Ref. No.: ICEIT 2024-33

128x128 massive MIMO design to QoS improvement for next generation mobile system

Abstract:

Next generation mobile system starting from 4G used MIMO system to increase the data rate and more improvement in quality of service which begun using 2x2 MIMO until 8x8, the of higher data rate lead to design 5G mobile system in which first used 16x16 MIMO, 32x32 then 64x64, in this work, 128x128 massive MIMO has been proposed to more increase in data rate and quality of service, the most MIMO parameters has been simulated and compared to 64x64 as shown in the results.

Keywords: Next generation mobile system, MIMO system, massive MIMO system

Introduction

The first generation (1G) analogue cellular systems, which were initially introduced to the mobile phone market in 1980, are the source of the mobile telecommunications business. In the United States, these systems are represented by Advanced Mobile Phone System, and in Europe by Nordic Mobile Telephone. Since then, the market has seen the introduction of a new generation of mobile communications almost every ten years. About 1990, the second generation digital cellular networks took the role of the first generation analogue systems.
Despite a number of rival systems, the Global System for Mobile Communications, or GSM (Vriendt et al., 2002), was extremely successful commercially and made mobile voice, brief texting, and low-cost data services available to over a billion people worldwide. The third generation (3G) systems (Dahlman et al., 1998), which are represented by WCDMA, CDMA2000, and TD-SCDMA, were designed and initially implemented in 2001 to provide high-speed data access at a rate of several megabits per second. They did this by utilizing a new technique called Code-Division Multiple Access (CDMA).
The first commercial Long Term Evolution (LTE) networks (Astely et al., 2009) offering fourth generation (4G) mobile broadband service were introduced in December 2009 in the Scandinavian cities of Stockholm and Oslo. The 4G network, which is made possible by the ingenious combination of orthogonal frequency-division multiplexing (OFDM) and multi-input multi-output (MIMO), promotes the growth of smartphones and the trillion-dollar mobile Internet market. We entered the 5G era in April 2019, when the three mobile carriers in South Korea and Verizon in the United States fought over who should be the world's first provider of 5G communication services.
The word "5G" has continued to be one of the most popular buzzwords in the media over the last two years, garnering extraordinary interest from the general public. It even transcended economics and technology to become the centre of geopolitical conflict. In contrast to its predecessors, which were primarily concerned with enhancing network speeds, 5G extends mobile communication services beyond devices to include both vertical industries and humans. With nearly infinite interconnectedness between people, machines, and objects, the potential scope of mobile subscription is greatly expanded from just billions of people on Earth. Numerous services, including Industry 4.0, virtual reality (VR), the Internet of Things (IoT),

and automated driving, are made possible by it, ranging from conventional mobile broadband to these (Andrews et al., 2014). 2020 sees a sharp increase in the global death toll from the COVID-19 pandemic, which also presents hitherto unheard-of difficulties for society and the economy.

However, this public health emergency underscores the special contribution that networks and digital infrastructure make to maintaining society's functionality and family ties, particularly with regard to the potential benefits of 5G services and applications—like remote surgery, virtual learning, remote work, autonomous cars, unmanned delivery, robots, intelligent healthcare, and remote manufacturing. While 5G is still being implemented globally, academics and industry need to start focusing on sixth generation (6G) systems, which will surpass 5G in order to meet the demands of information and communications technology (ICT) in 2030.

Commercial 5G mobile networks have been deployed globally since the middle of 2019 and have already attained a very significant size in certain nations. By the end of 2020, China, for instance, will have over 500,000 5G base stations operational, catering to over 100 million 5G users. In keeping with the custom of a new generation emerging every ten years, it's time for industry and academia to start investigating 5G's successor. Advancing toward 6G.

Mobile communications are under tremendous pressure as a result of the unprecedented amount of smart products, interactive services, and intelligent applications that are emerging and evolving quickly in this day and age. It is anticipated that the massive amount of mobile traffic in 2030 and beyond will be difficult for the 5G infrastructure to handle. According to an estimate by ITU-R (ITU, 2015) in 2015, the global mobile traffic will continue to grow explosively due to the proliferation of rich-video applications, enhanced screen resolution, machine-to-machine (M2M) communications, mobile cloud services, etc. Global mobile traffic will reach 5016 EB1 per month in 2030 compared with 62 EB per month in 2020.

