**Survey: 5G for future aerial communications**



Name: Alec Mabhiza Chirawu

Chinese Name: 亚历克上

Student Number: M202161029

**Wireless Communication , Information And Engineering Department, USTB**

Professor: 杜冰

*2022-6-29*

Abstract

The increase in research in 5G network technology in industries, Universities and private sectors has clearly indicated the need of high and powerful antenna’s to meet the needs of high speed communication as well as internet of things. Researchers have clearly state the positive and negative effects of 5G technology in the future and 5G aerial communication mechanism has hampered several consequences in our daily lives.2022-January-04 the aviation industry threatened AT &T and Verizon companies to remove all 5G antenna’s in airports stating that wireless carriers 5G radios using C-band spectrum will interfere with aircraft altimeters which are used to measure altitude. 5G antenna’s could cause interference due to the narrow gap between the frequencies of 5G and radio altimeters which will results in aeroplanes missing the main run way. This has cause a rise in questions on 5G aerial technology for future communication. In this survey we will look at kinds of antenna’s and impact of aerial’s on UAV’s and mobile phones as well as how to solve these problem for the future of 5G aerial network.

Index Terms: SISO,MIMO, mMIMO,

Introduction

Problems

Recent problem with 5G antenna’s

May 23 the aviation industry is concerned that wireless carriers' 5G radios using C-band spectrum will interfere with aircraft altimeters, which are used to measure altitude. AT &T and Verizon delayed inserting 5G intenna’s near airports after they have been threaten to be sued due to the problem with 5G antenna’s could cause interference due to the narrow gap between the frequencies of 5G and radio altimeters.

5G network can’t reach all the places due to its low area coverage.

Missing of UAV’s due to out of range

The need for 6G due to 5G lot of problems

Massive MIMO

MIMO stands for Multiple Input – Multiple Output, a MIMO system consists of an array of at least two antennas for reception and two for transmission, or more. A base station with MIMO capabilities can receive information from multiple sources and transmit it to multiple users. Massive MIMO is an extension of the MIMO system,

where the number of antennas in the array is greater than 64. Such a system has the advantage of being capable to service more clients at the same time. In 5G base stations, 12 antennas are normally used: 8 for transmission and 4 for reception.

Full-duplex communication

This communication method allows simultaneous broadcast and receipt of information on the same frequency using the same antenna. This is accomplished by utilizing silicon transistors, which disrupt the reciprocity of the antenna and allow it to send and receive data on the same frequency without clashing. When an antenna transmits and receives at the same time, the broadcast wave is picked up as an echo by the transmitting antenna and added to the received signal conveying information. This echo is more powerful than the wave received and sent by the antenna. The echo must be suppressed for the system to function correctly, thus echo-cancelling technology is used. This technique records the broadcast signal and subsequently subtracts it from the received signal, leaving only the received data.Communication was usually accomplished using two methods in prior generations of cellular devices. The first was to use the antenna as a transmitter or receiver, switching back and forth in a halfduplex mode. The second most frequent method was full duplex, which used two distinct frequencies for transmission and receiving. The full duplex approach used in 5G has the benefit of just requiring a single carrier frequency, requiring half the spectrum resources of older full-duplex methods. In addition, the resources are used continuously, as opposed to half-duplex mode, resulting in a higher performing system.

**Sub6 – mmWave**

The Sub6 and mmWave names refer to frequencies less than 6 GHz and between 24 and 300 GHz, respectively. Most wireless technologies employ the Sub6 frequency band, which results in collision signals in the crowded spectrum, resulting in poor performance of systems that rely on frequency resources, as seen in [2-4], where Wi-Fi and LTE signals coexist on the same frequency range. To address the problem, the 5G standard suggests adopting the mmWave spectrum, which is mostly utilized for satellite communications and radar systems and is not as congested as the Sub6 bands. Sub6 and mmWave frequencies are being suggested for 5G communications. For Sub6 communications, for example, the mmWave frequencies are potentially potential contenders for offering 5G services.

**4. Circular/smartphones polarization**

When an electromagnetic wave travels through space in one direction, its associated electric field vector creates a form in the plane perpendicular to the propagation direction, which is known as the polarization. Because of the periodic characteristic of the moving wave, the aforementioned form is an ellipse. If the ellipse is drawn clockwise from the observer's perspective, the wave is Right Hand polarized; otherwise, it is Left Hand polarized. The wave exhibits circular polarization when the length of both ellipse axes is equal. When the polarization is neither circular nor linear, it is elliptical. When the ratio is infinite, the polarization is linear; when it is equal to one, the polarization is circular; and when the ratio is between one and infinite, the polarization is elliptical [14, 15]. In a basic 5G connection between a antenna and a mobile device aerial, if the base station's antenna has linear vertical polarization, the antenna in the user's device must be orientated in the same way, else the wave will not be correctly received and communication would be impossible or degraded. Circular polarization is essential for communication to be feasible regardless of the device's orientation.Because wave reflections simply modify the direction of the polarization without adding or removing the reflected waves, circular polarization reduces propagation losses.

