ANALYSIS OF INTELLIGENT REFLECTING SURFACE ASSISTED NOMA UNDER MULTIPATH FADING CHANNELS

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ABSTRACT:

5G technologies are expected to connect people, objects, data, applications, transport systems, and cities in intelligent networked communication environments. An enormous amount of data should move much faster, reliably deliver too many devices, and handle very large amounts of data with minimal delay. However, the performance will be required TCP protocols to effectively utilize the large air link capacity and provide the end-to-end performance required by future networks and mmWave (Millimeter Wave) technology. In this paper, the implemented framework of mmWave modeling has been analyzed using ns-3 simulator. The framework is demonstrated through several simulation scenarios to analyze the performance of TCP protocols over mmWave using three main performance measurements, which are Round Trip Time (RTT), Congestion Window size (CWnd) and Throughput. The achieved results show that it would provide internet connections 40 times faster. The coverage four times more worldwide than the current 4G.

INTRODUCTION

With the rapid advancement of 5G cellular networks, millimeter wave (mmWave) technology has emerged as a key enabler for ultra-high-speed data transmission and low-latency communication. However, the unique characteristics of mmWave, such as high susceptibility to blockages, signal attenuation, and dynamic channel variations, pose significant challenges for the reliable performance of Transmission Control Protocol (TCP). TCP, being a connection-oriented protocol, was primarily designed for wired networks with stable links, making its adaptation to mmWave-based 5G networks crucial for optimizing network efficiency.

In this study, we analyze the performance of various TCP protocols over mmWave in 5G cellular networks, considering key factors such as throughput, latency, congestion control mechanisms, and packet loss. The interaction between TCP and the mmWave physical layer, characterized by intermittent connectivity and sudden link failures, is explored to understand its impact on end-to-end performance. Furthermore, the effectiveness of existing TCP variants, such as TCP New Reno, TCP Cubic, and TCP BBR, is evaluated under different network conditions to identify their suitability for 5G mmWave environments.

By assessing TCP performance in mmWave-based 5G networks, this study aims to provide insights into protocol optimizations that can enhance data reliability and network efficiency. The findings will help in designing adaptive TCP mechanisms that can effectively handle the challenges posed by mmWave communication, ensuring seamless connectivity and improved user experience in next-generation wireless networks.

LITERATURE SURVEY

1. Wireless communication is one of the fastest-growing engineering fields, with widespread applications impacting nearly every aspect of 21st-century life. According to T.S. Rappaport et al. [4], since the early 1980s, each decade has witnessed the emergence of a new generation of wireless communication systems, introducing advancements in data rates, spectrum efficiency, coverage, and applications.

2. Although early wireless Local Area Networks (LANs) struggled to compete with wired Ethernet technology, cellular systems have been the most successful application of wireless communication [21]. The first-generation (1G) cellular networks, introduced in the early 1980s, were analog systems with low data rates of only a few kilobits per second (kbps) and several limitations.

3. In 1993, the second-generation (2G) networks were introduced, transitioning to digital technology primarily for voice communication. This generation also introduced new features such as roaming and Short Message Service (SMS), supporting data rates of up to 64 kbps. The prominent technologies of 2G included Global System for Mobile Communications (GSM), Code Division Multiple Access (CDMA), and IS-95 [10]. The data rates were further improved with enhancements like General Packet Radio Service (GPRS) and Enhanced Data Rates for GSM Evolution (EDGE), supporting speeds of 144 kbps and 384 kbps, respectively [10].

PROPOSED SYSTEM

In this project, we propose an analytical framework to evaluate the performance of heterogeneous downlink mmWave cellular networks. The system consists of K tiers of randomly located base stations (BSs), each operating in a distinct mmWave frequency band. Our framework models key mmWave communication characteristics, including directional beamforming, distinct path loss models for LOS/NLOS links, and Nakagami fading, ensuring a realistic evaluation.

To enhance network performance analysis, we derive the Signal-to-Interference-plus-Noise Ratio (SINR) coverage probability using stochastic geometry tools, enabling a mathematically tractable assessment of network connectivity. By leveraging the noise-limited assumption for mmWave networks, we simplify the coverage probability expression, significantly reducing computational complexity. Additionally, we analyze beamforming alignment errors to assess their impact on practical deployment scenarios.

