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Research Article

Monte Carlo Channel Estimation Simulation in MIMO-OFDM for New Radio signals for Precise indoor signalling and Carrier phase reception in 5G Network

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ARTICLE INFO	ABSTRACT

The initial phase in finding 5G New Radio (NR) cells is to conduct a thorough analysis of the system's cross-layer frame structure. A PSS temporal synchrony approach is suggested for MATLAB simulations with frequency offsets because of how well it works. Crucial for high-speed wireless communication is multiple-input multiple-output orthogonal frequency division multiplexing, which can achieve spectral efficiency and prevent multipath fading. To recover supplied data effectively, receivers in MIMO orthogonal frequency division multiplexing systems need to make correct channel estimates. The efficacy of Monte Carlo estimation in MIMO-OFDM systems is investigated in this paper using Monte Carlo simulations with basic channel conditions.

Keywords: 5G New Radio, MIMO-OFDM, subcarrier spacings, software defined radio.

I. Introduction

New technologies that enhance wireless communication are crucial in an era when having digital connection is a need, not a luxury. Among the most recent developments in this field is multiple input/multiple output (MIMO), a game-changing method for improving the performance and dependability of wireless networks. Multi-input multiple-output (MIMO) technology allows for more efficient data exchange and greater capacity channels via the use of several antennas for transmission and reception, which is crucial in the dynamic world of digital interaction. Beginning with a brief overview of the technology and its usage in OFDM (Orthogonal Frequency Division Multiplexing) to optimise spectrum efficiency, this article delves into the complexity of MIMO. Increasing data throughput and signal quality are only two of the many benefits of using a system that employs many inputs and outputs. A better user experience is the sum of these benefits. Further analysis of MIMO's implementation in existing wireless standards reveals the critical role it will play in shaping the future of global connectivity[1][2]. In today's wireless landscape, MIMO is more crucial than ever, and this comprehensive analysis will show readers why. Multiple input multiple output (MIMO) is a very effective antenna technique in the field of wireless communications. A number of antennas are installed at the respective sites of the transmitter and the receiver. This setup substantially boosts the capacity of radio transmissions by lowering error and increasing data speed by enabling data to go along several signal paths simultaneously. By sending out several copies of the same signal, multiple-input multiple-output (MIMO) technology reduces the amount of noise and increases the rate of correct transmission[3]. With a more steady connection and less congestion, the likelihood of data reaching the receiving antenna unaffected by fading rises due to this redundancy. Single-input, multiple-output and multiple-input, single-output antenna technologies provide the basis of multiple-input multiple-output. By using several antennas to transmit and receive different data streams concurrently over a single radio channel, MIMO has enhanced these ideas. Once a source of interference, this technology now uses multipath propagation—the process by which transmitted information bounces off objects and reaches the receiving antenna—to enhance communication. When compared to wireless networks that rely just on multiple antennas, MIMO vastly improves transmission and reception speeds, reliability, and efficiency. These days, this technology forms the foundation for wireless communication protocols[4][5].

MIMO in Recent Wireless Systems

Wi-Fi: Multiple Input and Multiple Output technology that uses many transmitters and receivers to send more data Simultaneously, is supported by all 802.11n wireless equipment. 802.11n can achieve faster rates than devices that lack this feature. MU-MIMO technology was added with the transition to Wi-Fi 6 (802.11ax), increasing the maximum number of users that a single access point could accommodate. As a result of this substantial improvement over the earlier single-user MIMO (SU-MIMO), MU-MIMO is now an essential component of the Wi-Fi 6 protocol, which developed from 802.11ac.

Advanced LTE and LTE: In order to improve system efficiency and achieve greater peak rates, the Third Generation Partnership Project has merged multiple input and multiple output technologies into LTE. These technologies uses beamforming, transmit diversity, and spatial multiplexing. By utilising Multiple Input and Multiple Output's additional capabilities, 3GPP's LTE-Advanced extension seeks to meet the standards of the International Telecommunication Union Radiocommunication Sector for IMT-Advanced[3][6]. With a 20 MHz transmission bandwidth, 2x2 MIMO, and 64QAM, LTE Rel. 8 introduces Single-User MIMO (SU-MIMO) for the downlink, attaining target data rates of over 100 Mbit/s.

5G New Radio: 5G New Radio fully supports 5G NR Massive Multiple Input and Multiple Output, a general advancement in wireless communication technology. Because it extensively uses additional radio links to dramatically increase network capacity, user throughput, and coverage, Massive Multiple Input and Multiple Output, or MIMO, is a key component of 5G deployments. In mid-band TDD spectrum, MIMO has become the preferred choice for new 5G deployments. It improves both downlink and uplink performance by using multi-antenna techniques like beamforming, null forming, and spatial multiplexing[7]. The importance of 5G types of new radio broadcasts in today's rapidly evolving digital ecosystem cannot be overstated. Understanding the subtleties of the 5G network's signaling is essential with its launch. So, what is 5G NW signaling exactly? Within the framework of the 5G network infrastructure, it speaks of the communication protocols that offer seamless connectivity and data transfer.

Types of new radio signals in 5G: the different new radio signal types which make up the 5G network is essential for the significance of 5G NW signaling. 5G introduces three main types signal:
1. Enhanced mobile broadband (eMBB),
2. Massive machine-type communications (mMTC), and
3. Ultra-Reliable low latency communications (URLLC). consumers needs fast gaming, smooth streaming, and high-quality video conversations, eMBB concentrates on providing high speeds and more bandwidth[8]. However, massively Multicast/throwable Cloud (mMTC) networks are built to handle the IOT's huge connection demands. It gives intelligent infrastructure, linked homes, and smart cities by providing a large number of devices to connect at once. The third signal type URLLC aims to offer dependable and low-latency communications, which uses like remote surgery and driverless cars.