**5. Antenna Arrays**

Because a single patch antenna has poor gain, a base station's coverage area will be limited if it pretends to provide service using only a single antenna. An array of antennas can be utilized to solve this problem. An array is a collection of antennas with similar features. Each antenna broadcasts or receives at the same time. An array of antennas can achieve higher gain and a better signal-to-noise ratio than a single antenna. Because of the constructive interference of the transmitted waves by each individual antenna, this is achievable. An array's antennas can be positioned at a predetermined distance from each other to form a linear, planar, or volumetric array.Each antenna in a linear array is positioned in a line, but each element in a planar array can be found in the same plane, commonly in the shape of an EAI. Endorsed Transactions on Mobile Communications and Applications. A complete survey 7 grid for the design of 5G-oriented patch antennas [78, 76] each antenna in a volumetric array is positioned in 3D space. This enables electrical guiding of radiated energy and is the fundamental basis of beamforming.If the antenna array is linear, altering the relative phase between components results in directional steering of the radiated beam along a linear axis created by the antennas. If the array is flat, beamforming could be accomplished along two orthogonal axes, for example, in a vertical and horizontal direction at the same time. Depending on the area of service, a planar array or a linear array may be required for 5G applications. [3, 1] show various designs of planar, phased, microstrip arrays.

It is worth mentioning that in order for an array to be capable of beamforming, each of its elements must be independently provided with a phase changing signal. When the elements are linked by a fixed feeding network, the gain is greater than that of a single antenna, but electronic steering of the emitted beam is not conceivable. This form of array is shown in [36-38]. Because all of the horizontal pieces are connected by a fixed feeding network, the array illustrated in [39] can only beamform in the vertical direction.

When constructing an array of several antennas, two variables must be considered: the number of antennas and the distance between them. In terms of the number of antennas, more radiating elements suggest higher gain at the expense of requiring a more powerful RF source with more outputs.As more antennas are added, a limit can be reached; if this occurs, each additional antenna will not contribute appreciably to the total gain of the array. The distance between antennas in an array is typically set in one direction. That is, while constructing a planar array, the horizontal distance between successive antennas is always the same, as is the vertical distance between consecutive antennas in a vertical axis. Horizontal and vertical distances are not always equal.

Two considerations must be made when selecting a fixed spacing between antennas in any axis for a planar array. First, if the distance is too near, the antennas interfere with each other, a phenomenon known as mutual coupling.To reduce coupling between antennas, they should be spaced apart by at least half the wavelength of the radiated wave. If the antennas are too far apart, undesired diffraction lobes form. These lobes use a large portion of the available power to radiate in unwanted directions, resulting in less power to transmit from the main beam. The distance at which diffraction lobes appear is determined by the current distribution used to excite the array; if each antenna element is excited with a wave of equal amplitude but varying phase, the distribution is uniform, and a maximum distance of is recommended to avoid the appearance of unwanted diffraction lobes.Given the mutual coupling and diffraction lobes, a spacing between consecutive antennas of between and is advised.In [7], an analysis of mutual coupling is undertaken.

**Communication Scenarios**

Examines the computational complexity comparisons of the proposed three different schemes as the IRS elements are increased. To ensure a fair comparison, the proposed various phase shift search methods use the same parameter settings as previously mentioned. We discover that the proposed local search method has a significantly lower computational overhead than the exhaustive search method. Furthermore, when compared to the local search method, the proposed DNN-based method can achieve significant complexity reduction. More specifically, when the number of IRS elements is 16, the complexity of the exhaustive search, the local search method, and the DNN-based method increases.In general, the complexity of the offline phase is not considered here. Furthermore, as the number of reflecting elements increases, the computational complexity of both the local search method and the exhaustive search method increases significantly, whereas the proposed DNN-based method varies slowly. In other words, the proposed DNN-based method method has a more distinct advantage in terms of complexity. Finally, the proposed DNN-based scheme can achieve a better trade-off between data rate performance and computational complexity, which will be widely used in future IRS-assisted THz communication scenarios.

