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Performance Evaluation of Mm Waves MIMO Beam forming Techniques Using UAV Relay for Sixth Generation (6G) Communication

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Abstract –*Unmanned Aerial Vehicle (UAV) relaying is regarded as a promising solution for the 6G wireless networks of tomorrow to increase the rate and widespread connectivity attainable in millimeter-wave (mm-wave) systems. In this paper, we study both performance and user association optimization for a UAV relay-assisted mm-wave massive multiple-input multiple-output (MIMO) communication system, where multiple base stations (BSs) are connected with the help of their respective users. Serve a beamforming UAV relay. Both beamforming and UAV relays have an essential effect on the achievable sum-rate of the system. Thus, a multi-user hybrid beamforming scheme is designed to reduce the issues of inter-user interference and achieve a better trade-off between performance and complexity in UAV-enabled communications. Furthermore, to exploit the UAV relay-based architecture in servicing various ground BS-user pairs, we propose a UAV relay assisted multi-BS mm-wave giant MIMO system with a hybrid beamforming architecture, which supports the high path Prevents sudden link disconnection due to loss and line -of-sight (LOS) interruption in the mm-wave frequency band. Then, we formulate a user association problem with multiple constraints such that the sum-rate of the overall UAV relay-assisted mm-wave giant MIMO system is maximum. Simulation* results *are provided to demonstrate the effectiveness of the proposed UAV relay-enabled architecture.*

Keywords- *Unmanned aerial vehicle (UAV) relay, mm-wave communications, massive MIMO, 6G.*

I - INTRODUCTION

Millimeter-wave (mm-wave) communication has been seen as a prime candidate for increasing data rates, while wireless networks supports a wide variety of applications beyond 5G [1]. These advantages are mainly due to the huge bandwidth availability in their frequency bands, and they offer great potential for miniaturization of antennas [2]. However, the biggest challenging factor with these high frequencies is severe path loss and easy interruption by bottlenecks, especially given the very long transmission distances involved [3], [4], thus causing substantial system performance loss if the network is not happens to be configured properly. To counter the above issues, researchers have proposed several key enabling technologies, such as, massive multi-input multiple-output (MIMO) technology, network density, use of unmanned aerial vehicles (UAVs), etc. [5]. Another powerful solution for establishing high-quality communication links and expanding the coverage of external mm-wave systems is through a relay-based beamforming approach [6].With regard to its great potential in 5G wireless networks, massive MIMO with hybrid beamforming structure is considered as an innovative research direction of 5G wireless communication, where hybrid beamforming plays a paramount role [7]. This latter has recently been proposed as a viable solution for mm-wave MIMO communication through a trade-off between system performance and hardware efficiency. Hybrid beamforming approaches typically employ a few radio frequency (RF) series to realize low dimensional digital beam formers, followed by a large number of high dimensional analog beam formers [8], [9] to realize There are cost effective phase shifters. As a result, analog beam formers can provide sufficient beamforming gains to compensate for the enormous path loss in the mm-wave frequency band, and digital beam formers can offer the flexibility to realize multiplexing techniques [10].

Furthermore, communication through UAVs, popularly called drones, is one of the most important enabling technologies to realize massive amounts of connections for 6G wireless networks. Recently, UAV communication has attracted great attention both in industry and academia [11], [12].This interest is driven by their flexibility, low acquisition and cost efficiency, and their targeting of potential applications such as device to device (D2D) communications, smart city construction, Internet of Things (IoT), public security, etc. [13], [14]. In fact, UAV-assisted wireless communication becomes a promising solution for providing temporary wireless connectivity, extended coverage range and longer transmission distance for ground users [15].The use of UAVs equipped with large-scale MIMO beamforming is a very attractive solution to enhance the propagation performance of mm-wave systems and realize the ambitious goals of future 6G wireless networks [16].On the one hand, UAVs can fly from obstruction areas to establish line-of-sight (LOS) links, which results in overcoming the above penetration losses, and therefore satisfies low latency communications [17]. On the other hand, the short wavelength of mm-wave allows larger antennas to be placed in a smaller UAV so that the beamforming structure can be carefully designed to overcome the shortcomings of mm-wave communications [18], [19]. For example, in [18] a three-dimensional (3D) beamforming approach has been explored to achieve flexible coverage for target areas by designing wide beams in mm-wave-UAV communication. [19] In [19], large-scale MIMO schemes have been integrated into mm-wave-UAV communication systems to increase network coverage and system spectrum efficiency by taking advantage of beamforming advantages.