The NR signals of 5G are significant because they fulfil the fundamental promise of next-generation networks; in other words, they constitute a tool for achieving the goal. One solution to the issues of on-demand connection and the exponential increase in data quantities used is 5G signals. 5G broadcasts have many advantages over its predecessors, one of which being faster speed. This paves the way for the possibility of streaming high-definition material, more immersive experiences, and applications that work in real-time. A greater number of users may establish simultaneous connections to the same radio network[9]. A linked world where objects may readily communicate is being made possible by the Internet of Things, which is using bigger bandwidth. Low latency, or the amount of time it takes for data to travel from its destination to its source, is another much-requested characteristic of 5G's new radio waves. No one will use virtual reality if their eyes are two seconds behind their minds, therefore this functionality is crucial in situations when things need to happen rapidly, such with driverless automobiles or virtual live stars[10]. Consequently, all future technologies become feasible when there are little apparent delays.

Strengths of 5G network signaling: 5G network signalling has several advantages beyond only speed and latency. There are a lot of benefits to 5G signals that make them practically necessary for the next coherent connection level. First, there's the issue of capacity and dependability. Signalling protocols provide dependable and high-capacity operation since they are designed to manage the resources of the networks. Important industries like healthcare or maintenance rely on it heavily. The improved energy efficiency is the second[11]. Products on the market also contribute to people's efforts to reduce energy use. Reduced environmental impact is a direct result of 5G signals' enhanced power efficiency, which benefits powered devices. Network slicing, made possible by 5 G network signalling, further allows for the physical network to be partitioned into many virtual networks. As a result, service providers can guarantee the best possible speed and quality of service for all use cases by allocating network resources correctly[12]. Dedicated resource-intensive fields, such as public safety and industrial automation, may benefit from the offered capability.

Key features and capabilities of 5G network signaling: 5G signalling is radically different from its predecessors since it is built on cutting-edge technology and communication protocols, which give it a plethora of new features and possibilities. The 5G network signal stands out because of its AI capabilities, which allow the network to self-manage in a more intelligent and efficient manner, use predictive analytics to anticipate demand and optimise capacity in advance, and make a plethora of automated decisions and optimise tasks independently. The integration of AI into 5G signals will allow them to dynamically adjust to the present, resulting in optimal utilisation of resources and a seamless user experience[13]. An additional crucial aspect of the 5G network signal is the ability to display network parts. Network slicing allows for the creation of virtual circuits that are optimised for certain functions or kinds of enterprises, as mentioned before[14][15]. Each network slice may have its own distinct set of features, security protocols, and service quality standards, which allows for the specific needs of diverse use cases to be satisfied. Future 5G network signalling that incorporates AI and network slicing will use sophisticated modulation techniques, beamforming, and MIMO technology. These methods will boost network performance by increasing spectrum utilisation, expanding coverage, and enhancing signal quality.

5G network signaling protocols and standards: It was necessary to implement new protocols and standards in order for the 5G network to allow for smooth communication between fixed and mobile networks. Data transmission, the signalling mechanism, and network administration are all governed by these protocols. The 5G Network Signalling Protocol is primarily supported by 3GPP, a worldwide organisation responsible for standardising and maintaining the protocols for the 5G signalling connection. From protocols for radio access networks (RANs) to protocols for cell radio systems (CRSs), the 3GPP (Third-Generation-Partnership-Project) has developed a plethora of standards. The NG core (NGC) contains the structural design of the core network and protocols, while 5G New Radio (NR) embodies the air interface and physical layer characteristics; they are some of the fundamental signalling services and specifications of the 5G network[16]. The 5G network signalling components of the network equipment makers and service providers will cooperate and be linked via the establishment of such protocols and standards, allowing for a strong and efficient network architecture. Challenges and considerations in implementing 5G network signaling: While the very notion of a 5G network making use of self driving cars and devices to exchange information more swiftly is captivating, the process, bringing it to the people, is not an easy task. Therefore, these factors have to be handled so that 5G signals can be shown as completely promising. Among the main obstacles are the problems of the infrastructure deployment as such. To ensure the building of a strong and reliable 5G network, one is prone to allocating a lot of resources to the erection for the new network base stations, antennas and backhaul infrastructure. Besides that, the use of small cells and the network indensification are fundamental to the virtuous improvement in the 5G signals capacity and scope. The last but not least thing is that the allocation of spectrum must be conducted. The signals of 5G need the use of a whole bunch of frequencies bands of different sorts, including the low-frequency and the high-frequency bands[17]. The allocation and coordination of frequency resources among operators and services operate at different wavelengths, like radio and television, are faced with limited spectrum resources which in turn need to be properly managed otherwise, interference ensues, and efficient utilization is compromised. Security in handless 5G communication signaling is another crucial factor where robust compliance and encryption systems should be deployed to protect the entire network.

The role of 5G network signaling in enhancing network performance: Signaling in the 5G network network is the crucial thing not only what we should be asked to put emphasis at but also it how could be efficiently used and thus helps reducing times of latency and at last overall improving network reliability. One of the primary reasons of dynamic spectrum sharing in 5G networks leading to better performance is that it utilizes this feature. It allows different operators to simultaneously use a part of the same spectrum resource, i.e., it improves the utilization of the available frequency and enhances the network capacity at the same time[18]. The Dynamic Spectrum Allocation for 5G technology grants the opportunity to change the actual working conditions based on traffic so the performance will always be optimal. Besides, 5G network signaling can make possible the implementation of a network slicing that was discussed before. By dynamically allocating spectrum based on demand, 5G signals can adapt to changing traffic patterns and ensure optimal performance. Additionally, 5G network signaling enables network slicing, as mentioned earlier. Through Splitting the spectrum so that 5G traffic can adjust to traffic patterns and so that 5G networks perform the best. Besides, 5G is part of an overall 5G network signaling that allows the network slicing, as was already mentioned above. Thus, the network is able to maximize performance by allocating specific resources that are more tailored for either a particular application or a type of industry based on their unique use. This provision would guarantee that the tools which require higher quality of bandwidth, lower latency and redundancy would be given priority over those which do not have such a harming effect on the performance of the network[19]. Also, the signaling signals 5G network radios make use of beamforming technology, which improves the coverage quality and coverage. The beamforming process works this way: low-angle transmit and receive beams with little interference and high signal strength in the intended points. This is why we have less congestion and so a better network performance and a user experience with no huge volatilities.