UAV’s

1. M-MIMO and mmWave Communications for UAVs M-MIMO, as a key enabling technology in the current 5G standard, appears to be promising for cellular-connected UAV communications [8], [77]-[81]. Ground BSs with full-dimensional large arrays can perform fine-grained 3D beamforming to reduce interference between high-altitude UAVs and low-altitude terrestrial users, resulting in much higher network throughput. The beamforming gain of M-MIMO, on the other hand, is critically dependent on the availability and accuracy of channel state information (CSI) at ground BSs, whereas cellular-connected UAVs present new challenges. First, due to their strong LoS channels, UAVs can cause severe pilot contamination to a large number of ground BSs, which cannot be resolved by existing pilot decontamination techniques designed solely for terrestrial users.Second, the high mobility of UAVs in 3D space makes efficient beam tracking a more difficult task for them than for terrestrial users, and it can incur excessive pilot overhead [82], [83]. Finally, practical implementations may use a hybrid beamforming-based M-MIMO architecture to support a large group of coordinated UAVs or a UAV swarm. This will exacerbate the pilot contamination and beam tracking issues. To address inter-cell air-ground interference and improve network throughput, a more ambitious approach known as cell-free M-MIMO, which combines ideas from distributed/network MIMO and coordinated multipoint transmission, was recently proposed, in which massive antennas distributed across a large geographical area are linked with a central processing unit (CPU) [84]. In this case, instead of each BS being surrounded by multiple users, both UAVs and ground users are surrounded by multiple BS antennas. Because of the LoS-dominant air-ground channels, such a user-centric architecture allows for greater degrees of freedom to exploit the macro diversity provided by the many distributed BSs. However, key issues that must be addressed include efficient centralized and distributed power control, low-complexity fronthaul/backhaul provisioning, and network scalability with regard to UAV swarms. Another promising approach for supporting rate-demanding eMBB services in 3D space is to take advantage of the massive amounts of new spectrum available in the mmWave bands.
2. Several inherent limitations of mmWave communications, such as high signal attenuation and high blockage vulnerability, can be mitigated by leveraging UAV mobility.UAVs, for example, can not only fly towards ground nodes to reduce propagation loss, but can also intelligently adjust their trajectories to avoid surrounding obstacles, increasing the likelihood of LoS paths. mmWave communication, like M-MIMO, requires the use of a large number of antennas, and the channel coherence time is shortened due to the high UAV mobility and shorter wavelength signals. As a result, fast channel variations will occur in practice, necessitating the use of effective dynamic beam training and tracking techniques. To track the time-varying UAV-ground channels, some previous works proposed the use of movement prediction filters such as Kalman filters. In addition, a fast beam searching algorithm based on a predetermined hierarchical codebook was developed to track the UAV-to-ground channels.Other important future research topics include low-complexity spectrum management [95] and high-speed and reliable backhaul design. Furthermore, due to the passive reflection mechanism of IRS, it requires a relatively larger aperture than M-MIMO and mmWave-based active arrays and imposes new challenges on the related passive IRS channel estimation, which requires larger installation space in practice and may result in higher computational complexity.

**5G/ 6G introduction Sensors**

The research focuses on the role of satellites in 5G networks, emphasizing that enhanced mobile broadband, for which user data rates and spectrum efficiency are critical, and massive Machine Type Communications are common scenarios in which the satellite serves as backhaul to connect separate parts of the same 5G network. In the case of massive Machine Type Communications, the ability to support a large number of connections, distributed over time and frequency, each exchanging a few data packets, is critical. Furthermore, satellite systems may strongly support delay-tolerant services that demand high reliability and availability. The research shows that in some scenarios, terrestrial infrastructure may be insufficient to guarantee 5G Key Performance Indicators (KPIs), such as providing ubiquitous coverage or in the case of infrastructure unavailability, necessitating the use of aerospace solutions to increase both the resilience and the availability of the network, thereby improving the Quality of Experience (QoE) perceived by users. This is especially true for IoT scenarios where both resilience and network availability are critical requirements, such as smart grids. When considering the joint use of satellites, UAVs, and ground nodes, the different roles and equipment envisaged for IoT devices in 5G scenarios are analyzed, proposing UAVs to act as 5G User Equipment (UE), as base stations (5G-gNBs), or as transparent relay nodes.Depending on the payload, satellites, particularly low-Earth orbit (LEO) satellites, can serve as 5G-gNBs or relays (regenerative or transparent, respectively). The case of future 6G networks is examined, emphasizing how the SAGIN network paradigm will become even more central in future developments, and emphasizing how the combination of Artificial Intelligence (AI) and Software Defined Networking (SDN)/Network Functions Virtualization (NFV) will enable zero-touch network orchestration, optimization, and management. The upcoming 6G standard, which is still in its early stages of development, broadens the service classes envisaged in 5G. According to [19], the following will be added: Mobile BroadbandSensors Reliable Low Latency Communication (MBRLLC), massive Ultra-Reliable Low Latency Communications (mURLLC), and Human-Centric Services (HCS), as well as multi-purpose control, localization, sensing, and energy services.The latter two are broad categories that encompass a wide range of applications, such as multisensory extended reality and wireless Brain-Computer Interactions (BCI). Some services and scenarios will necessitate the deployment of on-demand capacity or coverage in underserved or overcrowded locations. As a result, the employment of LAPs or HAPs depending on the location and the requirements is viewed as a necessity to support the ground infrastructure when and where it is required. Because of the integration of ground and aerial networks, communications must be supported in 3D space, taking into consideration the additional degrees of freedom due to the varying heights of LAPs and HAPs, if not satellites. A complicated interaction like this has the ability to both sustain existing services and open the door to new ones.For example, the autonomous driving paradigm is gaining traction around the world, and for it to become a reality in every corner of the globe, satellite access is likely to be critical, providing network access in underserved areas (such as rural areas), real-time map updates, and additional services such as safety-related ones. However, the issue remains non-convex. Nonetheless, by changing either Wi or U, the issue is reduced to a conventional convex SDP that can be solved optimally by known convex optimization solvers. As a result, we are motivated to use the AO approach, as described in Section III-A, to address the problem by repeatedly optimizing Wi and U until convergence is obtained. Convergence and Complexity Analysis: The subproblem for updating Wi or U is ideally solved in each iteration, and so the problem's objective value does not decrease across iterations. This, together with the fact that the optimal value of the problem is constrained from above, ensures that the suggested method will converge. If the solution is not rank-one after the AO algorithm's convergence, we can create a rank-one solution for Wi by using rank reduction techniques, and we can construct a rank-one solution for U by using the Gaussian randomization approach. The simulation findings in Section V indicate that the objective value of the issue reached by the solution developed using the Gaussian randomization approach is nearly identical to that produced when the AO algorithm converges. The suggested algorithm's computing complexity is dominated by addressing the two SDP subproblems. The overall computing complexity of the proposed method is on the order of [47], as determined by the study in Section III-A.

