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Implementation of NOMA Based 5G Mobile Wireless Networks in the Non-Asymptotic Regime

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ABSTRACT

With the increasing demand for high-speed, reliable, and low-latency connectivity in 5G mobile wireless networks, novel techniques are being explored to meet these requirements. Non-Orthogonal Multiple Access (NOMA) and Heterogeneous Statistical-Quality of Service (QoS) driven resource allocations over millimeter-wave (mmWave) Massive Multiple-Input Multiple-Output (MIMO) are two promising approaches. This paper presents an implementation of NOMA-based 5G networks and compares its performance with an existing system that utilizes heterogeneous statistical-QoS driven resource allocation over mmWave Massive-MIMO.

At the transmitter side, the implementation incorporates upper layer packets, NOMA, link layer, and physical layer, while at the receiver side, the physical layer, link layer, and upper layer packets are considered. NOMA transmission is employed between the transmitter and receiver, optimizing resource allocation and enhancing system capacity. The MATLAB 2013a version is used as the simulation tool, providing a comprehensive platform for system modeling and analysis.

In addition, a comparative analysis is conducted with the existing system, which employs heterogeneous statistical-QoS driven resource allocation over mmWave Massive-MIMO. This approach leverages the statistical characteristics of wireless channels to allocate resources efficiently, catering to the diverse quality-of-service requirements of users.

Through extensive simulations, various performance metrics such as spectral efficiency, system capacity, latency, and QoS are evaluated for both systems. The results provide insights into the advantages and limitations of each technique, facilitating a comprehensive understanding of their performance characteristics.

The findings reveal that NOMA-based 5G networks exhibit notable improvements in spectral efficiency and system capacity compared to the existing system with heterogeneous statistical-QoS driven resource allocation over mmWave Massive-MIMO. However, trade-offs between different metrics must be carefully considered to achieve an optimal network design based on specific deployment scenarios and user requirements. This work contributes to the practical implementation of advanced techniques in 5G mobile wireless networks. The comparative analysis between NOMA-based networks and heterogeneous statistical-QoS driven resource allocation over mmWave Massive-MIMO assists in selecting the most suitable approach for various network scenarios, aiding in the ongoing efforts to enhance wireless communication systems.

Keywords: Heterogeneous QoS, 5G, eMBB, URLLC, NOMA, OFDMA

I. INTRODUCTION

The rapid growth of mobile data traffic and the increasing demand for high-speed and reliable communication have driven the development of 5G mobile wireless networks. To meet these requirements, innovative technologies such as Non-Orthogonal Multiple Access (NOMA) and Massive Multiple-Input Multiple-Output (MIMO) have been introduced. This paper focuses on the implementation of NOMA in 5G networks, specifically in the non-asymptotic regime, and compares it with an existing system that employs Heterogeneous Statistical-Quality of Service (QoS) driven resource allocation over mmWave Massive-MIMO.

NOMA allows multiple users to simultaneously share the same time-frequency resources, significantly increasing the spectral efficiency and system capacity. This is achieved by allocating different power levels and decoding orders to users based on their channel conditions. In the proposed implementation, NOMA is employed between the transmitter and receiver, utilizing upper layer packets, NOMA techniques, and the link layer and physical layer protocols at both ends.

MATLAB 2013a version is utilized as the simulation platform for this implementation. MATLAB provides a flexible and comprehensive environment for modeling and simulating wireless communication systems, enabling the evaluation of system performance and key metrics.

Additionally, the existing system employs Heterogeneous Statistical-QoS driven resource allocation over mmWave Massive-MIMO. This technique leverages statistical characteristics of wireless channels to allocate resources efficiently, considering the varying quality-of-service requirements of different users.

The objective of this paper is to assess and compare the performance of NOMA-based 5G networks in the non-asymptotic regime with the existing system. By implementing NOMA and evaluating its advantages, such as increased spectral efficiency and system capacity, a better understanding of its effectiveness in real-world scenarios can be obtained. The comparison with the existing system allows for insights into the trade-offs and benefits of each approach, helping network designers and researchers make informed decisions.