Recently, there has been an increased interest in developing UAV relays in 6G wireless networks, aimed at improving connectivity and coverage of ground wireless devices [20]. Compared to traditional terrestrial infrastructure deployments such as ground relays, aerial relay-assisted communication provides an efficient way to prolong mm-wave transmission range, provide an improved signal quality, and communicate between two or multiple terrestrial nodes. Increases the data rate. mm-wave band [21]. This is simply due to the fact that the placement of UAVs at altitude can effectively overcome obstacles on the ground, and those are more likely to have a LOS link, and result in a better channel gain. On the other hand, UAVs can move freely in 3D space to adapt to network mobility and enhance system performance [6]. Naturally, employing large MIMO antennas in UAV relay-assisted mm-wave networks presents additional challenges in designing 6G system architectures, particularly related to the limited power issue, resulting in their energy consumption. Strict constraints arise [22].Theoretically, an analog beamforming structure represents the best solution for UAVs to achieve low power consumption, as it adopts the simplest electronic components and requires a single RF chain [23]. However, and only because of the limited flexibility of analog beamforming, many UAVs were suggested to provide omnidirectional network coverage to ground users, which can consume significant energy for propulsion. Furthermore, selecting multiple UAVs can be quite challenging in practice as there are complex aspects involved with synchronization, altitude control, cost and power optimization; etc. [22], [24].

With this issue in mind, the research community is increasingly leaning toward the development of hybrid beamforming configurations for MIMO systems, which enable the simultaneous transmission of multiple data streams from a single UAV station, and UAV swarms. Makes it possible to reduce the size and its relative. Cost compared to analog beamforming counterpart [25]. Despite these viable advantages, significantly less research work has been devoted to incorporating hybrid beamforming into the hot topic of UAV-based relaying communications systems.

In light of these above advantages of mm-wave communication and UAV relay network, in this paper we present a multi-user mm-wave system employing multiple BS to serve multiple ground users with the help of UAV relay-based hybrid beamforming structure. Consider the huge MIMO network. To increase the rate and wider connectivity attainable in mm-wave communication.

II- LITERATURE REVIEW

There is an increasing number of functions that integrate UAVs into mm-wave networks because of their promising properties. [26] In this, the authors provided a comprehensive survey on UAV assisted mm-wave communication and their Main challenges. [27] In Performance evaluation of assisted UAVs mm-wave networks are investigated, where UAVs were deployed as communicating mm-wave access points with land users. [28] In the study, the authors studied the quality of Coexistence for Service (QoS)-based performance analysis. A network of sub-6 GHz and mm-wave UAV-based communications. [29] mm-wave outage display in UAV swarm networks are studied where more than one UAV BS Provide connectivity to a far-flung user in the presence of Blockages. [30] In a situation and attitude prediction-based Learning algorithms for mm-wave UAV-to-UAV communication has been proposed using