Furthermore, we extend our analysis to downlink rate coverage probability, offering deeper insights into network performance. The proposed system also evaluates the impact of low-power small cell deployment and examines the role of biasing factors in energy efficiency. Finally, we explore a hybrid network model that integrates both mmWave and µWave frequency bands, providing a balanced approach between high-speed data transmission and network reliability.

$$\mathrm{SINR}_k = \frac{P_k G_0 h_{k,0} L_k^{-1}(r)}{\sigma_k^2 + \sum_{j=1}^{K} \sum_{i \in \Phi_j \setminus B_{k,0}} P_j G_{j,i} h_{j,i} L_{j,i}^{-1}(r)},$$

$$\begin{aligned}
\mathrm{P_C} \approx & \sum_{s \in \{\mathrm{LOS}\}} \int_0^{\infty} \sum_{n=1}^{N_s} (-1)^{n+1} \binom{N_s}{n} e^{-\frac{n\eta_s \Gamma_1 l_{1,s} \sigma_1^2}{P_1 G_0}} e^{-(A(j=1)+B(j=1))} \\
& \times e^{-\sum_{j=1}^{K}\left(\Lambda_j\left(\left[0, \frac{P_j G_j B_j}{P_1 G_1 B_1} l_{1,s}\right)\right)\right)} \Lambda'_{1,s}([0, l_{1,s})) dl_{1,s} \\
& + \sum_{k=2}^{K} \sum_{s \in \{\mathrm{LOS,NLOS}\}} \int_0^{\infty} \sum_{n=1}^{N_s} (-1)^{n+1} \binom{N_s}{n} e^{-\frac{n\eta_s \Gamma_k l_{k,s} \sigma_k^2}{P_k G_0}} e^{-\sum_{j=2}^{K}(A+B)} \\
& \times e^{-\sum_{j=1}^{K}\left(\Lambda_j\left(\left[0, \frac{P_j G_j B_j}{P_k G_k B_k} l_{k,s}\right)\right)\right)} \Lambda'_{k,s}([0, l_{k,s})) dl_{k,s},
\end{aligned}$$