The accuracy of ITU-R's estimate is supported by a report from Ericsson (Ericsson, 2020), which shows that at the end of 2019, global mobile traffic reached 33 EB per month.

Due to the widespread availability of mobile broadband (MBB), the number of smartphones and tablets has increased exponentially during the past ten years. The 2020s will see a continuation of this trend because the use of smartphones and tablets is not oversaturated, particularly in emerging nations. In the meantime, new-style user terminals—like VR glasses and wearable electronics—are rapidly entering the market and gaining customer acceptance. As illustrated in Fig. 1, it is anticipated that there will be 17.1 billion MBB customers globally by 2030. On the other side, when more MBB users join the firm, the traffic demand per MBB user keeps increasing. This is primarily due to the widespread adoption of mobile video services like as Tik-Tok and, more lately, Netflix and YouTube, as well as the steady advancement of mobile screen quality.

Two thirds of all mobile traffic currently originates from mobile video services (Ericsson, 2020) and is expected to continue to grow in dominance in the future. Rich-video services are driving significant traffic increase in certain developed nations before 2025, and the widespread use of augmented reality (AR) and virtual reality (VR) apps will sustain long-term growth. As shown in Figure 1, the average monthly data consumption of each mobile user will rise from approximately 5GB in 2020 to over 250GB in 2030. Apart from communications focused on people, M2M terminals will grow in size at a faster rate and reach saturation by 2030 at the latest. It is anticipated that there would be 97 billion M2M subscriptions, which is almost 14 times more than there will be in 2020 (ITU, 2015). This serves as another driving force for the explosive growth of mobile traffic.

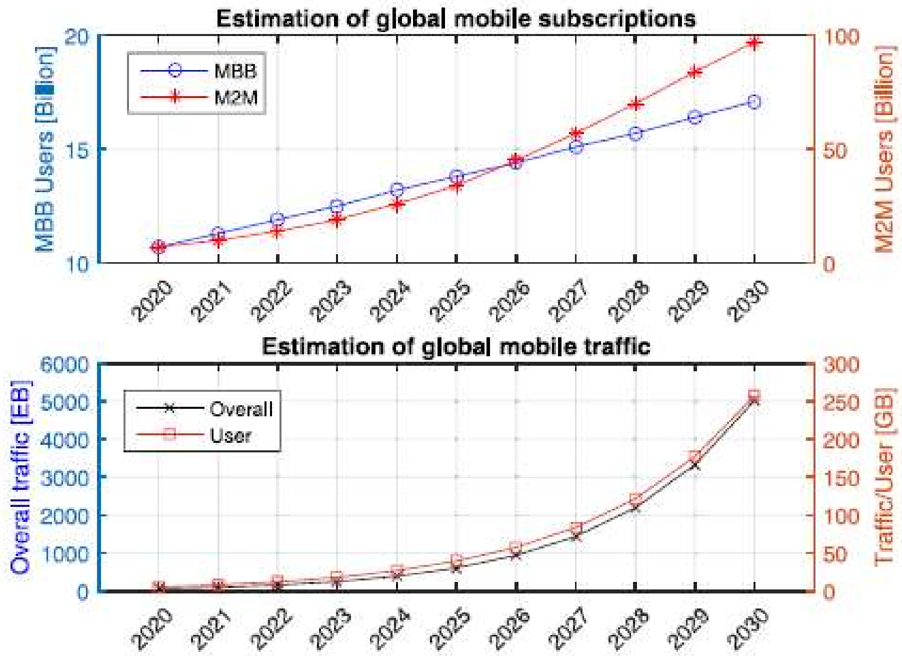

Figure 1: Estimated global mobile subscriptions and mobile traffic from 2020 to 2030. (ITU, 2015)

Massive MIMO System

Massive MIMO is the new wireless access technology in 5G, in both sub-6 GHz and mm Wave bands. Since its inception about a decade ago, it has evolved from a wild "academic" idea to become the core technology that likely will be utilized in all future wireless technologies, figure 2 is the downlink massive MIMO in line of sight communication.