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conventional equal planar arrays (UPA). [31] The problem of maximizing the achievable in mm-wave UAV system the sum rate of all users is checked, Where UAV acts as BS. [32] Author-centered on network coverage and performance optimization Problem in UAV-assisted powered mm-wave network. In fact, we simply increase the number of BS antennas Go big and take advantage of hybrid beamforming techniques. Different from previous works, this study considers UAV Relay-Assisted MM-Wave Network to Further Improve Receivable rate performance and comprehensive connectivity in mm-wave communication. Potential profits to deploy UAV-based relays in mm-wave networks has been studied by many works [12], [23], [33], [34]. [12] The authors proposed to deploy UAVs as aerial Relay nodes to enable dynamic routing in mm-wave backhaul link, thereby reducing interruptions due to random dynamics of blocking users. Recently, [34] the authors proposed to improve upon a hybrid beamforming-NOMA approach Reachable Rate of Downlink MM-Wave Half-Duplex UAVs Relay-assisted large-scale multi-user MIMO network. Apart from this, in [23], full duplex UAV relays have been employed to improve Receivable rate display of mm-wave communication, in which an analog beamforming is used to reduce self-intervention. [12], [23], [33], [34] can provide research work in With a good picture of us employing UAV relaying to enhance the performance of mm-wave networks. However, some important points in the earlier works are not yet has been adequately addressed in recent studies. For example, Most of them mainly focus on single-antenna UAV relay assisted mm-wave communication except mentioned [23], [34] Contribution. In addition, the UAV is relay-capable mm-wave network for multiple Bs, which is tested in this paper, not yet considered. Also, all former Work is still underway on a UAV network using the mm-wave band Minimal and looks like no prior task is focusing User association problem in UAV mm-wave relaying Networks with a hybrid beamforming architecture.

Keeping in mind the scope of our work, the process of joining there is another important issue for the user and the BS mm-wave Network. Multi-BS. The issue becomes more challenging for massive MIMO system because each user not only receives desired signal but interference from multiple antennas Many B.S. at different places. The problem of User engagement in mm-wave networks and large-scale MIMO the deployment has been extensively scrutinized [35], [36]. In Referring to HetNets with the goal of maximizing the sum backhaul rate, the appointment of an effective union and [37], [38] backhaul hubs have been studied, where UAVs used as backhaul aerial hubs between small cells and the core network and FSO are connected through the link. Similarly, [39] A genetic algorithm for the association of the combined optimal location of the UAV-hub and the small-cell base. Stations (SCBS) have been proposed in such a way that the sum rate of the overall system can be maximized. In [40], the authors used the idea of employing UAVs using supervised learning-based k-means clustering algorithm and then union SCBS is performed with UAVs, resulting in Lower bandwidth consumption while achieving higher sum-rates. In the context of mm-wave networks, several studies have [41], [42] has been proposed. [41] In BS Placement and User association issues with the aim of minimizing the probability of an outage in mm-wave networks is analyzed. [43] A user association problem in mm-wave backhaul Small cell networks aimed at maximizing the network the energy and spectrum efficiency are checked. [44] In, a joint coordinated user association and spectrum allocation the problem has been studied in 5G HETNETS hat use the mm-wave band. [45] In, a combined beamforming and cell association optimization Problem is investigated in mm-wave cellular network Aim to maximize users' throughput. [42] The problem of association in a two-tier network Large-scale deployment of MIMO in both macro and female Levels are checked. Also, the work addressed in [35], [42],

User Association in UAV Relay-Assisted MM-Wave Massive the MIMO system, which has been examined in this paper, does not have so far considered. Despite our best knowledge, Orientation towards exploitation of mm-wave bands, this is the first article that provides both achievable Rate performance and user association optimization problem maximizing the sum-rate of the overall UAV relay assisted mm-wave large-scale MIMO communication system.

In addition, the positive effect of UAV relay-based hybrid Beam forming structure on both user union and sum-rate Performance in prior work is not considered for any User association scheme for mm-wave networks. However, the advantage of massive MIMO for sub-6 GHz Was Channel hardening and favorable diffusion properties result [46]. However, establishing a UAV-based mm-wave link introduces unique technical challenges, so our ability It is yet to take advantage of these attractive conditions of MIMO in a big way Suspicious [17], [47]. Recall that in [17] the work is addressed Open issues of UAV mm-wave channels and their specific Features, scenarios and challenges. Actually, the mm-wave and terahertz (THz) frequency bands are characterized by rare and low-grade channels, where no. The number of NLoS links decreases as we increase the carrier frequency [17], [47] of the operation.

III- METHODOLOGY

In this section, we first introduce the relay-assisted UAV Multi-user mm-wave largely followed the MIMO system model 3D geometry based-UAV by mm-wave channel model.