Future prospects and developments in 5G network signaling: 5G signal are supposed to be the thing for the next years implying further development and great breakthrough. Because the technology is rapidly going ahead, new breakthroughs and capabilities will be brought forward in future, leading to the further improvement of 5G capability. One of the most important areas of development is the performance of edge computing, signaling 5G network. Edge computing literally moves the processing of rate closer to the edge of network reducing in turn latency, and enabling instant processing of data. Through combining edge computing with 5G transmissions, applications that with demands for super-low latency and immediate response, such as the self-driving cars and AR/VR technologies, can be fully liberated. One more aspect of our concentration is the taking of 5G in together with other emerging technologies for instance blockchains and virtual reality[20]. Effective utilization of these capabilities can lead to modernization of business models as well as varied applications, increasingly extending the application of 5G network signaling in other fields. The success in this case also gaps the improvement in power consumption of various elements of the signaling network, through the continuous research and development efforts. Additionally, the efforts to constantly research and develop 5G network signaling for increasing its energy efficiency will continue. Efficient and reduced energy utilization combined with the emission can lead to a more environmental-friendly and ecological future. In final, the principal role of 5G network signaling on the future of communication with its present scenario is very significant. It elevates speed and capacity many times and decreases the latency to the level that used to be impossible before. Such changes are as the foundation of the new ideas and the economic growth. Apprehension of various emerging radio signals of 5G and benefits they provide and challenges they come up with should be patietntly studied both for businesses and personalities[21]. In the emerging era of connectivity we are stepping into, types of NR new radio signals will not only change the way we speak, work and live in the digital world but also make digital life so convenient for us[22].
To accommodate a wide range of services across several frequencies and deployment types, 5G NR has an extendable set of CP-OFDM parameters and a scalable OFDM numerology (see Table).

Table 1. Resource within an SSB block for PSS,SSS,PBCH and DM-RS for PBCH

RESOURCES WITHIN AN SSB BLOCK FOR PSS, SSS, PBCH, AND DM-RS FOR PBCH

Channel or signal	OFDM symbol number l relative to the start of an SSB block	Subcarrier number k relative to the start of an SSB block
PSS	0	56,57, ... ,182
SSS	2	56,57, ... ,182
Set to 0	0	0,1, ... 55,183,184, ... 239
	2	48,49, ... 55,183,184, ... 191
PBCH	1, 3	0,1, ... ,239
	2	0,1, ... ,47,192,193, ... ,239
DM-RS for PBCH	1, 3	[0,4,8, ... 236] + V
	2	[0,4,8, . . . 44] + V [192,196, . . . 236] + V

Time-frequency resources are used for transmission via the physical layer in 5G NR. One subcarrier in a single OFDM signal, known as a resource element (RE), makes up the lowest physical time-frequency resource. Groups (or groups) of twelve subcarriers, or physical resource blocks (PRBs), are used to schedule the transmissions. The resources for time-frequency is illustrated in Figure below

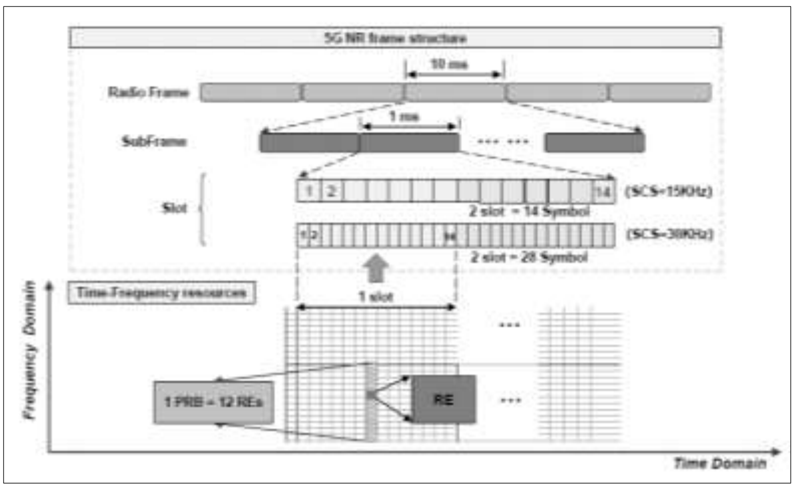

Fig. 1. 5G NR time-frequency resources and frame structure.

where the time domain is used to organise the transmissions of the physical signal into signal frames, subframes, and slots. Each of the ten subframes that make up a signal frame has a length of one millisecond. A subframe is made up of one or more slots that are next to one other. The studies conducted in this paper used a 30 KHz subcarrier spacing setting, which results in two slots per subframe and fourteen OFDM symbols per slot. [24].

Due to unpredictability in synchronisation signals and frame design in Near Radio, a thorough initial cell search is essential to establish up downlink synchronisation between user equipment and base station. A PSS temporal synchronisation approach is suggested, which proves to be more efficient than the conventional cross-correlation technique in MATLAB simulations with a frequency offset. We do this by looking at MIMO-OFDM systems through the lens of Monte Carlo (MC) estimation, a fundamental method for channel estimation. Combining MIMO's spatial diversity with OFDM's multi-carrier modulation yields substantial benefits for wireless communication; this technique is known as MIMO-OFDM. Nevertheless, multipath fading and other distortions introduced by the wireless channel may significantly impair system performance. Estimating channels is to Increasing the SNR leads to an improvement in the MSE of MC estimate. An improved channel estimate is achieved as the signal-to-noise ratio increases.

A technique known as carrier frequency measurement may be used by the receiver to ascertain the degree to which the received signal is out of phase with respect to the transmitting signal [1]. It is critical to look at the carrier phase range for accurate positioning. Although OFDM systems have seen extensive usage, global positioning satellite systems (GNSS) are still in their infancy. The use of carrier phase technology allows OFDM systems to attain better levels of location accuracy. Multipath and non-line-of-sight propagation are two important phenomena that impact the carrier phase. The question of where exactly to put the two carrier phases must also be resolved. We provide a carrier phase-based ranging algorithm that works in a multipath setting.