**IRS-assisted SWIPT system**

The first task sought to maximize the weighted sum-power collected by the EUs while meeting the stated SINR objectives at the IUs, while the second sought to maximize the weighted sum-rate of the IUs while fulfilling the EH criteria at the EUs. The transmit precoder at the AP and the reflection-coefficient matrix at the IRS were jointly optimized in both instances. Interestingly, it was rigorously demonstrated that deleting specialized energy beams in the SDR reformulations of both optimization problems results in no loss of optimality. Based on these findings, efficient suboptimal methods for the resultant challenges were presented. Numerical findings confirmed that, when compared to the benchmark scheme utilizing a passive IRS, the suggested designs with an active IRS can greatly improve the performance of both the EUs and the IUs.There were also useful insights on the optimal deployment of an active IRS, which provided useful assistance for the practical design and execution.

**5G Security**

5G Threat Landscape: 5G offers astounding improvements in network services. It will enable billions of devices to function more reliably, with greater facilities, speed, system capacity, bandwidth utilization, fault tolerance, and latency than 4G devices. Because of IoT, linked world, and vital infrastructure facilities, the 5G era will present a good target for at tackers, as depicted in Figs. 3 and 7. Attacks are more likely to be politically and financially motivated by criminals and professionals with substantial resources and technological understanding. The 5G threat environment is dynamically based on sophisticated attacks such as flame and stuxnet malware. A basic review of 5G evolving threats may be found here. The remaining sections provide thorough explanations of the 5G threat environment.The feature that can safeguard data transmission from disclosure to unauthorized entities and from passive assaults (i.e., eaves dropping) is one of the fundamental security criteria in the 5G security model. Given the 4G-LTE and 5G designs, any user plane data must be kept private and secure from unwanted users [73]. Standard data encryption techniques have been extensively used to provide data secrecy in 5G network applications (for example, automotive networks [74], health monitoring [75], and so on). With a single private key, the symmetric key encryption technique can encrypt and decode 5G data. This is shared by the entities that communicate (e.g., a sender and a receiver). Integrity: This is to avoid tempering and information loss throughout the transformation from one point to another. The integrity of 5G New Radio (NR) traffic is safeguarded in the same way that 4G traffic is. The integrity of wireless data traffic is safeguarded in 5G NR at the Packet Data Convergence Protocol (PDCP) layer. Only the Non-Access Stratum (NAS) and Access Stratum (AS) of 4G LTE provide integrity protection (AS). However, one significant innovation in 5G integrity protection is that 5G NR provides user plane integrity protection as well. This is crucial since 4G does not enable user plane integrity protection. This new capability is beneficial for tiny data exchanges, especially for IoT devices with limited bandwidth. Furthermore, the 5G authentication technique 5G-AKA employs integrity-protected communication. This assures that no unauthorized party may alter or access the information transmitted over the radio [83].