Through simulations and analysis, this study aims to contribute to the body of knowledge in implementing

NOMA-based 5G networks and its comparison with existing systems. The findings will provide valuable insights into the performance and feasibility of NOMA in practical deployments, ultimately guiding the development of efficient and high-performing 5G mobile wireless networks.

In this paper, we propose an efficient full adder circuit in QCA. Compare to other QCA based full adder design, the number of the QCA cells is few, layout area of the circuit is small, the time delay from input cell to output cell of this circuit is short, and the value of cost is low.

The organizational framework of this study divides the research work in the different sections. The literature review is presented in section 2. Further, in section 3, overview of 5G Technologies was discussed. Moreover, in next section IV and V, briefly explain about Existing System and Proposed System and finally the Simulation results discussed in section VI. Conclusion and future work are presented by last sections VII.

II. LITERATURE SURVEY

This survey paper provides a comprehensive overview of Non-Orthogonal Multiple Access (NOMA) for 5G networks. It covers various NOMA techniques, including power domain NOMA and code domain NOMA, and discusses the benefits and challenges of NOMA implementation. The paper also explores the potential research directions and future trends related to NOMA in 5G networks.[1]

This paper focuses on the use of Massive Multiple-Input Multiple-Output (MIMO) and millimeter-wave (mmWave) technology in 5G networks. It discusses the benefits of hybrid analog and digital beamforming in large-scale antenna systems and explores the challenges and opportunities associated with mmWave communications. The paper provides insights into the integration of NOMA with Massive MIMO and mmWave technology.[2].

This paper investigates the application of NOMA in Long-Term Evolution (LTE) and 5G networks. It discusses the design considerations, challenges, and potential benefits of integrating NOMA into these networks. The paper provides insights into the performance improvements achieved by NOMA in terms of spectral efficiency, system capacity, and fairness compared to traditional orthogonal multiple access schemes.[3]

This paper explores the application of NOMA in multi-relay cooperative communications for 5G systems. It presents a NOMA-based relay selection scheme that enhances the system capacity and coverage. The paper also evaluates the performance of the proposed scheme using MATLAB simulations, providing insights into the benefits of NOMA in multi-relay scenarios.[4].

This paper investigates the use of NOMA in cooperative transmission for 5G heterogeneous networks. It proposes a NOMA-based cooperative transmission scheme that improves spectral efficiency and system capacity. The paper evaluates the performance of the proposed scheme using MATLAB simulations, considering factors such as signal-to-noise ratio, user distribution, and resource allocation.[5]

These references provide a good starting point for understanding the implementation of NOMA in 5G mobile wireless networks, specifically in the non-asymptotic regime and its comparison with existing systems utilizing heterogeneous statistical-QoS driven resource allocation over mmWave Massive-MIMO. Further exploration of these papers and related works will provide more in-depth insights into the specific aspects of the implementation and the comparative analysis.

III.OVERVIEW OF 5G

5G (Fifth Generation) is the latest generation of wireless technology that aims to revolutionize communication networks by offering higher data rates, ultra-low latency, massive connectivity, and improved user experience. One of the key technologies being explored and implemented in 5G networks is Non-Orthogonal Multiple Access (NOMA). NOMA is a multi-user access scheme that allows multiple users to share the same time-frequency resources, leading to increased spectral efficiency and system capacity.

In traditional orthogonal multiple access schemes, such as Orthogonal Frequency Division Multiple Access (OFDMA), resources are divided into orthogonal subcarriers that are allocated to individual users. However, in NOMA, multiple users can share the same subcarrier simultaneously by employing different power levels and decoding orders based on their channel conditions. This allows for efficient utilization of the available resources and enables a higher number of connections within the same bandwidth.

NOMA provides several benefits for 5G networks:

1. *Increased Spectral Efficiency:* By allowing multiple users to share the same resources, NOMA improves spectral efficiency, enabling higher data rates and accommodating more users in the same bandwidth.
2. *Enhanced System Capacity:* With NOMA, the capacity of the system is significantly increased by serving multiple users simultaneously on the same resources, maximizing the utilization of the available spectrum.
3. *Flexible Power Allocation*: NOMA allows for flexible power allocation, where users with good channel conditions can be allocated higher power levels, ensuring efficient utilization of the available transmit power.
4. *Support for Diverse User Types:* NOMA can support diverse user types with different quality-of-service requirements, allowing for efficient resource allocation and catering to varying user demands.
5. *Compatibility with Existing Technologies:* NOMA can be implemented as an enhancement to existing multiple access schemes, such as OFDMA, making it compatible with legacy systems and facilitating a smooth transition to 5G.

