5G SA Throughput Performance Evaluation for Different MIMO Configuration

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***Abstract*—Modern users demand data services to be fast and reliable, and because of that, one of the primary purposes of radio technology has been to increase data rates to offer better services. The antenna configuration used is critical to determining service quality in relation to data rate. This article describes the findings of laboratory tests performed on 5G smartphones to assess the effect of different Multiple-Input Multiple-Output and Single-Input Single-Output configurations on data rate over a 5G network. According to the data, more transmitters and receiver schemes dramatically improve throughput and decrease the transfer time needed to complete a download. The MIMO-4X4 scenario, in particular, increased transfer rates by up to 281% concerning the SISO scenario while reducing transfer times from 3.32 minutes to 56 seconds for a 10Gb file.**

***Index Terms*—5G, SA, SISO, MIMO**

I. Introduction

The fifth generation of mobile networks (5G) represents a significant advancement over previous technologies. The next generation of mobile communication introduces new features such as ultra-reliable low-latency communications (URLLC), enhanced mobile broadband (eMBB), and massive machine-type communications (MTC). To offer these advancements, 5G continues to use some technologies from the previous generation. Techniques like multi-input multi-output (MIMO) are widely applied to enhance the throughput for user equipment (UE) [1] [2].

MIMO for mobile networks refers to the fact that when a packet enters the channel, It is transmitted via multiple antennas and received by multiple antennas upon exit. In contrast, a Single-Input Single-Output (SISO) system has one antenna at each end of the link. This technique enables the transfer of more bits per second, resulting in improved performance for User Equipment (UE). As defined in [4], many Transmission Modes (TM) can be applied in a 5G network; MIMO transmission may be performed in a variety of modalities, such as diversity transmission, in which the same signal is delivered to several antennas, boosting reliability in diverse propagation paths. Another method for transmitting data via MIMO is spatial multiplexing, which sends separate data streams to each transmitting antenna, boosting data rate [3] [4]. This researcher used diversity transmission for the MIMOs scenario to keep the focus on the best throughput for the UE.

This work is structured as follows: Section II discusses the essential elements of the 5G and MIMO. Section III presents the methodology used to assess the performance of all simulated scenarios. Section IV shows the results of all measurements. Section V presents the conclusion of this work.

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II. Key Concepts

A. 5G New Radio

5G technology seeks to deliver more reliable communication for humans, smart devices, and systems. The 5G system integrates innovative technologies like intelligent antennas, adaptive modulation, and network virtualization to give more bandwidth, lower latency, and enhanced connection capacity. 5G networks can accommodate a variety of wireless technologies. MIMO is a crucial technology in 5G, enabling the network to modify the number of antennas available to send data according to network conditions to ensure the Quality of Service (QoS) and throughput necessities of the final user [5] [6].

B. MIMO for Mobile Network

MIMO for mobile communication is an antenna configuration paradigm designed to increase data flow by utilizing various configurations of antennas to send and receive packets. MIMO can provide users with improved quality signals transmitted from mobile networks and high throughput performance in UE services [7].

The technical specifications for the 3GPP include details on how to enhance communication between base stations (eNBs) and user equipment. This improved transmission method aims to enhance throughput, reliability, and user management. One example is Single-Input Single-Output (SISO), which uses a single antenna on both sides for essential communication. Multiple-Input Multiple-Output (MIMO) enhances reception by employing multiple receive antennas at the UE. Different scenarios leverage MIMO technology with multiple transmit antennas at the eNB, incorporating feedback from the UE for improved performance. Later versions introduced even more complex MIMO configurations for higher capacity. Release 10 introduced techniques for reducing interference and improving stability by separating data and reference signals. This work focuses explicitly on MIMO diversity transmission, aiming to achieve and compare high data rates in multiple antenna configuration scenarios [3] [8].

III. METHODOLOGY

The test configuration used a high-end smartphone with a Snapdragon 8 Gen 3 chipset and a Snapdragon X75 modem with 5G SA capabilities. The Anritsu Signaling Tester

MT8000A was employed to simulate an ideal measurement environment, which can emulate 5G base station functions. The Anritsu MA8161A shield box could be employed to prevent external radio interference. Three measurement scenarios were created with the following parameters: band NR n78 with a bandwidth of 100 MHz, Sub-Carrier Spacing (SCS) of 30 kHz, and Modulation and Coding Scheme (MCS) of 256-QAM and 27, respectively. All data collected during the test was for a 90-second duration, and the throughput values were calculated for each successful frame of data received by the device, with an average of 0.5 seconds.