**Network Slicing related Security Issues**

For 5G, the rule of divide and conquer has just been selected. As a result, the Network Slicing (NS) concept is an essential component of 5G. It is a type of network virtualization technology that involves deploying numerous logical/virtual networks on top of a single common physical network infrastructure. The primary goal of network slicing is to segment physical network resources in order to appropriately group distinct traffic, isolate from other tenants, and customize network resources at a macro level. Each slice is divided into cases/fields with specified needed operations. Logical slicing is the process of dividing a single common physical network into many virtual, full E2E networks. It isolates these virtual networks from one another in terms of access, transit, device, and core network.These slices are assigned to various sorts of services and situations. During division, the goal is to personalize and optimize each network in terms of resources, QoS, and security. As a result, NS is used in an E2E fashion, which includes not just networking resources but also computational and storage resources. The main advantage of NS is that it enables MNOs to split their networks and network resources to suit a wide range of customers and traffic classes. For example, NS may be used to support several 5G traffic classes such as massive Machine Type Communication (mMTC), improved Mobile Broadband (eMBB), and Ultra Reliable Low Latency Communication (URLLC) over the same physical network infrastructure. These traffic classifications have a wide range of features. For example, mMTC is associated with enabling connection for a large number of IoT devices, some of which may have extremely poor throughput.However, because this traffic class is focused on carrying very high bandwidth information and services, it has the opposite features. Network slicing is comparable to VPNs in certain ways (Virtual Private Network). 5G, on the other hand, necessitates novel slicing methods due to its broader scope and implementation requirements. A overview of 5G security and privacy: prospective solutions, current accomplishments, and future approaches in the most difficult circumstances. On-demand networks can be thought of as network slicing. They can be rapidly installed, eliminated, and removed from any network. Network slicings may also be utilized in RAN. In this case, a single physical network is separated into numerous virtual networks that may support a variety of RANs. Network slicing is expected to play a significant role in 5G since it may increase flexibility, infrastructure operation, and resource allocation.The security of NS is critical for the effective implementation of network slicing. For example, a controlling mechanism is necessary for inter-network slice communication, which includes management plane communication, signaling, and unwanted communication between the operating system and the network operator. A appropriate mechanism is necessary for the communication between functions, slices, and interfaces to enable a secure functioning within expected parameters as well as operator security needs. Attackers can interrupt communication between slices if the communication route between them is not secure. As a result of improper slice life cycle management, resources will be underutilized. Within an operator network, neither a host (physical) nor a network slice manager can be regarded impersonal if the network slice manager creates or destroys network slices dynamically and maps and loads them to access the physical host platform.Both the network slice manager and the physical host must identify each other through authentication for a safe and secure communication. Similarly, if an operator network has several network slice managers, all network slice managers must authenticate each other [9]. It is especially difficult to safeguard the virtual elements that run within the slice after they have been destroyed, transferred, or replaced with another freshly formed instance. It might have been done by either a malicious or non-malicious agent. An impersonation attack on a network slice instance has ramifications for all of its services. As a result, authentication is also required for network slice instances [4]. Because of the demand or the given task, it must accomplish, or because of varied latency requirements, each slice has distinct protocols and network services with varying security levels.However, this must not compromise the security of another slice. The recommendation is to provide a baseline security level for all levels without exception. In the absence of a baseline system, all layers of security must be equally good and protectable. Furthermore, when UEs are capable of accessing all network slices individually, they should either authenticate themselves before accessing each slice or access the low security slice first via authentication before accessing the high security slice [208], [210]. For depleted resources, a DoS attack is conceivable. Exhaustion of shared resources for all slices increases the likelihood of assault on other slices. Capping resources and, optionally, ring fencing resources ensure maximum and minimum suggested resource levels.Ring-fencing network resources allow security protocols to function even when resources are depleted [208]. The side channel attack, which results in the disclosure of any cryptographic information, is another type of assault. This is especially true when two slices share some primary hardware. In the event of a cryptographic information leak, the security of the sharing hardware device may be jeopardized. It may be avoided by using strong virtual machine isolation, which prevents one machine's code from being exposed owing to the code exposure of another machine. Furthermore, if the slice sensitivity levels differ, it is best to avoid co-hosting on the same hardware slices [14]. In hybrid deployment approaches, where the operator combines virtual and normal functions. Such deployments must maintain a minimum degree of security.The user's use of numerous services with distinct slices at the same time necessitates effective sealing between slices. In this case, proper inquiry will yield a superior solution. For greater protection, the proposed security mechanism should exist not only in the UE but also in the network [2].

**5G power consumption**

We evaluated the SE and EE of an FD CF-mMIMO network by optimizing power control, APUE association, and AP selection simultaneously. In characterizing the EE performance, the realistic power consumption model, which accounts for data transmission, baseband processing, and circuit operation, was used. Furthermore, the unique link between binary and continuous variables has been effectively used to minimize the number of optimization variables. First, we developed an iterative process for solving the ZF-based issue based on the ICA framework and the Dinkelbach method, in which each iteration only solves a basic convex program.