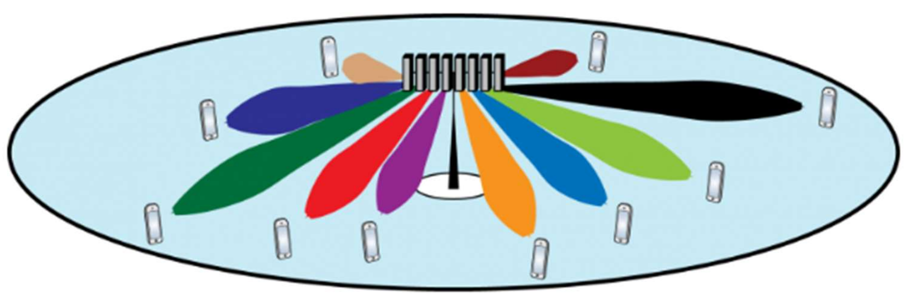

Figure 2: Illustration of downlink massive MIMO in line of sight communication

Massive MIMO is a multi-user MIMO (multiple-input multiple-output) technology that can provide uniformly good service to wireless terminals in high-mobility environments. The key concept is to equip base stations with arrays of many antennas, which are used to serve many terminals simultaneously, in the same time-frequency resource. The word "massive" refer to the number of antennas and not the physical size. The antenna arrays have attractive form factors: in the 2 GHz band, a half-wavelength-spaced rectangular array with 200 dual-polarized elements is about 1.5 x 0.75 meters large. Massive MIMO operates in TDD (Time Division Duplex) mode and the downlink beamforming exploits the uplink-downlink reciprocity of radio propagation. Specifically, the base station array uses channel estimates obtained from uplink pilots transmitted by the terminals to learn the channel in both directions. This makes Massive MIMO entirely scalable with respect to the number of base station antennas. Base stations in Massive MIMO operate autonomously, with no sharing of payload data or channel state information with other cells.

Massive MIMO is a promising technology that consists of a large number of controllable antenna arrays. It is supported by 3GPP in Rel-15 for 5G NR. 5G will exploit full benefits of MIMO by leveraging the uncorrelated and distributed spatial location of cellular-connected UAVs, as well as ground users. Massive MIMO enhances the signal strength, where multiple data streams can include unique phase and weights to the waveforms to be constructively generated at the UAV receiver (Mishra and Natalizio, 2020).

Research methodology

In massive MIMO frameworks, the transmitter as well as receiver are outfitted with a considerable number of antenna components (commonly tens or even hundreds). Note that the transmit antennas can be co-located or distributed (Distributed antenna system (DAS)) in various applications. Likewise, the tremendous number of receive antennas can be controlled by one device or appropriated to numerous devices. Other than acquiring the advantages of conventional MIMO systems, a massive MIMO framework can also extremely upgrade both spectral efficiency and energy efficiency (Rusek et al., 2013, Prasad et al., 2017). Besides, in massive MIMO frameworks, there is no impacts of noise and fast fading, and reducing of intracell interference can be do it by utilizing simple linear precoding and detection methods. And with MU-MIMO, the base station can send separate signals to individual users utilizing a similar time-frequency resource, as first pro. Therefore, these principal points of advantages enable the massive MIMO framework to be a promising candidate for 5G wireless communication systems. Ergodic capacity versus number of antennas in Raleigh fast fading channel.

In this work, first radiation pattern for the 128 antennas for a distance between the elements is 0.5 λ in three cases isotropic, weighted sin and whited poly types has been simulated, then, two cases of MIMO 64x64 and then 128x128 Ergodic capacity versus number of antennas in Raleigh fast fading channel calculated to compare between the two types of MIMO, and finally, normalized array factor radiation pattern versus Zenith angle for 128 x 128 sand 64 x 64 MIMO also to show the improvement in the system using the proposed massive MIMO in this work. All the research methodology has been calculated using MATLAB package with the MIMO equations and parameters.

Results

The proposed massive MIMO system in this work is 128 x 128, after the methodology has been presented in previous section, the design simulation results obtained.