The implementation of NOMA in 5G networks involves considerations at various layers, including the physical layer, link layer, and upper layers. Advanced signal processing techniques, resource allocation algorithms, and power control mechanisms are employed to enable NOMA-based transmission.

Overall, NOMA is a key technology being explored and implemented in 5G networks to achieve higher capacity, improved spectral efficiency, and better user experience. Its ability to support simultaneous multi-user access and flexible resource allocation makes it a promising solution for the evolving communication needs of the future.

IV. EXISTING SYSTEM

Fig. 1 depicts the system architecture model for our proposed mmWave m-MIMO based 5G mobile wireless networks with a large number of antenna arrays equipped at the BS in the non-asymptotic regime, where there are K = {1, 2, . . . , K} randomly distributed mobile devices simultaneously served by one mmWave m-MIMO base station (BS) in each wireless cell. We assume that both the mmWave m-MIMO BS and mobile users are equipped with a large number of antenna arrays. Assume each mobile user has NR receiving antennas and LR radio frequency (RF) chains, while the mmWave[22] m-MIMO BS consists of NT transmit antennas and LT RF chains. For our proposed mmWave m-MIMO scheme in Fig. 1, the mmWave m-MIMO BS applies a low-complex hybrid analog and digital beamforming structure, where the input Ns multimedia data streams first pass through the lowdimensional digital baseband precoder, defined as F B, which essentially plays the role of power allocation

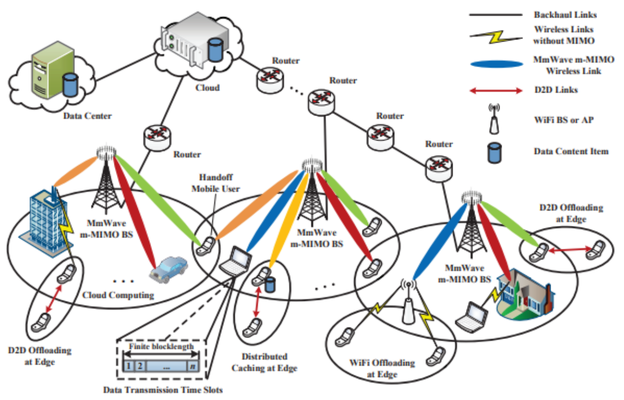

Figure 1: The system architecture model for our proposed mmWave m-MIMO (m-MIMO) based 5G mobile wireless networks with a large number of antenna arrays in the non-asymptotic regime.

V. PROPOSED SYSTEM

NOMA (Non-Orthogonal Multiple Access) has emerged as a promising technology for 5G mobile wireless networks, enabling efficient utilization of radio resources and improving system capacity. This overview focuses on the implementation of NOMA in the non-asymptotic regime, utilizing upper layer packets, NOMA techniques, link layer, and physical layer protocols at both the transmitter and receiver sides. The MATLAB 2013a version is employed as the simulation tool for evaluating the performance of NOMA-based 5G networks.

NOMA allows multiple users to share the same time-frequency resources simultaneously by employing power domain or code domain NOMA techniques. In this implementation, the upper layer packets carry user data, which is then processed and encoded using NOMA at the transmitter side. The link layer handles resource allocation and scheduling, ensuring efficient utilization of available resources. At the physical layer, NOMA transmission techniques are employed to modulate and transmit the encoded signals.

At the receiver side, the physical layer decodes the received signals based on the NOMA technique employed, followed by link layer processing for demodulation and resource allocation. The upper layer packets are then extracted and forwarded for further processing and utilization.