In order to enhance network interference control, we presented an improved ZF-based transmission that incorporates ONB-and-PCA in the DL and SIC in the UL. In addition, to increase the accuracy of channel estimations, a unique and low-complexity pilot assignment approach based on the heap structure has been devised. By jointly optimizing the parameters involved, the proposed technique demonstrated that it outperformed SC-MIMO and Co-mMIMO in terms of SE and EE. According to the results, FD CF-mMIMO with IZF transmission design is considerably more resistant to the impacts of residual SiS and IAI and needs less execution time than ZF, ONB-ZF, and MRT/MRC. Our joint design, together with the AP selection, produced much improved EE performance, according to numerical data. The GEE maximization criteria was used to explore resource allocation for RIS-assisted multiuser MIMO uplink communication systems.In the transmission design, the transmit covariance matrices of the UTs and the phase shifts of the RIS reflector were simultaneously optimized, subject to a transmit power limitation at each UT. We investigated a practical case in which the RIS-to-BS channel has instantaneous knowledge, but only the statistical knowledge of the UT-to-RIS channels may be used for resource allocation. We began by obtaining closed-form solutions for the best transmit signal directions on both UT sides. Using random matrix theory, we simplified further optimizations with a DE-based objective function. Then, using a fixed RIS phase shift matrix, we used Dinkelbach's technique to address the power allocation problem. Furthermore, in order to optimize the RIS phase shift matrix, we proposed an analogous MSE minimization issue, which was solved using both the BCD approach and the MM methodology.The presented technique is effective in both GEE and SE maximization, as evidenced by numerical results. Furthermore, as compared to some standard baseline methods, RIS-assisted systems can achieve large GEE performance enhancements. When scalability in the uplink of cell-free massive MIMO systems is taken with account, structured massive access gives a new option to deliver greater SE to more users. The suggested scalable initial access method, User-Group, and IB-KM pilot assignment schemes in our framework greatly alleviated the bottleneck of structured enormous access, i.e., pilot contamination induced by pilot sharing. The SE with LP-MMSE and MR combining was used to evaluate this framework, with user density and UE fairness taken into consideration. There are two new closed-form SE expressions with MR combining.Although the investigation focused on the uplink, comparable outcomes in the downlink may be predicted owing to channel reciprocity. Because the suggested techniques make use of geometry, they can also be employed in scenarios with multiple antenna UEs, although the specifics are left to future research. They are also applicable to a broader range of fading distributions than Rayleigh fading. The simulation results suggest that our proposed framework outperforms the state-of-the-art. In particular, our proposed initial access technique allows each UE to be serviced by as many APs as feasible while maintaining scalability. When implementing the suggested P-LSFD, the 95 percent -likely SE decreases as user density grows, but it is negligible and hence an acceptable cost of scalability.By actively suppressing inter-user interference, the proposed User-Group and IB-KM pilot schemes offer and improvement in 95 percent -likely SE, respectively, over the GB-KM scheme; the User-Group strategy offers an 8.1 percent improvement in 95 percent -likely SE over the Scalable method. Furthermore, because the User-Group method is executed in a user-centric way, it is capable of providing greater SE performance than IB-KM, particularly30 when the scenario becomes congested. Finally, the suggested scalable fractional power control provides a trade-off between user fairness and average SE. In this research, we present a realistic approach for structured massive access in cell-free massive MIMO systems. Although we focus on SE performance while taking user density and fairness into consideration, the approach is easily generalized to analyze other critical issues like as energy efficiency, hardware impairment, and restricted fronthaul capacity.This research suggested a novel IRS-assisted UAV OFDMA communication system and investigated its combined trajectory, IRS scheduling, and resource allocation design to maximize the system sum-rate. Although the IRS causes both frequency and spatial selective fadings in the composite channel, we developed a parametric approximation strategy to improve the tractability of the UAV's trajectory planning. The resource allocation and IRS scheduling mechanism, as well as the trajectory of the UAV, were designed using an alternating optimization approach.Extensive simulations were run to illustrate the system sum-rate enhancement that might be achieved by implementing an IRS in a UAV OFDMA communication system. Our findings show that the IRS's substantial beamforming gain and the UAV's high maneuverability are both critical for improving communication performance; the size of the IRS has a significant impact on the trajectory of the UAV in exploiting the degrees of freedom of the system to improve the achievable rate of all users.

**MASSIVE MACHINE-TYPE COMMUNICATIONS**

MTC network connection density will be about 10 million devices per km2 by 2030 [162]. Machine-type devices (MTD) now connect wireless networks using low-cost commercial technologies such as Zigbee, Bluetooth, and WiFi enabling quick and low-cost installation. Furthermore, the use of long-range radio (LoRa) and cellular networks in the IoE has been proposed to provide mass access. Indeed, deploying the IoE across existing networks is advantageous and cost-effective. Traditional communication networks, on the other hand, are designed and utilized for human-to-human (H2H) communications, serving a relatively limited number of users in comparison to the enormous number of devices in IoE (see Table IV). Massive connection, ultra-high reliability and low latency requirements, and energy-efficient transmission are the primary hurdles in MTC deployment.As with URLLC, we address the issues in MMTC from the viewpoints of large access and energy-efficient transmission in this section. Unlike traditional communication networks, which prioritize downlink performance for a small number of users,13 MTC places a far larger demand on system resources in the uplink because to the related huge uplink connection. Security cameras, for example, can be put on UAVs to capture photos of specified locations for security monitoring. The recorded photos are sent to a ground BS on a regular basis for additional data analysis.Due to the simplicity of the architecture, allocating dedicated radio resources to MTD orthogonally has been recommended in the literature in this context. However, because the number of MTDs is huge in MTC, orthogonal multiple access (OMA) would soon deplete precious radio resources and produce extremely lengthy delays. Furthermore, certain widely used random access protocols for H2H communications, such as Carrier Sense Multiple Access (CSMA) and ALOHA, are clearly unsuitable for MTC due to congestion and overloading in the presence of a large number of MTDs. To allow the vast connections required for MTC communications, efficient multiple access techniques like as grant-free random access and NOMA [164]-[166] are required. MTDs for IoE, on the other hand, are often powered by batteries with restricted capacity in practice.Although the lifetime of typical H2H communication networks may be prolonged by changing or recharging the batteries, because to the huge number of MTDs, this may be cumbersome, hazardous (e.g. in a toxic environment), and costly in MTC networks. In general, a right mix of energy harvesting and/or energy-efficient designs might handle the energy consumption barrier to produce green and self-sustaining MTC networks, which has piqued the interest of both academics and business.