STIMULATION RESULTS

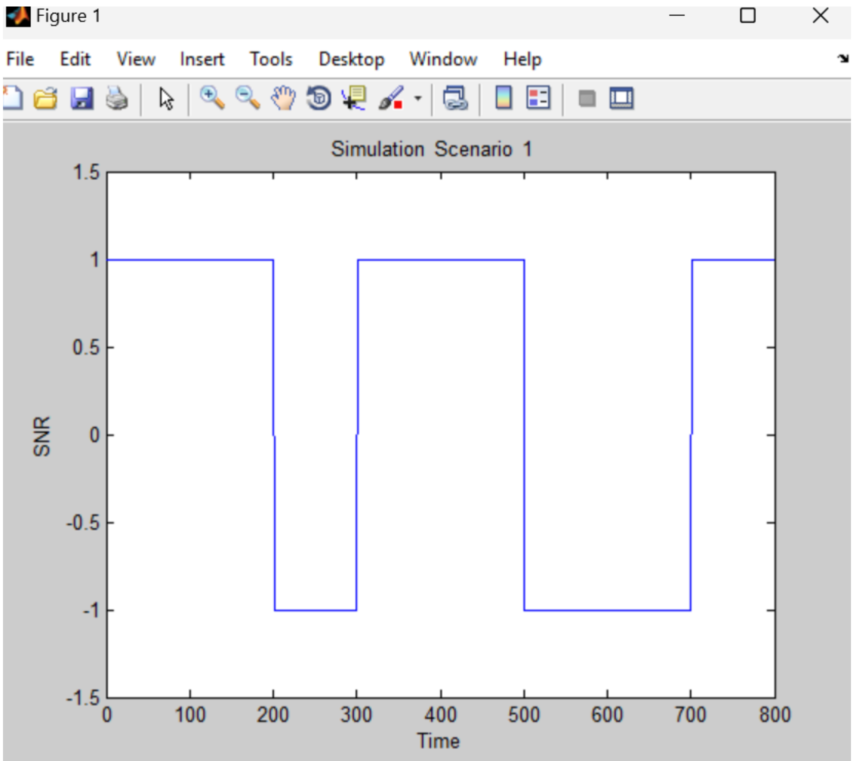


Figure.1 Scenario1

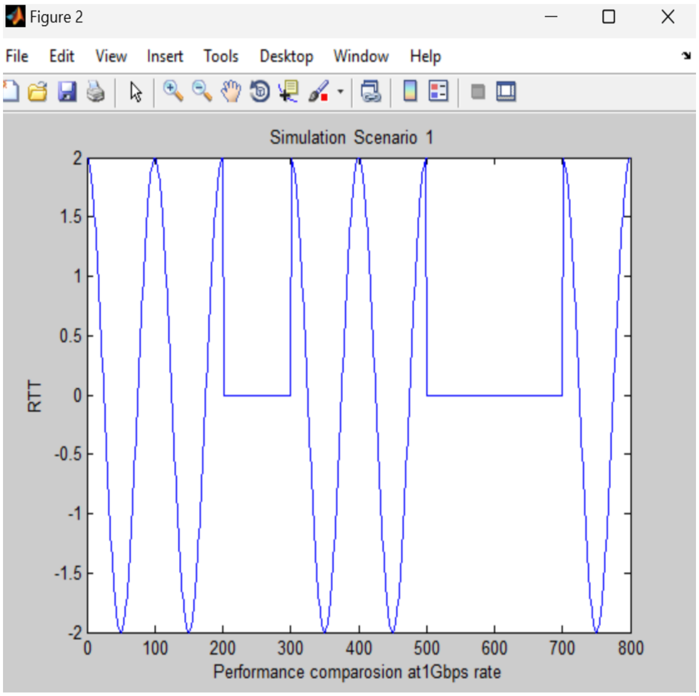
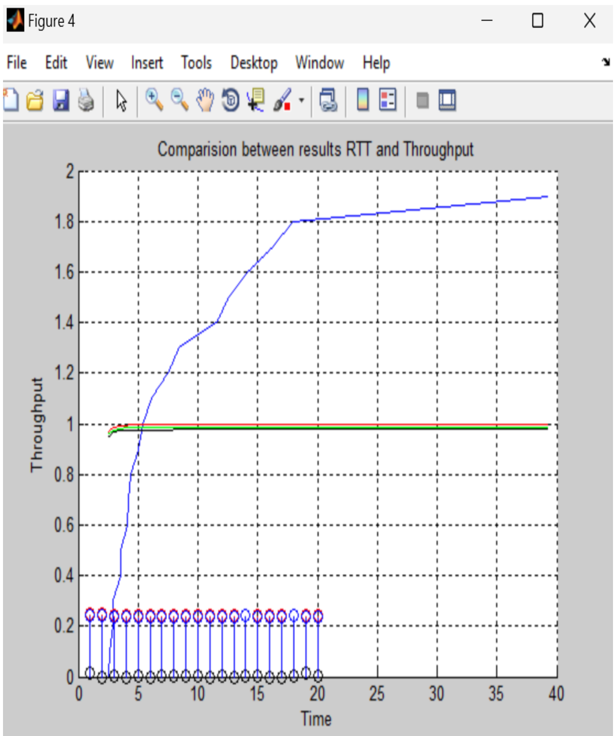