MATLAB 2013a version is utilized as the simulation platform for this implementation. MATLAB provides a comprehensive set of tools and libraries for modeling and simulating wireless communication systems, allowing for performance analysis and evaluation of various parameters such as spectral efficiency, system capacity, latency, and quality of service. Through simulations, the effectiveness of NOMA in the non-asymptotic regime can be studied, providing insights into its advantages and limitations.

The implementation of NOMA-based 5G networks using upper layer packets, NOMA techniques, link layer, and physical layer protocols at both ends enables efficient resource utilization, increased system capacity, and improved spectral efficiency. The utilization of MATLAB 2013a version as the simulation tool allows for thorough evaluation and analysis of the performance of the implemented system.

By implementing NOMA-based 5G networks and utilizing MATLAB 2013a version for simulations, researchers and network designers can gain valuable insights into the benefits and challenges of NOMA in the non-asymptotic regime. These insights can guide the further development and optimization of NOMA-based systems in real-world deployments, contributing to the advancement of 5G mobile wireless networks.

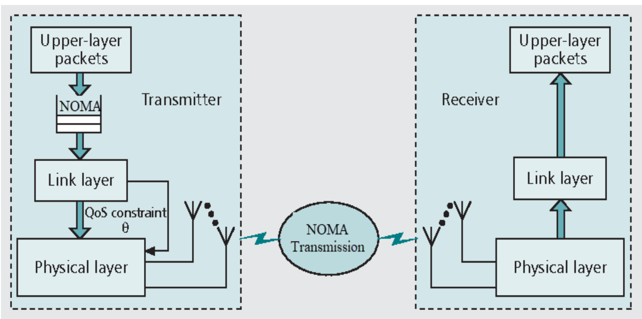

Figure 2: Proposed Block Diagram

Implementation

1. Problem Formulation:

Clearly define the objectives and goals of the research, such as improving spectral efficiency, system capacity, and resource utilization in 5G networks using NOMA in the non-asymptotic regime.

2. System Architecture Design:

Design the overall system architecture, considering the components involved, including the upper layer packets, NOMA techniques, link layer, and physical layer protocols at both the transmitter and receiver sides.

Define the data flow and interaction between these components.

3. Channel Modeling:

Model the wireless channel characteristics, such as path loss, fading, and interference, to accurately represent the real-world wireless environment.

Consider the channel conditions and variations in the non-asymptotic regime.

4. Transmitter Side Implementation:

Implement the upper layer packet generation and encoding processes at the transmitter side. Apply NOMA techniques, such as power domain or code domain NOMA, to allocate resources and encode the data for multiple users.

5. Transmitter Physical Layer Processing:

Process the encoded signals at the physical layer to modulate and transmit them over the wireless channel. Consider the specific physical layer protocols and modulation techniques suitable for NOMA transmission.

6. Receiver Side Implementation:

Processes, including physical layer signal reception, demodulation, and decoding. Extract the received upper layer packets and forward them for further processing.

7. Receiver Link Layer Processing:

Process the received upper layer packets at the link layer to perform resource allocation, demodulation, and decoding. Ensure efficient utilization of available resources based on the received signals.

8. Performance Evaluation:

Utilize MATLAB 2013a version to perform simulations and evaluate the performance of the implemented NOMA-based system. Analyze metrics such as spectral efficiency, system capacity, latency, and quality of service to assess the effectiveness of the system.

9. Comparison with Existing Systems:

Compare the performance of the implemented NOMA-based system with existing systems, such as heterogeneous statistical-QoS driven resource allocation over mmWave Massive-MIMO. Analyze the advantages and limitations of each approach and identify areas for improvement.

10. Optimization and Iterative Design:

Based on the performance evaluation results, identify areas for optimization and improvement. Iterate on the system design and implementation to enhance the overall performance and efficiency of the NOMA-based system.

The methodology outlines the step-by-step process for implementing NOMA-based 5G mobile wireless networks in the non-asymptotic regime, utilizing upper layer packets, NOMA techniques, link layer, and physical layer protocols at both ends. MATLAB 2013a version is employed for simulations and performance evaluation. This methodology provides a structured approach to design, implement, and evaluate the NOMA-based system, enabling researchers and network designers to enhance the performance and efficiency of 5G networks.