A. SYSTEM MODEL

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As shown in Figure 1, we consider a UAV relay-assisted mm-wave giant MIMO network including NBS BSS, U Single antenna user, and a UAV relay working in a half-duplex mode. In this system, there is no direct connection between the source nodes (BSS) and their destinations (users). Since mm-wave signals are sensitive to severe blockages. To ensure the widest coverage area, we extensively consider giant MIMO deployment in both BSS and UAV relays with Nre and Nt antennas, respectively.

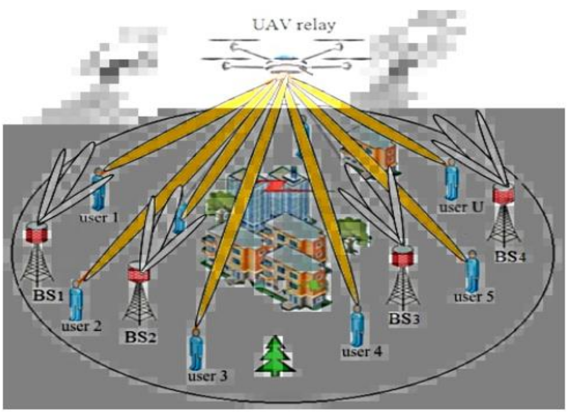

Figure 1: Graphical illustration of a UAV relay-enabled architecture Multi-BS mm-wave Giant MIMO multi-user system.

It should be noted that while one user may need to be allowed to be served by multiple BS more overhead to implement, and therefore it is a more divergent creed. To implement multiple-BS association as compared to single-BS association [48], [49].Therefore, even though the performance of Many BS association schemes are close to optimal [50], We chose to focus on one BS at a time but not all BS must be connected at the end of the association cycle and Leave the matter of multi-BS association scheme to future work. This notion is supported by its practical purposes because. This simplifies the beam forming/assembly process UAV relay and user association scheme. On this paper, we assume that all BS are connected to a central controller, Able to decide which particular BS serves its affiliated users Based on the information provided by the users. Upon receiving Union information from the Central Controller, all BS will transmit information data to its affiliated users.

To reduce the hardware cost of giant antennas Deployment in UAV Relay-Enabled Architecture, Hybrid Beamforming structure is applied among many BSS, UAV relay, and ground users as shown in Figure 2. Notably, both the BSS and the UAV bear the same number of RF series, denoted as NRF, where Nt ≥Nre >> NRF, and we assume NRF = U to achieve complete multiplexing benefits [51]. Similarly, the total number of transmitted currents NS= U. We further believe that every user is equipped With an RF chain, which can reduce the processing complexity of destination. It is worth noting that the number of active RF chains in each BS depends on the number of Associated User. Without loss of generality, we believe that Channel state information (CSI) is fully known in BS and UAV relays, which confirms these assumptions [31], [52]. CSI Acquisition in UAV-Assisted MM-Wave Systems Currently the subject of active research. Recently, incomplete CSI is brought in with reference to the mm-wave system. By exploiting the sparsity of mm-wave channels to embed Compressed Sensing (CS) Technique for the Assessment of These channels [53] [54].

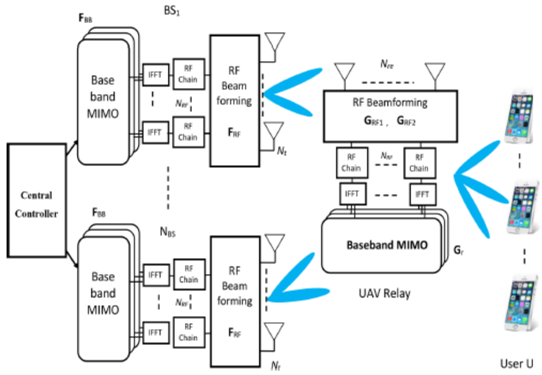

Figure 2: UAV relay based-hybrid beamforming architecture.