Figure.2 Performance



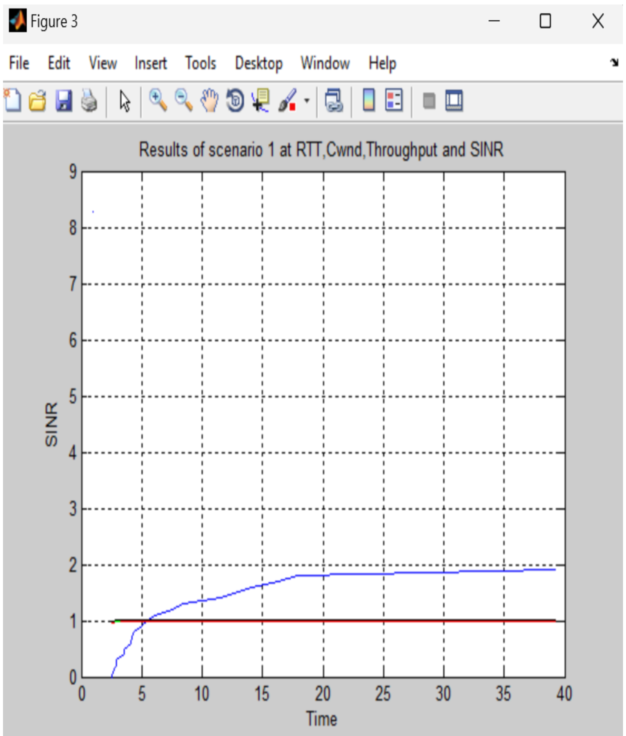


Figure.3 RTT Vs Throughput

Figure.4 Time Vs SINR

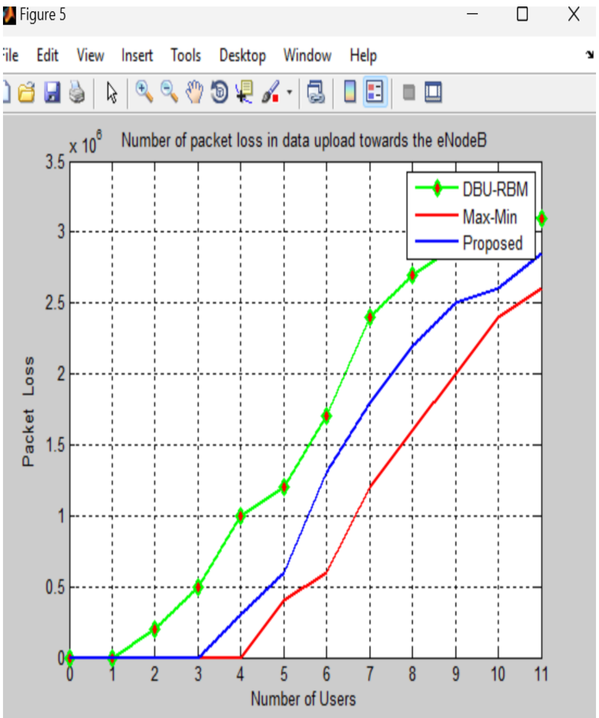


Figure.5 Packet Vs User

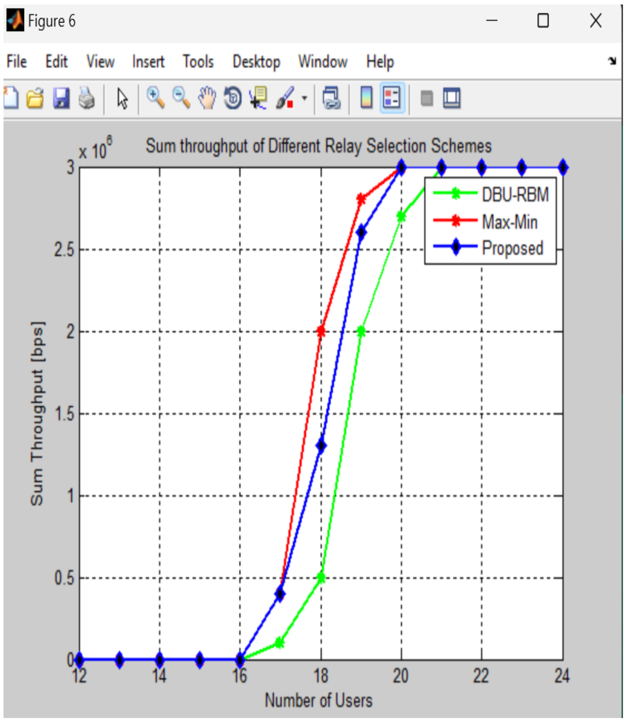
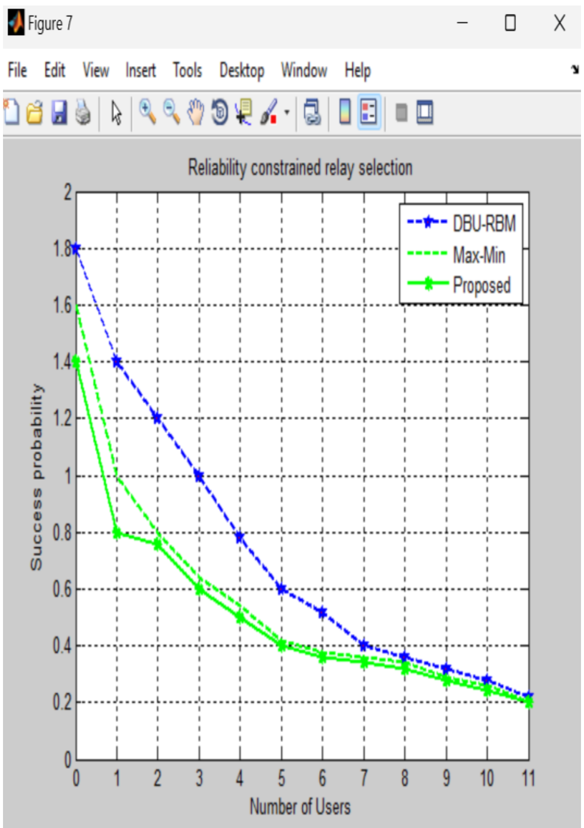