In response to the global rollout of 5G cellular networks, new approaches have been developed to improve the precision of wireless indoor locating systems[2–5]. In this research, we take into account the widely utilised and standardised 5G new radio technology (NR) when we analyse indoor location. Finding the start of the sync signal block is the first step in achieving coarse sync. Universal Software Radio Peripheral (USRP) (SSB) is the basic signal aggregation tool for the newly-developed 5G New Radio (NR) and Software-Defined Radio (SDR). One of the fundamental features of 5G-NR is the use of FFT-domain signal processing to enhance the spectral efficiency of OFDM-based waveforms [6-8]. By using the Fast Fourier Transform (FFT), a linear approximation technique known as fast-convolution (FC) filtering constructs efficient block-wise circular convolutions. The answer lies in the use of overlapping processor blocks. The FC processing may have a major effect on the OFDM signal creation and the subband filtering done at the receiver. Think about the unconventional NR of 5G and how it may be used in mixed numerology. Frames in continuous overlaying save and add systems with constant block size and overlap cannot be synchronised with OFDM symbols and FC processing blocks [9–12]. This paper develops a more effective FC processing method to address the issues with 5G-NR numerology, which prohibits transformation durations less than 128 and allows non-integer cyclic prefixes. The use of 16-point transformations for a subband allocation covering 12 subcarriers is made possible by the extrapolation approach, which greatly simplifies implementation. Synchronising FC-processing blocks with each OFDM signal is one way to reduce complexity and time.

Base stations for 4G LTE and 5G New Radio (NR) mobile phone networks are examined in this study, along with the processing challenges, implementation issues, and effectiveness of OFDM-based radars. The difficulties of frequency-domain radar processing and the unused MGCGDT subcarriers in the LTE and NR broadcast pass-band are the first topics covered. Developing and implementing an efficient interpolation method reduces the influence of unused subcarriers on radar processing. Accurate target locations, distances, and velocities have been demonstrated in simulated circumstances. The high data speeds and flexible subcarrier spacing of 5G NR waveforms make them ideal for use in sensing systems and radar. An accurate indoor positioning system is becoming more and more important. Since it could be difficult to receive satellite navigation signals inside, other high-precision positioning alternatives must be considered. Using wireless location services has been more popular in the last several years[17–19].

Even in densely populated urban areas, it is feasible to use a mobile phone network to pinpoint an inside location. Since 5G technology was introduced, there has been a lot of study focused on high-precision locating via the wireless access network. Time of arrival (TOA), relative position (RSS), and angle of arrival (AOA) are three ways that wireless networks may determine a user's precise location (TOA). By replacing the user's position with the terminal's relative orientation to the base station (BS), AOA allows for a more accurate location calculation [20].

Unfortunately, AOA's usefulness is restricted because to the high number of antennas that must be present at the receiver in order for it to function. Accurately representing the energy lost by signals is crucial when using RSS technology for measurements; otherwise, very precise findings will not be obtained. In time-of-arrival (TOA) based positioning systems, the arrival time is used to calculate the distance. More and more people are using TOA since it may be used with simpler positioning equipment. Developing accurate TOA measurement and location methods using OFDM is the primary goal of this work [21–23].

Most current radio access networks employ orthogonal frequency-division multiplexing (OFDM) as its multicarrier modulation technology. Simple integration of multiantenna schemes into physical layer processing of OFDM, subcarrier division, and cyclic prefix (CP) all make effective spectrum resource management much more accessible. Without accurate spectrum localization, developing scenarios for spectrum use, such as mixed numerology and asynchronous multiple access, becomes very challenging. These scenarios involve changing frame structures, subcarrier spacings (SCS), symbol and CP lengths to meet different service requirements. Due to its complexity, prior methods based on time-domain filtering are difficult to use. If you go with a more conventional (polyphase, for instance) filter bank idea, the subband widths and centres would not be as flexible, but it might be easier. Because FC is a block-wise processing system, it doesn't matter how long a block is; the bits of OFDM symbols that matter may be anywhere in a transmitted OFDM signal frame. The CP lengths and usable symbol durations must be integer multiples of the sampling rate that is smaller than the rate necessary for transmitter OFDM in order to use the typical continuous processing model. This raises the computing complexity and narrows the range of possible transform sizes. A 16-bit transform is enough if a 4G or 5G subband in telephony only has one physical-layer resource block (PRB). Both time-domain filtering and FC-based continuous processing systems are impacted by this limitation.

A revolutionary technique, Multiple-Input Multiple-Output Orthogonal Frequency Division Multiplexing (MIMO-OFDM) has just arisen in the dynamic world of wireless communication. Enhanced spectral efficiency and strong defence against multipath fading are two of the many benefits offered by this novel method, which combines the spatial diversity of MIMO with the multi-carrier modulation of OFDM.

But, distortions may be introduced by the wireless channel due to its intrinsic complexity, which might compromise the system's performance. To reduce these distortions and allow the receiver to successfully retrieve transmitted data, accurate channel estimate is crucial. Using extensive Monte Carlo simulations designed for MIMO-OFDM systems functioning in New Radio (NR) 5G networks, this research explores the complexities of MC estimation, a crucial channel estimate approach, and assesses its effectiveness.

The Crucial Function of Channel Estimation in MIMO-OFDM Networks: As a double-edged sword, the wireless channel introduces multipath fading and offers potential for spatial multiplexing in MIMO-OFDM systems. To make the most of the channel's positive aspects while minimising its negative ones, accurate channel estimate is crucial. The receiver is able to adjust for distortions and retrieve data reliably by precisely describing the channel impulse response (CIR).

In order to estimate, the Monte Carlo method takes use of the channel's statistical characteristics and the known pilot symbols that are part of the OFDM signal. To account for channel uncertainties, this technique creates several random noise realisations by utilising the link between the received and broadcast pilot symbols. Ultimately, the channel estimations are averaged over these realisations.