To deal with frequency selective fading, mm-wave Large-scale MIMO systems typically use orthogonal frequency division. Multiplexing (OFDM) scheme. We assume that the number of OFDM sub-carriers is K. it is important to emphasize here the RF beamforming matrix is the same for all sub-carrier, because the RF beam former cannot be implemented separately for each sub-carrier [6]. Transmission occurs during the process from source to destination two sequential steps.

During Phase-I, each BS node applies a Nt x U beamforming Fj to transmit a symbol to each user. Transmitted signal kth subcarrier can be expressed from jth BS using as x j (k) = f j (k) s j (k), ----- (1) Where F j (k) = Fj RF f j BB(k) is hybrid beamforming matrix for Jth BS, with f(j)RF ∈ ℂ Nt x NRF analog RF with constant magnitudes, while FjBB (k) = [f(1;j) BB(k), ----, f(u;j)BB(k)] ∈ ℂ NRF xU is baseband beam forming matrix, and sj(k) =[s (1;j) (k), ------, s (U;j) (k)]T represents Symbols transmitted from jth BS node, such as E[sj (k) (sj (k)) H] = IU. Received signal in UAV relay in the kth sub-carrier then can be shown a

$y(k) = \sum_{j=1}^{N_{BS}} H_{1}^{J}(K) \sum_{I=1}^{U} F_{RF}^{J} f_{BB}^{(I,J)}(K) S^{(I,J)}(K) + W(K)$, ----- (2

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Where s(i;j) is the transmitting symbol that BS j wants to User i, $H_1^J(K) \in \mathbb{C}^{N_{re} \times N_t}$ is the frequency domain channel matrix between the jth BS and the UAV relay, and w(k) is the additive noise vector at the UAV relay with (0, σ_r^2) elements.

In phase –II, the transmitted signal from the BSS travels through the U x Nre analog receive matrix GRF2 at the relay, then is amplified by the NRF x U baseband matrix Gr (k), and is subsequently forwarded all users through the Nre x NRF analog transmit matrix GRF1. The received signal at the ith user can be modeled as:

$$Y_i(k) = H_{2,i}^H(K) \sum_{J=1}^{N_{BS}} G(K)\, H_1^J(K)\, F_{RF}^J\, f_{BB}^{(I,J)}(K) S^{(I,J)}(K) + \sum_{I' \neq i}^{U} \sum_{j=1}^{N_{BS}} H_{2,i}^H(K)\, G(K)\, H_1^J(K)\, F_{RF}^J\, f_{BB}^{(I,J)}(K) S^{(I,J)}(K) + W_i(K),$$

Where $\sum_{J=1}^{N_{BS}} G(K)\, H_1^J(K)\, F_{RF}^J\, f_{BB}^{(I,J)}(K) S^{(I,J)}(K)$ is the superposition of desired signals that user i receives from the BSS, H2,i(k) is the frequency domain channel between the UAV relay and the ith user, $G(K) =$ GRF1 Gr(k) GRF2 represents the overall relay processing matrix, and

$W_i(K) = H_{2,i}^H(K)\, G(K) w(k)$ Encompasses the equivalent noise vector. For the UAV relay-assisted mm-wave communications involved herein, both channels $H_1^J H_{2,i}$ are the Fourier transforms of temporal channels, which are represented using a 3D geometric model.

IV- RESULT & DISCUSSION

In this paper, we have developed an efficient design of UAV deployment in which the UAV acts as a beamforming mm-Wave relays in the giant MIMO communication context, to reduce the shortcomings of link interruptions encountered in mm-wave networks. After that, a good link there is credibility between each BS and multiple ground users maintained. In particular, by considering the impact of UAVs Relay based beamforming approach, a consortium of users

The problem is formulated so that the sum rate of the overall UAV Relay-assisted mm-wave giant MIMO systems can be maximized. In addition, to minimize interference Constraints and Shortcomings in massive MIMO Hardware Complexity, hybrid beamforming relay scheme devised between multiple BS, relay and ground users, spatial processing and amplified-forward merging Operation. Simulation results demonstrated adequate Performance gains derived from deploying UAV Relay Assisted mm-Wave Massive MIMO System with Our Hybrid beamforming design compared to traditional system, and uncover the effect of UAV altitude

Receivable rates display. It is also learned that User-BS association achieved satisfactory usability performance Compared to the B&B method in terms of associated users and Achieves similar sum-rate performance. More importantly, the performance achieved with this approach is remarkable High in the presence of the UAV relay. In future work, we will Examine Possible UAV Relaying Schemes with Impact of channel estimation taking care of computational Complexity issue.