Figure 3 is the radiation pattern for 128 elements used in 128 x 128 massive MIMO proposed design in this work for isotropic, weighted sin and weighted poly versus zenith angle, as shown weighted sin has better radiation pattern because the sidelobes is less which is preferred for the proposed design. The main parameters for MIMO are MIMO channel capacity when CSI (Channel State Information) is not available and channel capacity of random MIMO channels, the outage probability,

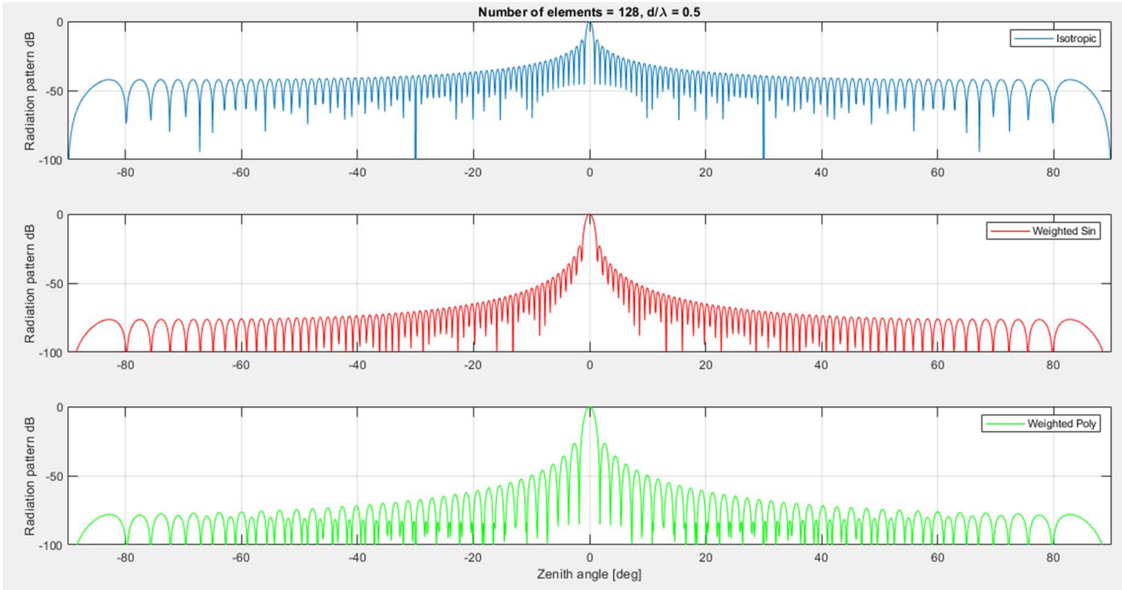

Figure 3: Radiation pattern for 128 elements used in 128 x 128 massive MIMO proposed design in this work for isotropic, weighted sin and weighted poly versus zenith angle

The most important parameter for MIMO is the ergodic capacity and the number of antennas used in the MIMO system, in this work the proposed number of the antennas are 128 because it is 128 x 128, Figure 4 is the comparison of the SIMO, MISO and MIMO for 16 antennas, while Figure 5 is for 128 antennas, as shown the 128 MIMO system the Ergodic capacity is about twice that for 64 in Rayleigh fast fading channel.