II. LITERATURE SURVEY

Sr. No	Author Name	Title	Journal	Summary
1	JuhaYli-Kaakinen; Toni Levanen; Markku Renfors	"FFT-Domain Signal Processing for Spectrally-Enhanced CP-OFDM Waveforms in 5G New Radio	Xplore:, vol. 35, no. 4, pp. 2032-2039, 21 February 2019.	Orthogonal frequency-division multiplexing (5G New Radio) waveforms will be built on this technology, but modern transmission settings require improved OFDM spectrum. Fast convolution computation and receiver-side subband filtering are adaptable and successful technologies. Circular convolutions based on fast Fourier transform can efficiently combine processing blocks, but block size and overlap are fixed in 5G NR.
2	Liang Chen; Xin Zhou; Feifei Chen; Lie-Liang Yang; Ruizhi Chen	"Carrier Phase Ranging for Indoor Positioning with 5G NR Signals",	IEEE Internet of Things Journal, vol. 66, no. 2, pp. 1108-1118, 13 November 2021.	Indoor positioning is crucial for AI and IoT development, but accuracy remains a challenge due to interior complexity. 5G cellular networks could improve wireless indoor positioning systems. This study evaluates indoor location using 5G New Radio, using an indoor locating system and a software-defined receiver to achieve coarse synchronization.
3	Ramesh Chandran; Amarpreet Singh	Sethi "A Novel Method for Pilot Pattern Selection in 5G NR Systems"	IEEE Xplore Volume: 35, Issue: 2, 05 May 2021	The Third Generation Partnership Project developed 5G New Radio (NR) to meet diverse performance needs, enabling simultaneous linking of mobile devices. However, channel response estimation is challenging due to configuration options and higher frequencies. The effectiveness and choice of pilot patterns have not been thoroughly explored using channel estimate methodologies.
4	Young-Hwan You; Hyoung-Kyu Song	"Efficient Sequential Detection of Carrier Frequency Offset and Primary	IEEE Transactions on Vehicular Technology Volume:	This study presents a new technique for identifying the principal synchronization signal in 5G IFOs, estimating the IFO despite prior knowledge.

		Synchronization Signal for 5G NR Systems"	69, Issue:8, Aug. 2020	Simulations and theoretical analysis support efficiency and ease of implementation.
5	Karina Fors; Erik Axell; Sara Linder; Peter Stenumgaard	"On the Impact of CW interference on 5G NR"	IEEE **Xplore**Volume: 36, Issue: 2, 17 October 2019	OFDM should be included in DAB, DVB, and LTE specifications, and is the future standard for 5G mobile networks. This study tested 5G New Radio's robustness against continuous wave interference. Limiters like frequency limiters and temporal domain limitations can enhance CW's resilience to interference, reducing the effects of single CW signals and maintaining original power levels.
6	Elena Peralta; MikkoMäenpää; Toni Levanen	"Reference Signal Design for Remote Interference Management in 5G New Radio"	IEEE Xplore Volume: 13, Issue: 2, 15 August 2019	This study explores the use of distant interference in 5G New Radio deployments. It explores two remote interference management designs and a receiver detection processing framework. The initial signal architecture is based on 5G NR channel state information reference signals, with the OFDM symbol-based RIM-RS architecture suggested for Long Term Evolution. Different parameterizations are used to compare solutions with real-world interference scenarios.

III. METHODOLOGY

The ability of cellular signals to navigate is severely limited. Certain receivers are necessary to decipher cellphone signals for navigational reasons. In addition to line-of-sight broadcasts, multipath signals are also received since cell towers sometimes transmit at low elevation angles. Because the receiver doesn't have access to the base stations' clock biases, we need to estimate them. Then, we need to characterise the achievable ranging accuracy in both multipath-rich and multipath-free environments. Finally, we need to develop a navigation framework that can use the derived navigation observables to find the receiver. It is possible that the anticipated navigation observables are inaccurate due to multipath.
A special kind of receiver called an LTE software-defined receiver (SDR) can take in several eNodeB LTE signals, store and track them, and then use that data to get crucial navigational information. the third It is possible to generate NR by using the carrier phase and coding of LTE transmissions. looking at how often the Doppler effect happens. It is also important to consider how well the measurement results are derived from the signal-to-noise ratio (SNR) and transmission bandwidth of the input signal.
In the end, this comprehension is necessary for our own gain. The secondary synchronisation signal (SSS) of LTE is preferred because of its large transmission bandwidth and the superior accuracy of CRS, which is unique to LTE cells, compared to a traditional reference signal. Thirdly, many separate frameworks for receiver-locating have been detailed, some of which are freestanding and others that are not.

Even in an unknown beginning condition, an LTE signal may be able to establish the receiver's arrival time and direction. Simultaneously collected and monitored by signal detection receivers (SDRs) are LTE TOA and DOA.
The ever-growing list of uses for mobile communications will only quicken once 5G becomes accessible. Increases in spectrum efficiency won't be enough to keep up with the massive demand surge; additional spectrum is required.
Included in Release 15 is comprehensive data on many spare spectrum blocks designated for non-renewable deployments. Between 2.50 GHz and 40 GHz is a possible frequency range for them. The intended frequencies for a faster deployment are 3.4 GHz to 5.0 GHz and 3.3 GHz to 3.8 GHz.
The United States, Europe, and even certain parts of Asia have all released the 3.3 GHz to 3.8 GHz spectrum, thus deployment might begin as early as 2018. 5G is expected to use even more expansive frequency ranges than those below 40 GHz, with speculation circulating about the possibility of using frequencies as high as 86 GHz.
One of the first decisions made for the 5G New Radio was to include an OFDM variation into the waveform. Since it was compatible with 4G, newer Wi-Fi standards, and many other systems, it became the perfect waveform for 5G's many uses. New optimisation opportunities arise with the increased processing capability of 5G.
The reference explains how the development of carrier phase technology might greatly improve the accuracy of indoor locating systems. The versatility of wireless networks is superior to that of GNSS positioning when it comes to error sources, route losses, and combinations of carrier frequencies.
Within the scope of this article, a carrier phase-ranging method based on OFDM is introduced. This study aims to quickly resolve integer ambiguity and monitor carrier phase in a multipath scenario in order to meet the high accuracy requirements.