The rest of the paper is organized as follows. SECTION II INTRODUCTION System and channel models. Multi-user hybrid the beamforming design is described in Section III. By considering various communication barriers, adaptation the problem formulation is taken up in Section IV. In section V, we present some results to validate the effectiveness of UAV relay-capable architecture. Finally, we conclude Paper in Section VI. In this section, simulation results are presented and discussed to demonstrate the effectiveness of the UAV relay-assisted multi-BS massive MIMO multi-user mm-wave communication system by comparing its performance with the alternative system where there is no UAV relay. The studied scenario consists of three BSs, U = 28 users, and one UAV relay working at mm-wave frequencies with a carrier frequency of 28 GHz. In particular, we consider a 4 × 4 km2 area, where both BSs and users are randomly distributed over a square region using Matern type-I hardcore process, with a density of λa = 2 × 10−6 per m^2, such that the distance between any two BSs and users is at least d min BS = 300 m and d min U = 100 m, respectively. Also, each BS is assumed to hold Nt = 64 antennas and 28 RF chains while there is only one RF chain at each user. All BSs are assumed to transmit Ns = 28 data streams to the destination via the assistance of the UAV relay, which is equipped with Nre = 32 antennas and NRF = 28 RF chains. The height of each BS is set to zj = 10 m, while that of UAV relay is set to hmin = 100 m.

V-RESULT VALIDATION

All results are averaged over N runs of Monte-Carlo simulations and at each run both BSs and users' positions are randomly reset. The achievable sum-rate has been formulated in the case of perfect channel estimation process. In Fig. 4, we investigate the total achieved sum-rate performance of UAV relay-assisted mm-wave massive MIMO system when using the analog, the hybrid, and the full digital beamforming structures, along with the impingement of the incorporation of UAV relay on its performance. To confirm the effectiveness of our hybrid beamforming (Algorithm 1), the performance of hybrid beamforming proposed in [48] is also portrayed in the

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simulation.

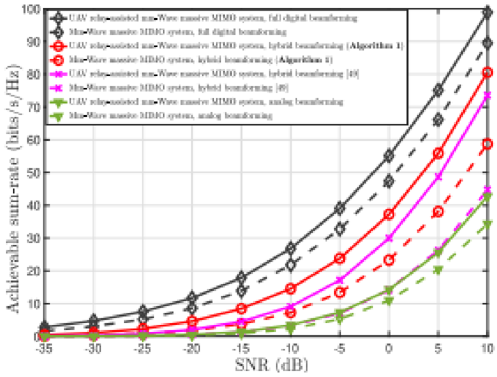

Figure 3Achievable rates performance using the analogue beam forming,

From this figure, it appears clearly that our hybrid beamforming scheme can perform VOLUME 10, 2022 49619 W. Belaoura et al.: Performance and User Association Optimization for UAV Relay-Assisted mm-Wave Massive MIMO Systems FIGURE 4. Achievable rates performance using the analog beamforming, the hybrid beamforming in [48], the hybrid beamforming (Algorithm 1), and the optimal full digital beamforming for the considered UAV relay-assisted mm-wave massive MIMO and the conventional systems, when the UAV relay altitude is hu = 100 m. much better than both the analog beamforming and the existing hybrid beamforming scheme [48] over the whole SNR range in consideration. Besides, the achievable rate of the proposed hybrid beamforming is very close to the fully digital beamforming case. On the other hand, when analog beamforming scheme-based system is used, the penalty of the path losses on the considered system is significant such that the cooperative diversity system becomes inferior in performance to the one of the counterparts without a relaying device. At the same time, we observe that the benefit of the relying enriched with the UAV relay-based architecture scheme finds its great efficiency at quite reasonable SNR values, since 20 bits/s/Hz performance gain is noted over the alternative system with no relaying, when SNR is 10 dB.