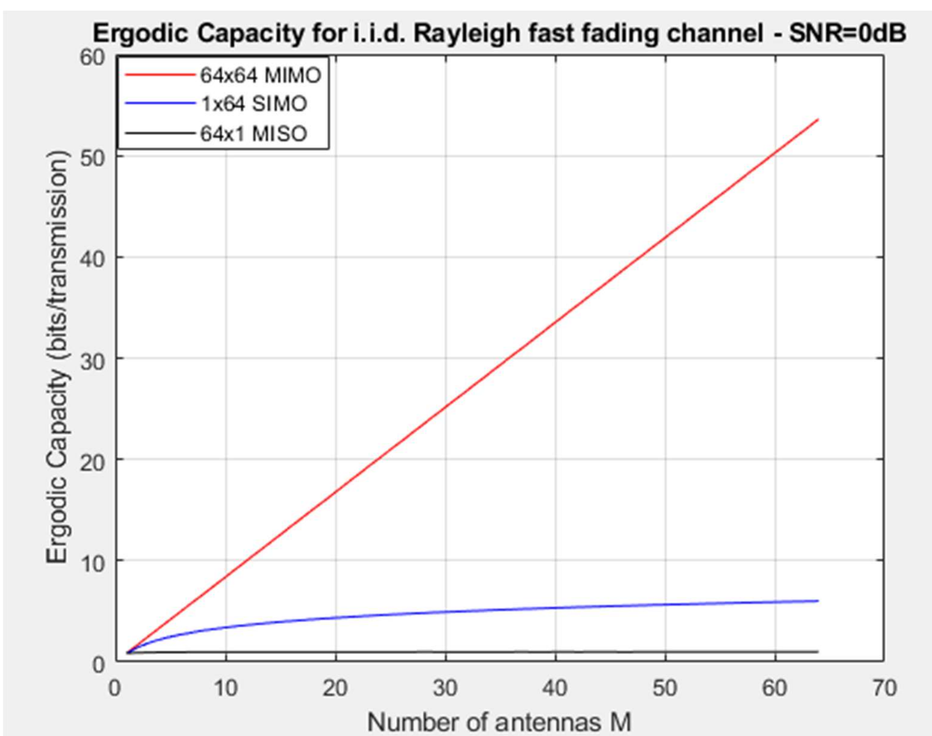

Figure 4: Ergodic capacity vs number of antennas in Rayleigh fast channel for 64 x 64

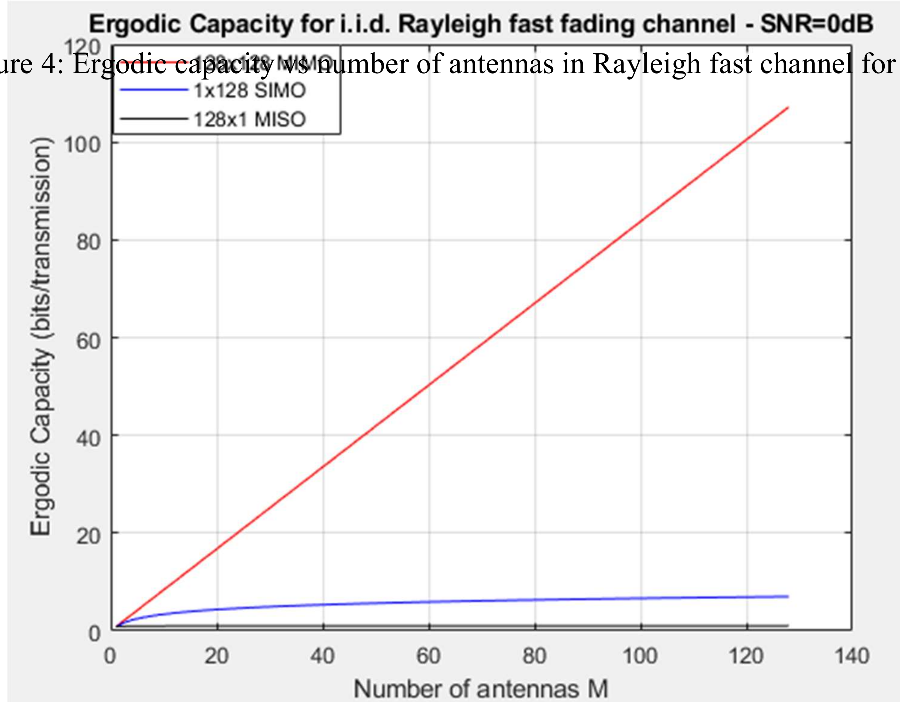

Figure 5: Ergodic capacity vs number of antennas in Rayleigh fast channel for 128 x 64

Then, the proposed design has been simulated according to the normalized array factor radiation pattern with Zenith angle as a comparison with 64 x 64 as shown in figure 6 and figure 7, assuming the distance between elements are same which is 0.5 λ, it is shown there will be two main lobes in 128 x 128 proposed massive MIMO design and the side lobes decreased which causes improvement in the coverage and signal quality.