Next, we'll take a look at why integer ambiguity occurs in a multipath setting. To clear up any uncertainty about integers, we recommend using an EKF, or enhanced Kalman filter. You may find the terminal's position and remove integer ambiguity using the EKF-based method. The EKF can aid in reducing errors in non-line-of-sight propagation.

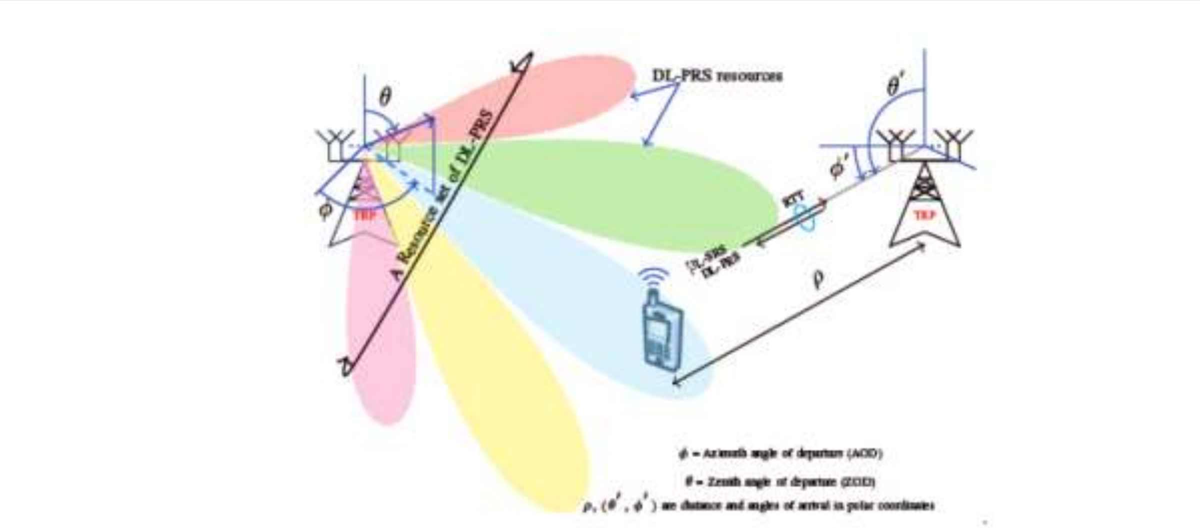

FIGURE 2. This is an example demonstrating the use of NR for placing a few components. Beams are presented as resources, and groups of beams are shown as collections of resources. The multi-RTT and angle-based positioning techniques now supported by the system are shown as an example. (Source: arXiv:2102.03361v1)

IV. PROPOSED METHOD

This research allows us to compare and contrast the downlink performance of mm Wave and LTE technologies in the same conditions with the same Base Station locations (BS). By using this cutting-edge ray-tracer, we are able to reproduce the channel's spatial properties, such as arrival and departure angles (AOD), for mm Wave antenna beam patterns. By doing so, we may potentially learn how spatial multiplexing and MIMO beamforming affect spectral efficiency at millimeter-wave frequencies. A comprehensive coverage map cannot be created without first converting channel data into bit rate measurements at the link level. Our method relies on selecting appropriate coding and modulation techniques (MCS), even if prior methods used Shannon's formula to estimate SINR. The bitrate for a certain MCS is defined by taking the physical layer overhead into consideration. Multiple sorts of systems were investigated, spanning from the most fundamental (SISO) to the most sophisticated (MIMO). We further investigated whether spatial multiplexing (SMP) and minimum ratio transmission (MRT) beamforming approaches may be beneficial for multiple-input multiple-output (MIMO) systems (SM).

Here are the primary findings of the study: The SINR in non-line-of-sight (NLOS) zones is noticeably low when using the SISO mm Wave architecture because to the substantial drop in bitrate induced by diffraction loss.

The average bandwidth improves by 72% when comparing the SISO architecture to LTE, however the coverage reduces by roughly 50%. Given its low cost, SISO architecture could be a good investment for public areas.

To compensate for diffraction loss, researchers are looking at advanced multiple-input multiple-output (MIMO) technologies that use phased array antennas and have beamforming capabilities. With its improved range, the MRT setup can now compete with LTE in terms of total coverage. This MIMO configuration is perfect for densely populated areas with widespread non-line-of-sight (NLOS) gaps.

When MIMO is set up with SM, the average bitrate is increased by 6.7 and the maximum bandwidth is doubled by 27, while the coverage loss is only 24%. places with poor coverage, not in the line of sight, and needing a lot of transfer rates.

Millimetre wave (mm Wave) communications might make it simpler for future wireless network generations to process the massive amounts of data. Significant transmission inefficiencies and air attenuation restrict the range of the mm Wave networks. It may be possible, though challenging, to extend the range of millimetre wave communications by the use of elevated, steerable antennas and multiple-input multiple-output (MIMO) beamforming capabilities. Using the latest 5G mobile network NR standard, this study aims to analyse millimeter-wave communication. Afterwards, we switch gears and compare NR's performance against that of the 4G long-term evolution (LTE) standard on an imaginary but real university campus. Limitations on the physical layer include things like transmission power, background noise, receiver noise figure, actual antenna gain, and what-not. More so, this work demonstrate the impact of MIMO on the throughput of a 5G NR mobile network.