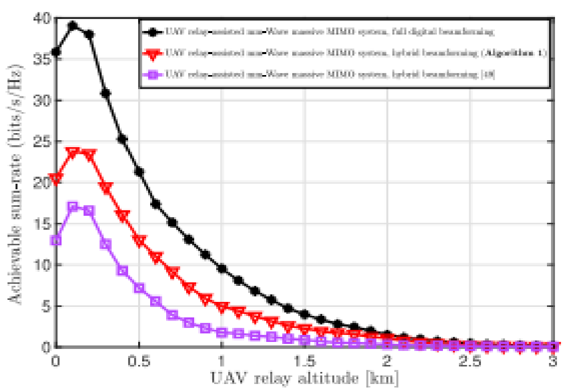

Figure 4Achievable rate performance versus the altitude of the UAV

Fig. 5 illustrates the effect of the UAV relay altitude on the achievable sum rates calculated by three different beamforming designs, when SNR = −5 dB. It can be seen clearly that the achievable sum-rate performance of the different beamforming design schemes increases when the UAV's altitude increases from the ground to 100 m. This might be due to the dual effects of higher LoS probability in the network when the altitude increases and to the efficient beamforming performed between the BSs and the UAV relay to a certain value of the altitude. Beyond those altitudes, the achievable sum-rate starts to decrease, due to the path loss effect related to the increasing distance between the UAV and the BSs. This means that, at a sufficient altitude, beamforming signals are propagated far away from their BSs, thereby causing serious performance losses. The performance of hybrid beamforming in [48] is worse than those of the other two approaches by about 6.67 dB bits/s/Hz compared to the proposed hybrid beamforming scheme. This is because beam gains may not concentrate on user directions of the strongest multipath components. The UAV relay altitude is set as 100 m in the remaining simulations.

FIGURE 5. Achievable rate performance versus the altitude of the UAV relay in the mm-wave massive MIMO system under different beamforming structures. Fig. 6 shows the users' association results at a particular iteration, as an example. The relay is assumed to be located at a horizontal position of xu = yu = 2.5 km. For comparison, we use Branch and Bound (B&B) method [60], as an optimal benchmark solution as shown in Fig. 6b.

Each user is marked with the same color as its associated BS. For the same scenario, it can be observed by comparing Fig. 6a and Fig. 6b that B&B and the proposed solution scheme (Algorithm 2) associate 21 and 20 users, respectively.

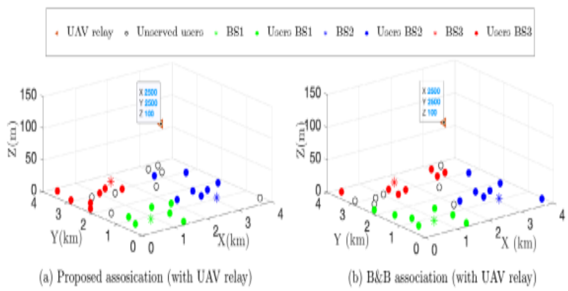

Figure 5Comparison of user association schemes in UAV relay-assisted-mm-wave massive MIMO system.

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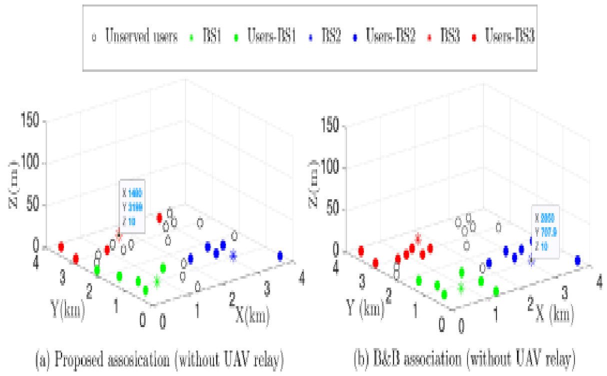