IV. Results

The results were achieved with the premise that SISO or MIMO configuration would be one of the most significant modifications in all three scenarios. To ensure that the best throughput valuer was collected, the SNR was set to the best scenario channel, making it possible to ensure the ideal network condition in all cases of the test, and it was possible to avoid interference or noise signal in the results. The signal level remains consistent for all transmission modes. Based on the above description, 1 displays the throughput profile for three transmission scenarios: SISO, MIMO - 2X2, and MIMO - 4X4. The results reveal that throughput (kbps) increases with more antennas being used to transmit data, i.e. when the scenario uses MIMO - 4X4, the data rate is significantly greater than with SISO and MIMO - 2X2 as expected. The transmission mode with MIMO - 4X4 went up to 1544.81 Mbps, MIMO - 2X2 reached 862.03 Mbps, and SISO achieved 405.63 Mbps.

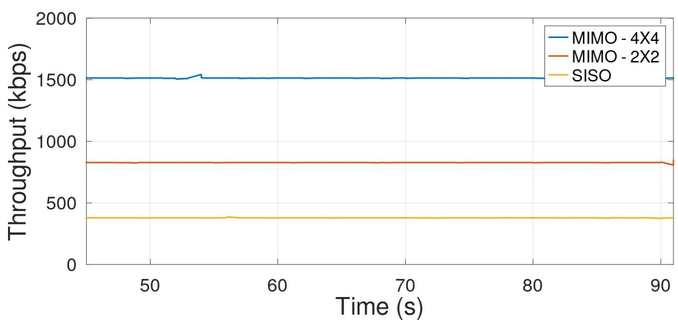

Fig. 1: Measurement data of all MIMO and SISO scenario

Using the data shown in the figure 1 and presented in the results section, it is possible to calculate the time cost in terms of the download time effectiveness of a file, where the best MIMO configuration, MIMO-4X4, must conduct the downloads faster than in other scenarios. Comparing MIMO-4X4 to MIMO-2X2 and SISO in terms of sample measurement will help illustrate this. Figure 2 indicates that the MIMO-2X2 can increase about 113% of the data rate concerning SISO configuration by more than twice the throughput. Looking for MIMO - 4X4, it is possible to find the most significant variation of the tests, where SISO could reach an increase of 281% , almost four times more data rate. From another viewer's point of time-saving, it is possible to go from 3 minutes and 32 seconds of download time of a 10 Gigabyte file to only 56 seconds. In addition, with MIMO-2X2 configuration, it is also possible to find significant results, enabling to reach 113% more data rate than SISO, which means downloading the same file of 10Gb in 1 minute and 40 seconds, a difference of 79% of MIMO-4X4.

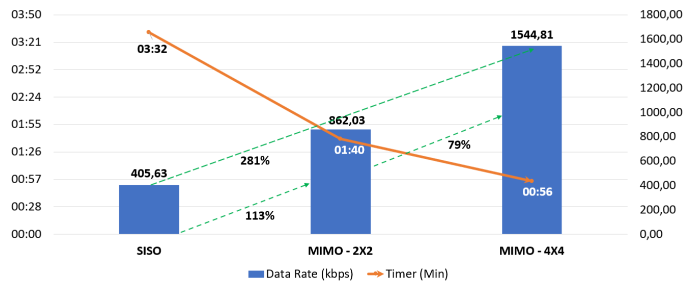

Fig. 2: Comparison between scenarios of MIMO and SISO

V. Conclusion

This work evaluated the impact of different transmission modes in 5G SA, considering three scenarios (SISO, MIMO-2X2, and MIMO-4X4). With the result of measurements in the simulated environment, as well as expected, the scenario with the highest transmission mode obtained the best results. In terms of the throughput achieved from each scenario, the MIMO-4X4 obtained values that were up to 281% greater than the SISO and 79% higher than the MIMO-2X2. Comparing the MIMO-2X2 scenario with that of SISO obtained a data rate of approximately 113% higher. From a download time perspective, the scenarios must download a 10Gb file in 0.56 seconds, 1.40, and 3.32 minutes for MIMO-4X4, MIMO-2X2, and SISO configuration, respectively. In conclusion, it is feasible to conclude that the higher transmission mode scenario outperforms the others, indicating that a set between device and network that provides MIMO-4X4 could improve the quality of throughput services for users.

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