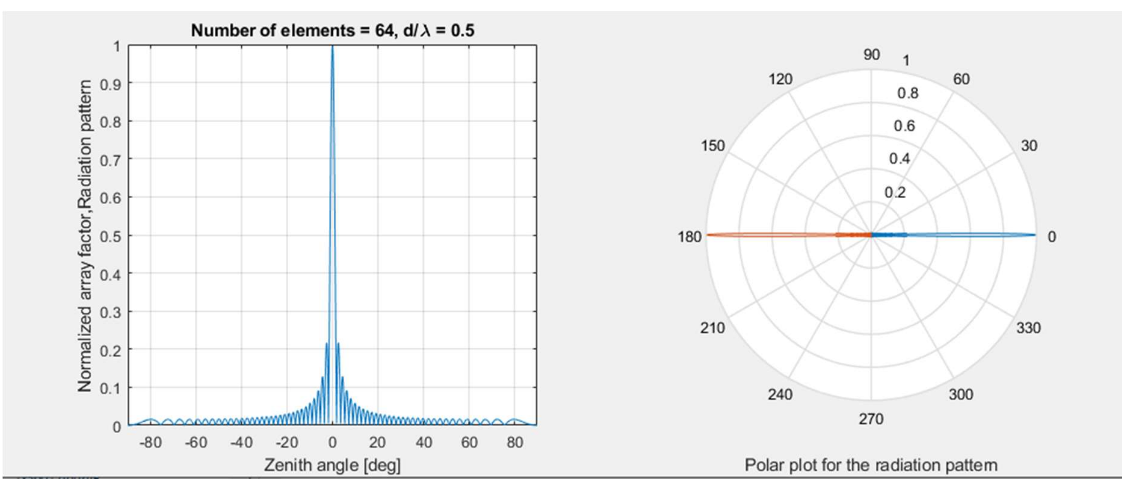

Figure 6: Normalized array factor radiation pattern versus Zenith angle for 64 x 64 MIMO

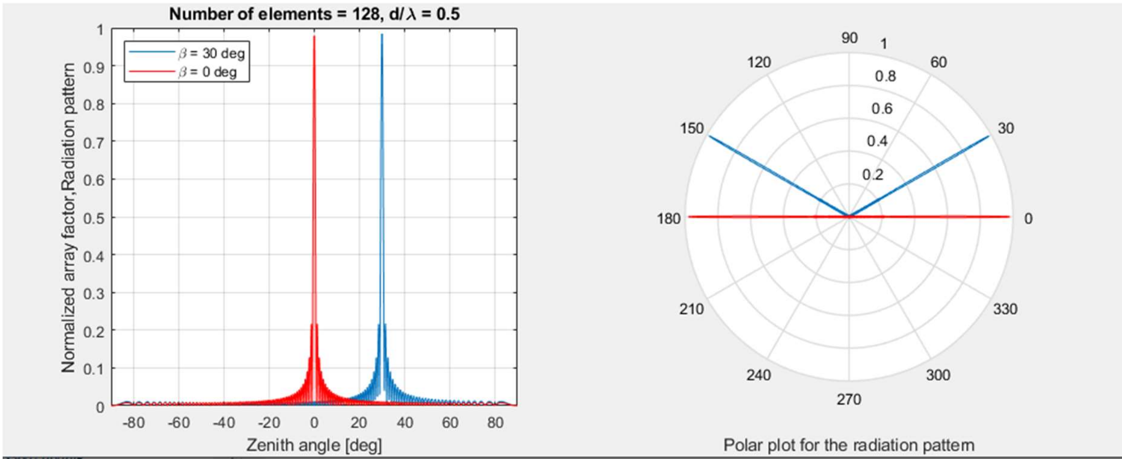

Figure 7: Normalized array factor radiation pattern versus Zenith angle for 128 x 128 massive MIMO

Conclusions

This paper is a contribution in the field of 5G mobile system, a proposed massive MIMO 128x128 has been presented, MIMO parameters has been simulated in the proposed design, and compared to that in 64x64 MIMO, it is shown that there will be improvement in the Ergodic capacity, data rate, also, as shown the radiation pattern as a function with Zenith angle the proposed massive MIMO there will be improve in the main lobe and decrease in the side lobes which leads to better coverage and signal quality.

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