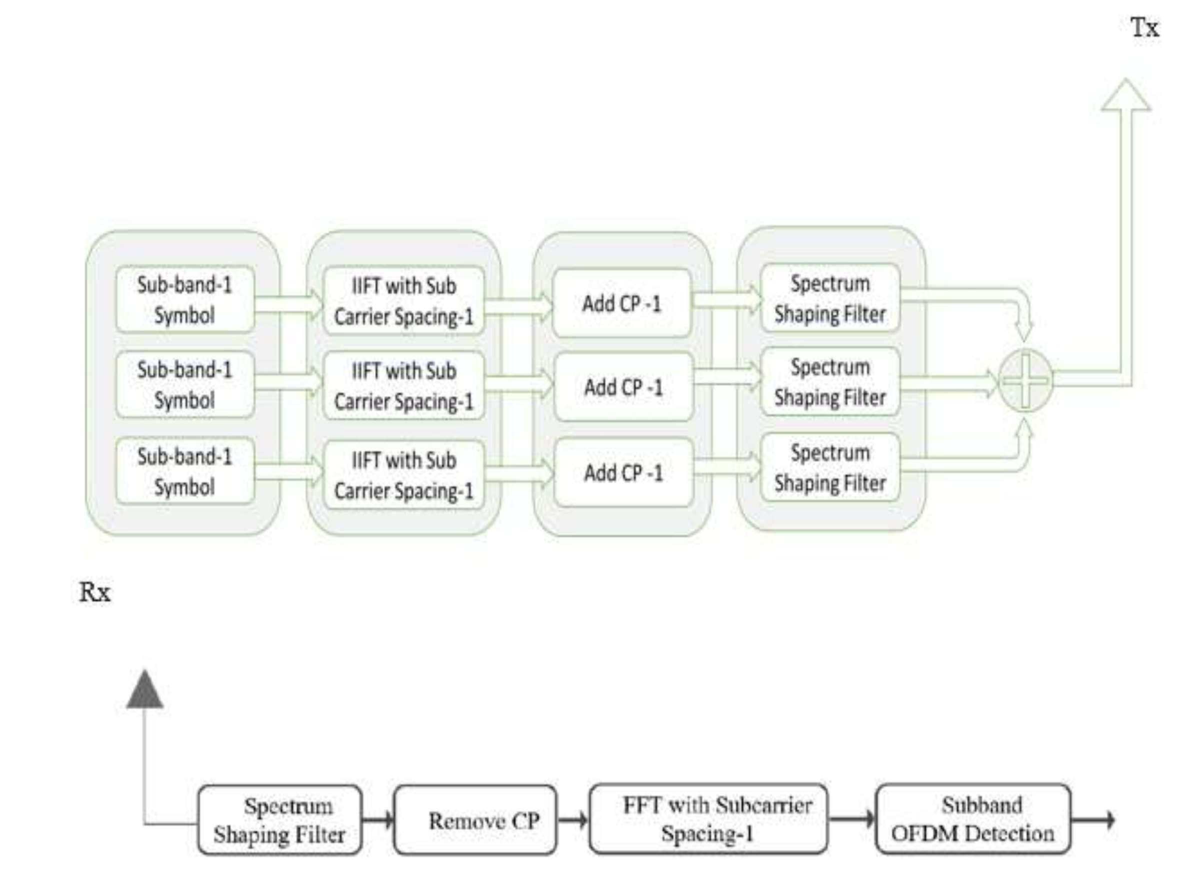

FIGURE 3. The adopted waveform for 5G NR

V. Monte Carlo Channel Estimation

Monte Carlo (MC) estimation is a straightforward approach for channel estimation in MIMO-OFDM systems. It leverages the statistical properties of the channel and knowledge of the transmitted pilots to estimate the CIR. Here's the basic principle:

1. Pilot Design: Known pilot symbols are embedded within the OFDM symbol. These pilots occupy specific subcarriers and carry predetermined information.

2. Received Signal Processing: The received signal is down converted and processed to extract the pilot subcarriers.

3. Channel Estimation: The relationship between the received pilot symbols and the transmitted ones is exploited to estimate the channel coefficients. In MC estimation, numerous random noise realizations are generated to account for channel uncertainties. The estimated channel is then obtained by averaging the channel estimates across these noise realizations.

III. Monte Carlo Simulation Setup

We evaluate the performance of MC estimation through Monte Carlo simulations using a MATLAB framework. The simulation setup includes the following parameters:
In this code we consider the least square error channel estimation for a MIMO OFDM system.

1. Input Parameter

Number of Blocks =	1e2
Number of transmit antennas =	2
Number of receive antennas =	3
Number of subcarriers =	128
Guard interval percentage =	1/4
QPSK Modulation =	4
Subcarrier space between two pilots =	1

2. Channel Parameters

Signal to Noise Ratio = 15
Number of taps in each transmit-receive antenna = 6

3. Control Parameters

ofdm.ifDemodulateData = 1; >>>> (1,0) if 1, the code demodulates the transmitted via LS data and calculates the BER
ofdm.ifDisplayResults = 1; >>>> (1,0) if 1, display the results in the command window

