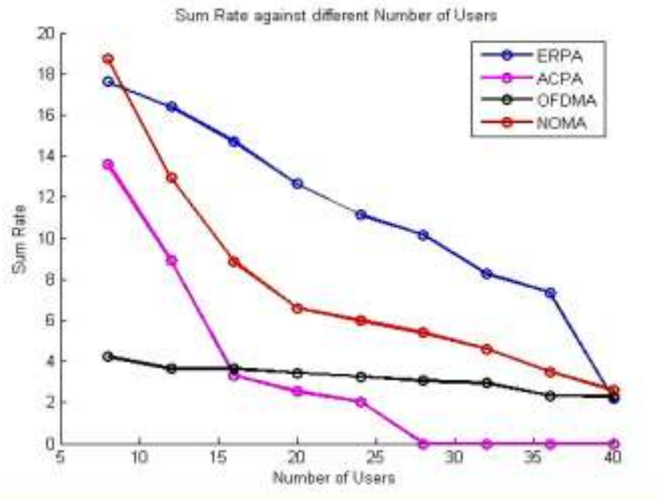

Figure 5: Sum rate against different number of users

Figure 5 is showing the sum rate against different number of users. Here total 40 numbers of users taken and sum rate is maximum 20 for NOMA.

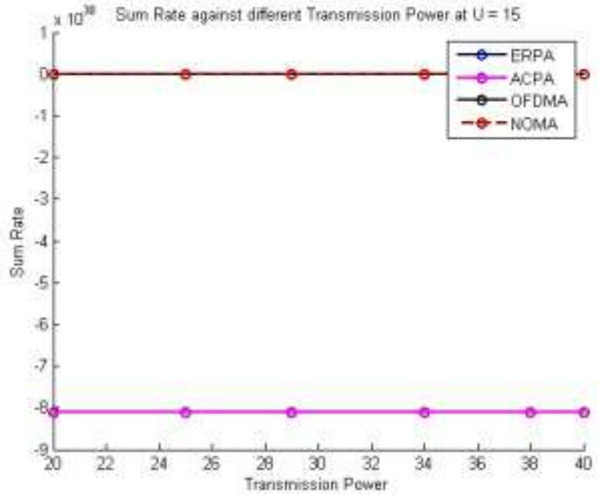

Figure 6: Sum rate vs transmission power

Figure 6 is showing the sum rate against different number of users. Here total 40 numbers of users taken and total sum rate is $1x10^{30}$ for NOMA.

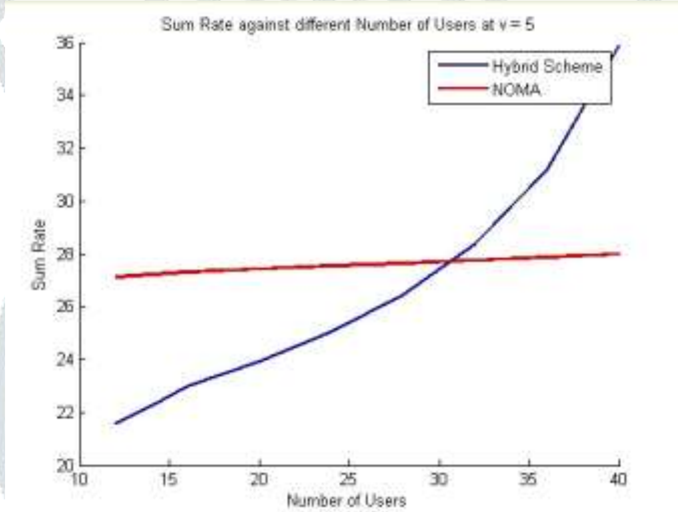

Figure 7: Sum rate against different number of users-5

Figure 7 is showing the sum rate against different number of users. Here total 40 numbers of users taken and sum rate is maximum 36 for Hybrid scheme and 28 for NOMA technique.

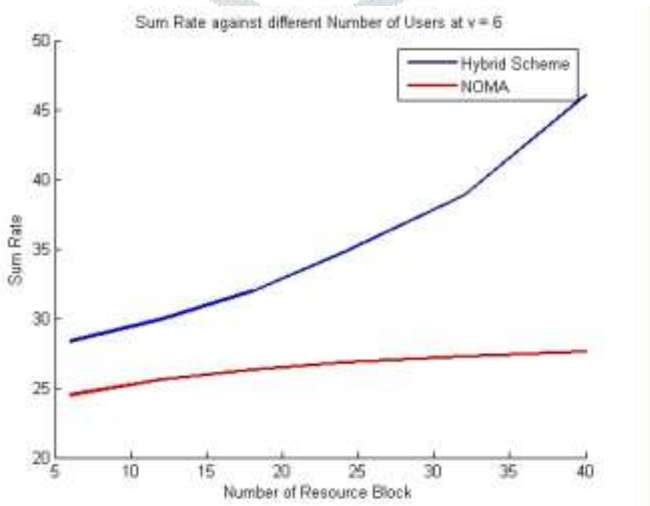

Figure 8: Sum rate against different number of users-6

Figure 8 is showing the sum rate against different number of users. Here total 40 numbers of users taken and sum rate is maximum 46 for Hybrid scheme and 25 for NOMA technique.

Table 1: Simulation Parameters

Sr. No	Approach	Transmission Power	No of users	Resource Block	Sum Rate	Cov. Prob.
1	ERPA	40	40	40	32	0.9
2	ACPA	40	40	40	32	1
3	OFDMA	40	40	40	9	0.3
4	NOMA	40	40	40	27	1
5	Hybrid	40	40	40	46	1

V. CONCLUSION

Thus the Resource Block was allocated using the 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. The pairs are then multiplexed in the power domain, which is obtained from a modified solution to the obtained sub- optimal ones in the two-user scenario. Furthermore, this paper proposed the idea of hybrid multiple accesses as a combination between NOMA and OFDMA to utilize the transmission schemes for varying channel conditions. Simulation results show that NOMA provides better performance than OFDMA in visible light communication.

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