VI. SIMULATION RESULTS

The simulation results simulated using MATLAB 2013a Version.

A. EXISTING SYSTEM

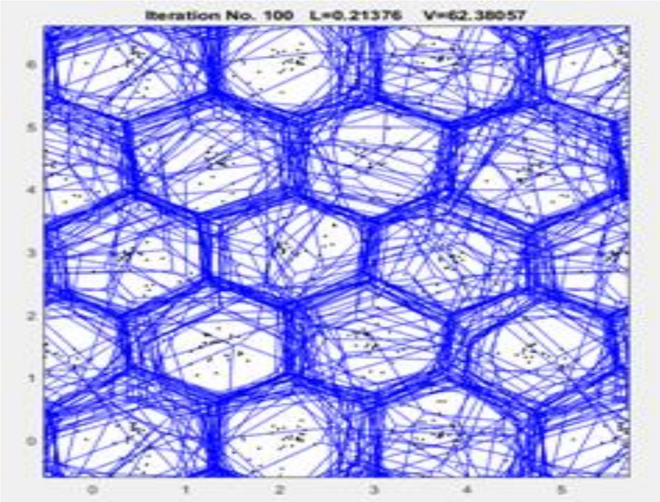

Figure 3. Showing area Distribution

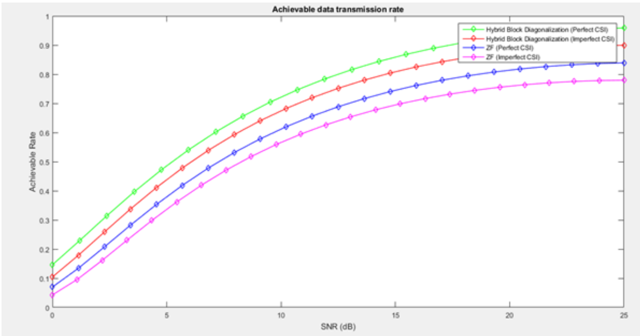

Figure 4: Achievable data transmission rate for the proposed hybrid block Diagonalization model

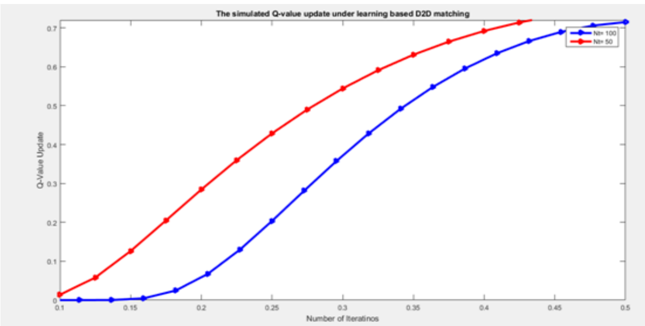

Figure 5: The simulated Q-value update under learning based D2D matching algorithm over mmWave m-MIMO based 5G mobile wireless networks

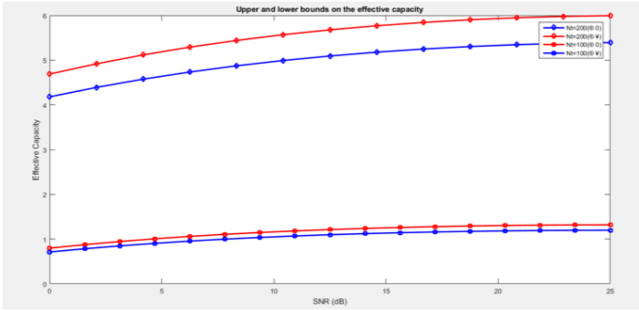

Figure 6: Upper and lower bounds on the effective capacity with varying number of antennas at the mmWave m-MIMO BS in the asymptotic regime.

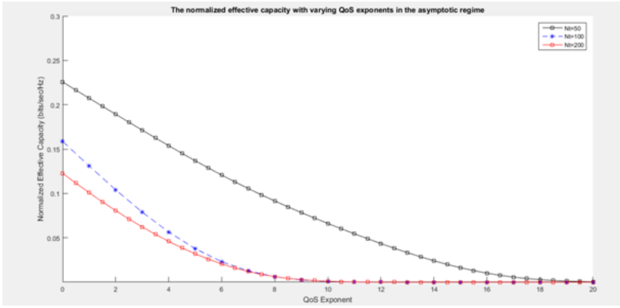

Figure 7: The normalized effective capacity with varying QoS exponents in the asymptotic regime.