IV. Simulation Results and Analysis

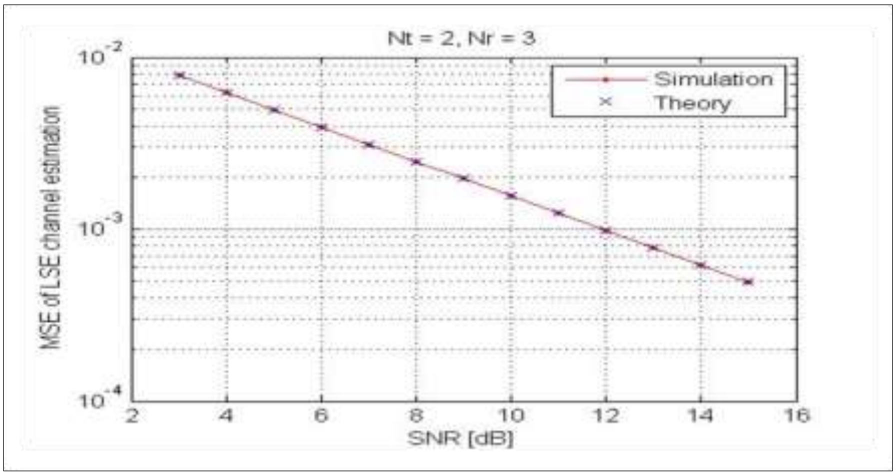

FIGURE 4. MSE of LSE channel estimation Vs SNR

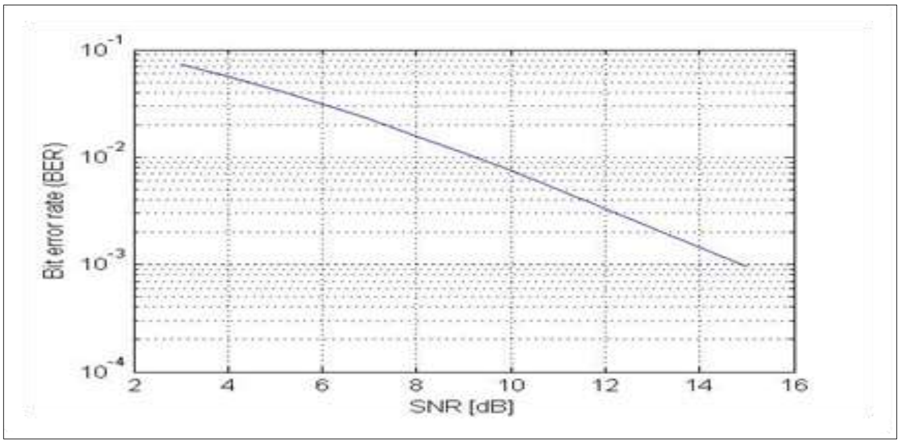

FIGURE 5. Bit Error Rate (BER) Vs SNR

1. Input Parameter

Number of Blocks = 1e2
Number of transmit antennas = 4
Number of receive antennas = 8
Number of subcarriers = 128
Guard interval percentage = 1/4
QPSK Modulation = 4
Subcarrier space between two pilots = 1

2. Channel Parameters

Signal to Noise Ratio = 15
Number of taps in each transmit-receive antenna = 6

3. Control Parameters

ofdm.ifDemodulateData = 1; >>>> (1,0) if 1, the code demodulates the transmitted via LS data and calculates the BER
ofdm.ifDisplayResults = 1; >>>> (1,0) if 1, display the results in the command window

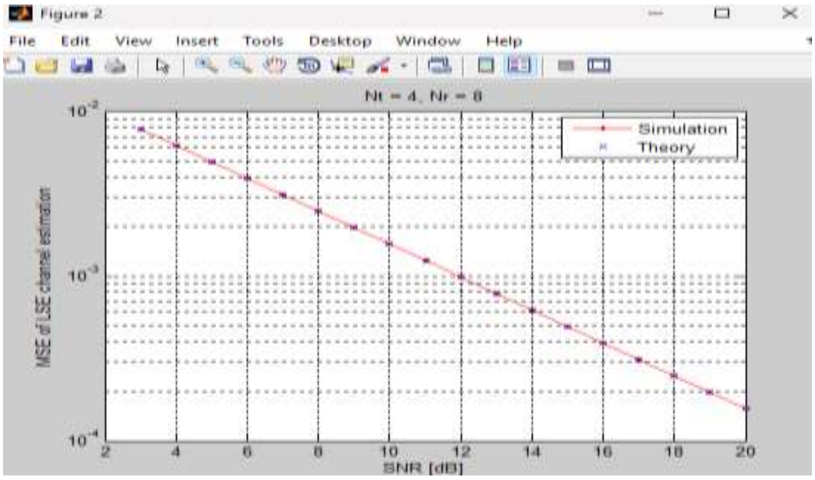

FIGURE 6. MSE of LSE channel estimation Vs SNR

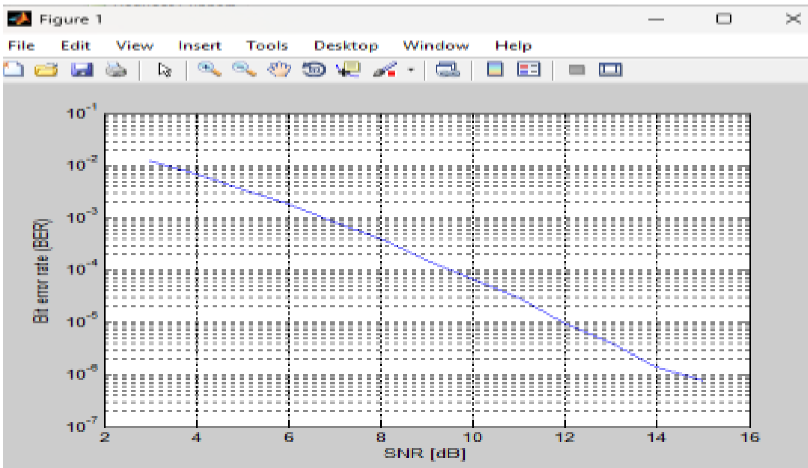

FIGURE 7. Bit Error Rate (BER) Vs SNR

- The MSE of MC estimation improves with increasing SNR. As the signal strength becomes stronger relative to the noise, the channel estimate becomes more accurate.
- The simulations analyze the Mean Squared Error (MSE) of the estimated channel as a function of SNR. The MSE measures the discrepancy between the true CIR and its estimate. Lower MSE translates to more accurate channel estimation.
- The number of pilot subcarriers affects estimation accuracy. A higher number of pilots provides more information for channel reconstruction, leading to lower MSE.
- The channel model also impacts performance. Fast fading channels (e.g., Rayleigh) typically exhibit higher MSE compared to slow fading channels (e.g., Rician) due to their rapid time variations.

Conclusion

This paper presented an investigation of basic channel estimation using a Monte Carlo approach in MIMO-OFDM systems. We outlined the underlying principles and evaluated its performance through simulations. While MC estimation offers a simple and computationally efficient solution, its accuracy is limited, particularly at low SNR or in fast fading channels. Future work can explore more sophisticated channel estimation techniques that provide improved performance under challenging channel conditions.

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