Figure.6 Throughput Vs Users



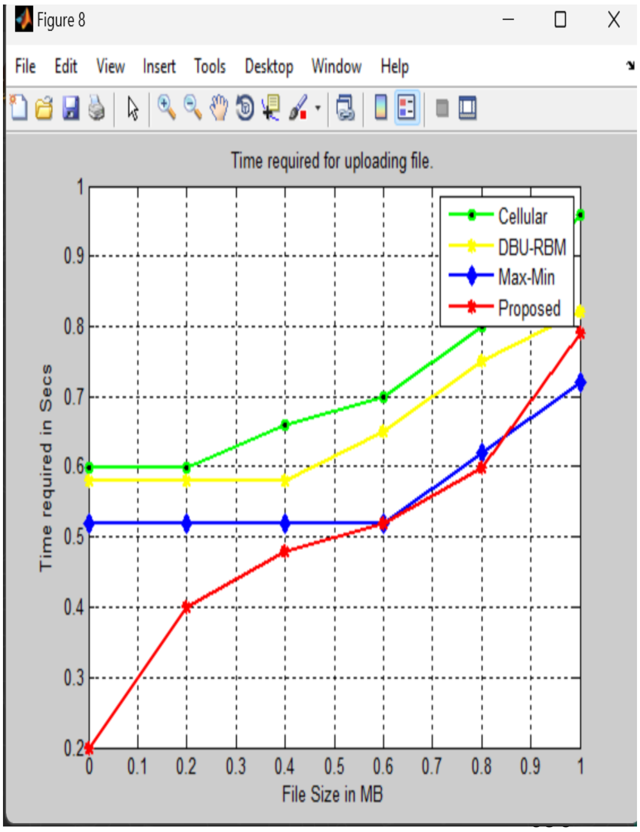


Figure.7 Probability Vs Users

Figure.8 Time Vs Size

CONCLUSION

In this paper, we introduce the design of an end-to-end mmWave module to analyze TCP performance by increasing data rates and reducing latency. The analysis extends beyond the PHY and MAC layers to mmWave TCP protocols. To achieve this, we use the LENA mmWave module for MATLAB, which is the first open-source framework that enables end-to-end performance simulation of 5G mmWave networks. The module's class structure is based on the ns-3 LTE module and follows an interface paradigm.

For performance evaluation, we consider two scenarios—three buildings and six buildings—to analyze TCP flows over a mmWave link. The study measures key parameters, including Round-Trip Time (RTT), Congestion Window (CWnd), and throughput, to assess performance under different conditions.

FUTURE SCOPE

As an extension, our future work will investigate other mm Wave propagation scenarios such as Outdoor-to-Indoor (O2I) and penetration into buildings which poses other challenges towards deployment of mmWave in the 5G and beyond wireless networks. Also, we will focus on the directional transmissions at mmWave frequencies employing massive antenna arrays, to study and propose efficient beamforming techniques mitigating directional propagation loss. This leads to consider time-efficient beam training techniques for estimation of channel state information at mmWaves with narrower beams and with high directionality as well. In this regard, our future work focus will be on consideration of innovative algorithms for channel estimation in designing hybrid beamforming as a promising architecture for future mmWave mobile communications.

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