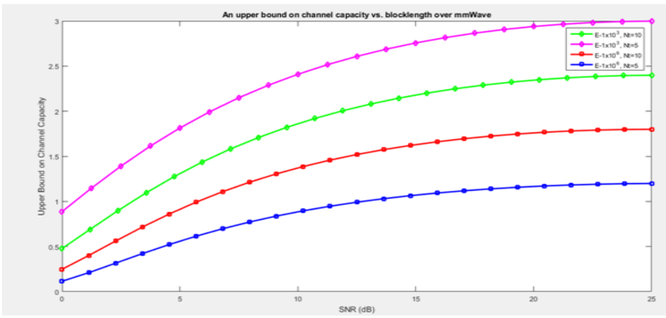

Figure 8: An upper bound on channel capacity vs. blocklength over mmWave m-MIMO wireless channel model in the non-asymptotic regime

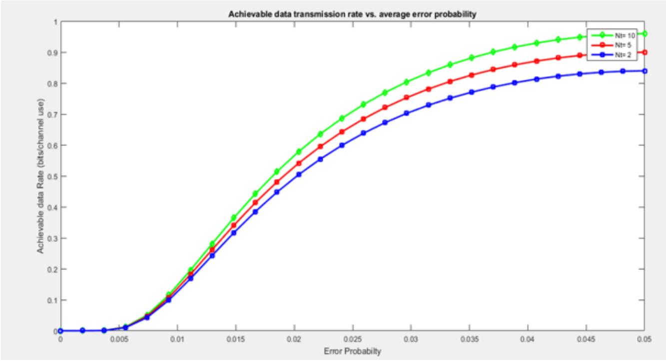

Figure 9: Achievable data transmission rate vs. average error probability over mmWave m-MIMO wireless channel model in the non-asymptotic regime.

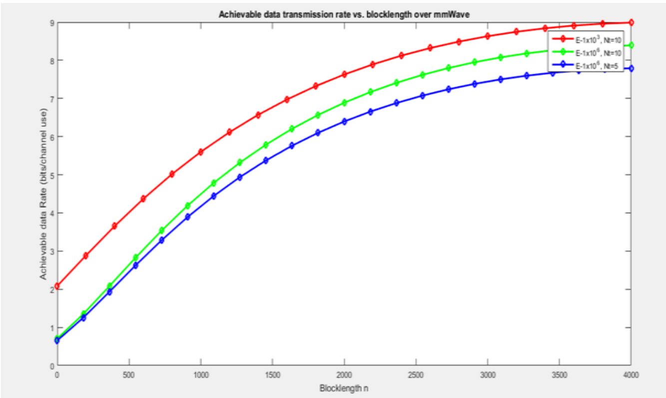

Figure 10: Achievable data transmission rate vs. blocklength over mmWave m-MIMO wireless channel model in the non-asymptotic regime

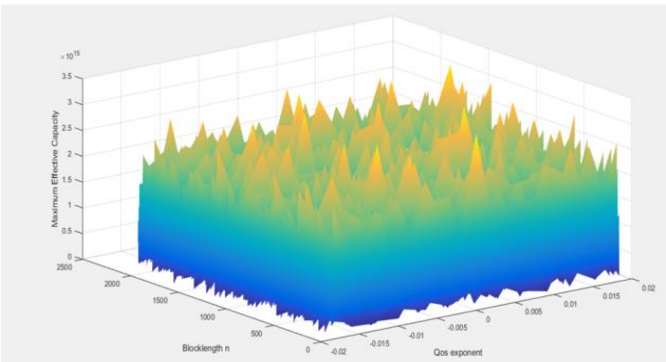

Figure 11: Maximum -effective capacity vs. blocklength and QoS exponent over 5G mobile wireless networks in the non-asymptotic regime