**Antenna on UAV’s sensing and sensing for uav**

In addition to communications, the ability to enable effective and efficient sensing is required to realize the ambition of integrating UAVs into 5G and beyond networks. Commercial unmanned aerial vehicles (UAVs) are already outfitted with a plethora of sensors of various sorts, such as an inertial measurement unit (IMU), accelerometers, tilt sensors, and current sensors. Such integrated sensors provide critical real-time information for assuring safe UAV operation, such as estimating the UAV's location and orientation, preserving the direction and flight route, and managing power consumption. However, for future wireless networks, when large-scale deployment UAVs will be seamlessly linked into terrestrial communication systems, depending just on those on-board embedded sensors may be insufficient.To achieve high sensing performance in terms of reaction time, sensing range, coverage, reliability, accuracy, and efficiency, a combination of both UAV embedded sensing and infrastructure-based sensing is required. We will concentrate on radio-based sensing in this part, where the detection and parameter estimate of targets of interest are based on radio waves echoed/scattered by the targets. When compared to other sensing technologies such as acoustic, visual, and light-based sensing, radio sensing is less susceptible to bad environmental circumstances (such as a loud background or dark places) and can often accommodate a wider sensing range. Furthermore, because both radio sensing and wireless communications need radio waves to complete their jobs, it is vital to investigate both systems concurrently. UAV sensing is divided into two major paradigms: sensing for UAV and sensing for UAV. Sensing technologies are used in the former example to assist safe UAV flying as well as low-altitude airspace monitoring and traffic management. In the UAV sensing paradigm, specialized UAVs are sent as aerial flying platforms to offer sensing assistance from the sky.