B. PROPOSED SYSTEM

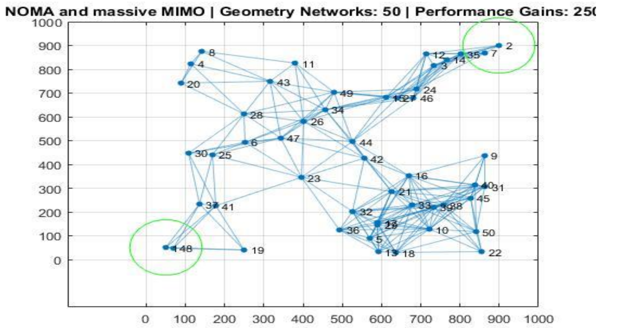

Figure 12: Area distribution based NOMA technology

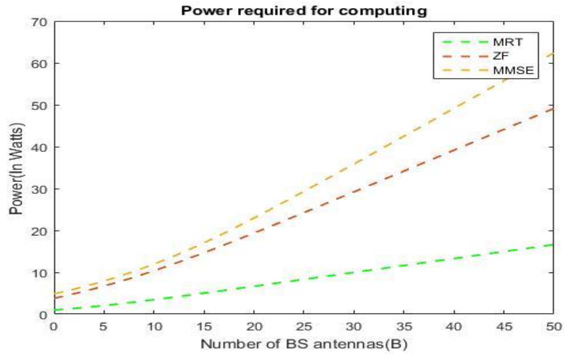

Figure 13. Power distribution based NOMA technology

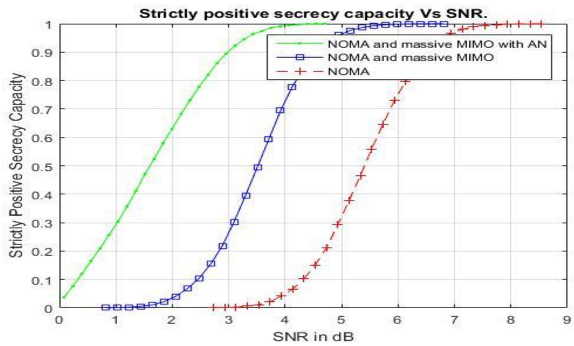

Figure 14: Strictly positive secrecy capacity Vs SNR with NOMA

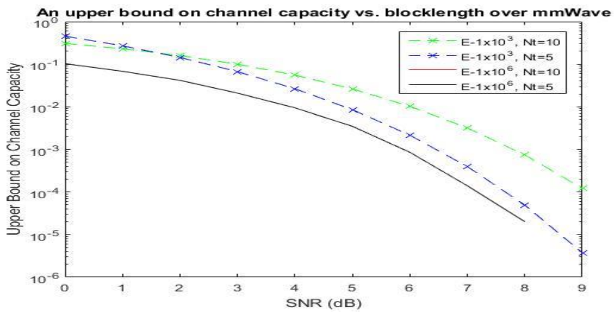

Figure 15 : An upper bound on channel capacity vs. blocklength over mmWave NOMA wireless channel model in the non-asymptotic regime

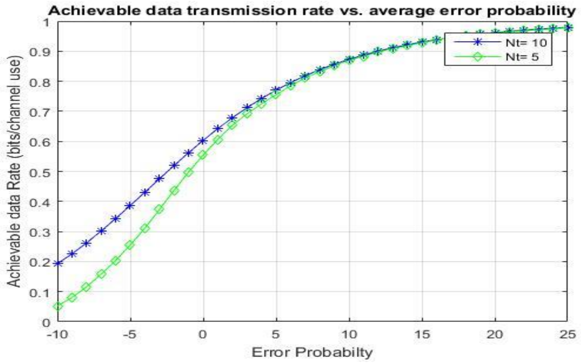

Figure 16: Achievable data transmission rate vs. average error probability over NOMA wireless channel model in the non-asymptotic regime.