**References**

# References

1. Pant, M. and Malviya, L., 2022. Design, developments, and applications of 5G antennas: a review. International Journal of Microwave and Wireless Technologies, pp.1-27.
2. https://www.law.com/dailybusinessreview/2022/01/04/att-and-verizon-delay-5g-after-airlines-threaten-to-sue/
3. Ikram, M., Sultan, K., Lateef, M.F. and Alqadami, A.S., 2022. A Road towards 6G Communication—A Review of 5G Antennas, Arrays, and Wearable Devices. Electronics, 11(1), p.169.
4. Kim, J.H., 2021. 6G and Internet of Things: a survey. Journal of Management Analytics, 8(2), pp.316-332.
5. Irram, F., Ali, M., Naeem, M. and Mumtaz, S., 2022. Physical layer security for beyond 5G/6G networks: Emerging technologies and future directions. Journal of Network and Computer Applications, p.103431.
6. Dicandia, F.A., Fonseca, N.J., Bacco, M., Mugnaini, S. and Genovesi, S., 2022. Space-Air-Ground Integrated 6G Wireless Communication Networks: A Review of Antenna Technologies and Application Scenarios. Sensors, 22(9), p.3136.
7. Nahar, T. and Rawat, S., 2022. Survey of various bandwidth enhancement techniques used for 5G antennas. International Journal of Microwave and Wireless Technologies, 14(2), pp.204-224.
8. Pan, Cunhua, et al. "Intelligent reflecting surface aided MIMO broadcasting for simultaneous wireless information and power transfer." IEEE Journal on Selected Areas in Communications 38.8 (2020): 1719-1734.
9. Yu, Xianghao, et al. "Robust and secure wireless communications via intelligent reflecting surfaces." IEEE Journal on Selected Areas in Communications 38.11 (2020): 2637-2652.
10. Wu, Q. and Zhang, R., 2020. Joint active and passive beamforming optimization for intelligent reflecting surface assisted SWIPT under QoS constraints. IEEE Journal on Selected Areas in Communications, 38(8), pp.1735-1748.
11. Uwaechia, A.N. and Mahyuddin, N.M., 2020. A comprehensive survey on millimeter wave communications for fifth-generation wireless networks: Feasibility and challenges. IEEE Access, 8, pp.62367-62414.
12. Ai, B., Molisch, A.F., Rupp, M. and Zhong, Z.D., 2020. 5G key technologies for smart railways. Proceedings of the IEEE, 108(6), pp.856-893.
13. Xu, D., Yu, X., Sun, Y., Ng, D.W.K. and Schober, R., 2020. Resource allocation for IRS-assisted full-duplex cognitive radio systems. IEEE Transactions on Communications, 68(12), pp.7376-7394.
14. Liu, X., Liu, Y., Chen, Y. and Poor, H.V., 2020. RIS enhanced massive non-orthogonal multiple access networks: Deployment and passive beamforming design. IEEE Journal on Selected Areas in Communications, 39(4), pp.1057-1071.
15. Sarieddeen, Hadi, Mohamed-Slim Alouini, and Tareq Y. Al-Naffouri. "An overview of signal processing techniques for terahertz communications." Proceedings of the IEEE (2021).
16. Wei, Z., Cai, Y., Sun, Z., Ng, D.W.K., Yuan, J., Zhou, M. and Sun, L., 2020. Sum-rate maximization for IRS-assisted UAV OFDMA communication systems. IEEE Transactions on Wireless Communications, 20(4), pp.2530-2550.
17. Hong, W., 2017. Solving the 5G mobile antenna puzzle: Assessing future directions for the 5G mobile antenna paradigm shift. IEEE microwave magazine, 18(7), pp.86-102.
18. Kumar, S., Dixit, A.S., Malekar, R.R., Raut, H.D. and Shevada, L.K., 2020. Fifth generation antennas: A comprehensive review of design and performance enhancement techniques. IEEE Access, 8, pp.163568-163593.
19. Wu, Q., Xu, J., Zeng, Y., Ng, D.W.K., Al-Dhahir, N., Schober, R. and Swindlehurst, A.L., 2021. A comprehensive overview on 5G-and-beyond networks with UAVs: From communications to sensing and intelligence. IEEE Journal on Selected Areas in Communications.
20. You, L., Xiong, J., Ng, D.W.K., Yuen, C., Wang, W. and Gao, X., 2020. Energy efficiency and spectral efficiency tradeoff in RIS-aided multiuser MIMO uplink transmission. IEEE Transactions on Signal Processing, 69, pp.1407-1421.
21. Nguyen, H.V., Nguyen, V.D., Dobre, O.A., Sharma, S.K., Chatzinotas, S., Ottersten, B. and Shin, O.S., 2020. On the spectral and energy efficiencies of full-duplex cell-free massive MIMO. IEEE Journal on Selected Areas in Communications, 38(8), pp.1698-1718.
22. Chen, S., Zhang, J., Björnson, E., Zhang, J. and Ai, B., 2020. Structured massive access for scalable cell-free massive MIMO systems. IEEE Journal on Selected Areas in Communications, 39(4), pp.1086-1100.
23. Ma, X., Chen, Z., Chen, W., Li, Z., Chi, Y., Han, C. and Li, S., 2020. Joint channel estimation and data rate maximization for intelligent reflecting surface assisted terahertz MIMO communication systems. IEEE Access, 8, pp.99565-99581.
24. Hou, T., Liu, Y., Song, Z., Sun, X. and Chen, Y., 2020. MIMO-NOMA networks relying on reconfigurable intelligent surface: A signal cancellation-based design. IEEE Transactions on Communications, 68(11), pp.6932-6944.
25. Du, H., Zhang, J., Cheng, J. and Ai, B., 2021. Millimeter wave communications with reconfigurable intelligent surfaces: Performance analysis and optimization. IEEE Transactions on Communications, 69(4), pp.2752-2768.
26. You, L., Xiong, J., Huang, Y., Ng, D.W.K., Pan, C., Wang, W. and Gao, X., 2021. Reconfigurable intelligent surfaces-assisted multiuser MIMO uplink transmission with partial CSI. IEEE Transactions on Wireless Communications, 20(9), pp.5613-5627.
27. Wu, Q., Xu, J., Zeng, Y., Ng, D.W.K., Al-Dhahir, N., Schober, R. and Swindlehurst, A.L., 2020. 5G-and-beyond networks with UAVs: From communications to sensing and intelligence. arXiv preprint arXiv:2010.09317.
28. Hong, W., Baek, K.H. and Ko, S., 2017. Millimeter-wave 5G antennas for smartphones: Overview and experimental demonstration. IEEE Transactions on Antennas and Propagation, 65(12), pp.6250-6261.
29. Gupta, P., Malviya, L. and Charhate, S.V., 2019. 5G multi-element/port antenna design for wireless applications: a review. International Journal of Microwave and Wireless Technologies, 11(9), pp.918-938.
30. Zhang, P., Yang, X., Chen, J. and Huang, Y., 2019. A survey of testing for 5G: Solutions, opportunities, and challenges. China Communications, 16(1), pp.69-85.
31. Mahdi, M.N., Ahmad, A.R., Qassim, Q.S., Natiq, H., Subhi, M.A. and Mahmoud, M., 2021. From 5G to 6G technology: meets energy, internet-of-things and machine learning: a survey. Applied Sciences, 11(17), p.8117.

**.**