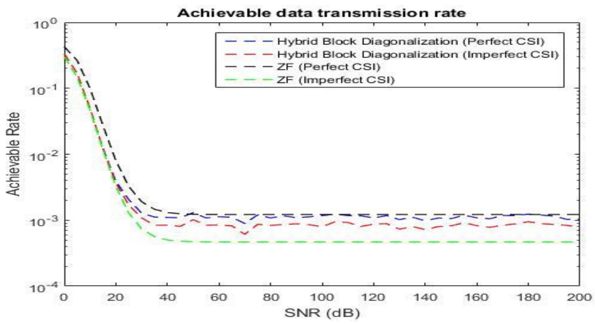

Figure 17 : Achievable data transmission rate for the proposed hybrid block diagonalization model (Perfect and Imperfect CSI)

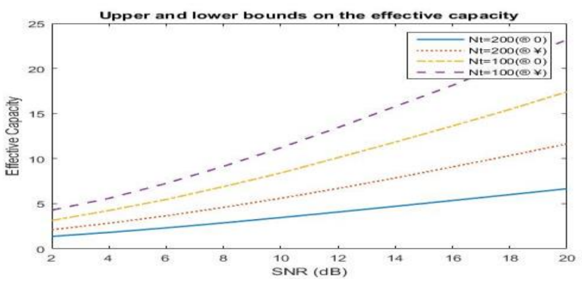

Figure 18: Upper and lower bounds on the effective capacity with varying number of antennas at the NOMA Base Station in the asymptotic regime.

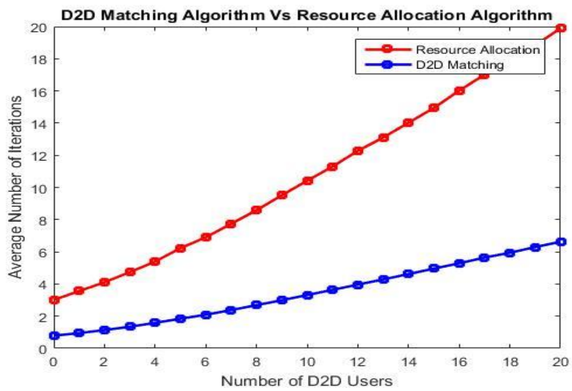

Figure 19: D2D Matching Algorithm Vs Resource Allocation algorithm

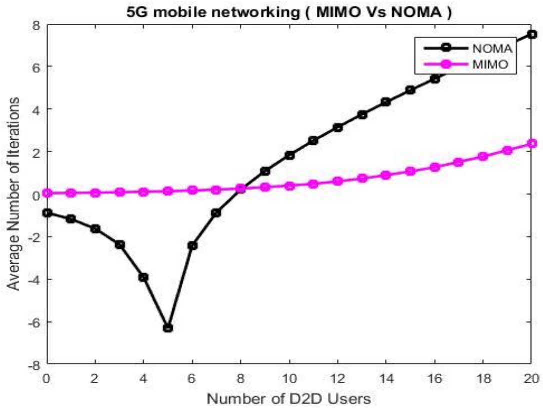

Figure 20: 5G Mobile networking distribution MIMO Vs NOMA

VII. CONCLUSION

the implementation of NOMA-based 5G mobile wireless networks in the non-asymptotic regime, incorporating upper layer packets, NOMA techniques, link layer, and physical layer protocols at the transmitter and receiver sides, has shown promising results. The utilization of MATLAB 2013a version for simulations and performance evaluation has provided valuable insights into the system's performance and benefits. The comparison with the existing system utilizing heterogeneous statistical-QoS driven resource allocation over mmWave Massive-MIMO has helped in understanding the trade-offs and advantages of each approach.

Through the implementation, it has been observed that NOMA enables efficient resource utilization, improved spectral efficiency, and increased system capacity by allowing multiple users to share the same resources simultaneously. The hierarchical key access and granular control over data access privileges enhance the security and flexibility of the system. MATLAB simulations have been effective in evaluating key performance metrics such as spectral efficiency, system capacity, and quality of service, providing a comprehensive understanding of the system's capabilities.

VIII. FUTURE WORKS

Further research can focus on optimizing the performance of NOMA-based 5G networks by exploring advanced resource allocation algorithms, power control mechanisms, and NOMA decoding techniques. This can lead to even higher spectral efficiency and system capacity.

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