Figure 6. Comparison of user association schemes in mm-wave massive MIMO system without UAV relay

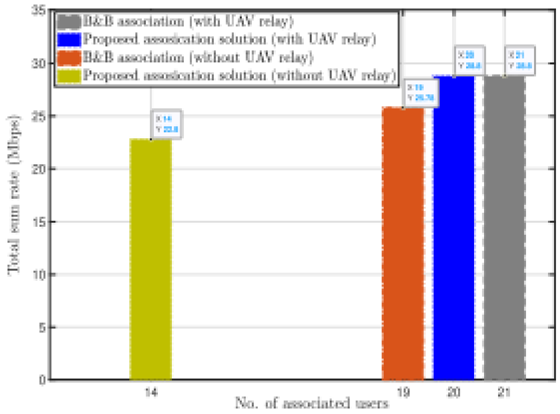

Figure 7. Total sum data rate vs. the number of associated users for B&B

The performance is close but the difference is mainly because of the data rate constraint. In this case, the UAV relay is mainly used to enhance the quality of the direct links between the users and their respective serving BSs. Fig. 7 presents the impact of the proposed association solution on mm-wave massive MIMO system without UAV relay, in which the hybrid beamforming is designed between the BSs and multiple user nodes (Algorithm 1). We first note that the proposed association solution is unable to associate all users with their BSs, which is due to the stringent mm-wave communication constraints. In particular, in the surroundings of BS 3, only 4 users are associated due to its adverse channel conditions (low SINR criteria (constraint (26c)). Also, the unassociated users are not served by other BSs due to bandwidth limitations (constraint (26b)). Further, by comparing Fig. 7 and Fig. 6, it can be concluded that the UAV relay-based architecture allows to serve a higher number of associated users for all BSs. In particular, 20 users are served in the considered scenario with the proposed association solution, whereas only 14 users are connected in the alternative system without relay. Furthermore, it is observed from Fig. 6 that all BSs serve the users that are closest to them. This is because the SINR of each user is mainly determined by its direct links with BSs (i.e., users-BS2 in Fig. 7a). In contrast, thanks to the UAV relay-based hybrid beamforming deployment, it is observed that BSs 2 and 3 serve users that obtain better signal quality instead of the nearest users as in 49620 VOLUME 10, 2022 W. Belaoura et al.: Performance and User Association Optimization for UAV Relay-Assisted mm-Wave Massive MIMO Systems FIGURE 6. Comparison of user association schemes in UAV relay-assisted-mm-wave massive MIMO system.

FIGURE 7. Comparison of user association schemes in mm-wave massive MIMO system without UAV relay. FIGURE 8. Total sum data rate vs. the number of associated users for B&B method and proposed association algorithm. Fig. 6(a). In this way, the effective link between BS and users can be stronger than the direct link between them. With the same distribution and parameters as in the previous simulation, Fig. 8 compares the total sum data rate versus the number of associated users of the proposed association solution with the one achieved by the optimal B&B method, to provide more straightforward results and demonstrate the performance of mm-wave massive MIMO system with and without UAV relay. It is worth mentioning that due to the UAV relay, the proposed association solution and B&B schemes both achieve a higher communication rate gain, and also provide the same sum data rate and thus have the same performance. In contrast, the total sum rate in the alternative system without UAV relay result in lower rates due to the communication between users and BSs which is greatly affected by obstacles in mm-wave bands. For instance, our algorithm achieves a sum-rate of 22.8 Mbps for maximum number of sources. Note that the number of connections in each BS also plays an important role in the sum data rate performance.

VI- CONCLUSION

In this paper, we describe a UAV relay-assisted multi-BS. Consider Multi-user mm-wave giant MIMO system via hybrid beam-forming structure, in which the source is a set of several Distributed BS and destination is a set of many Single-antenna user. Main feature of Mana system UAV relay to be equipped with massive MIMO antennas. To overcome the severe propagation disadvantages of mm-wave signals and to exploit hybrid beamforming designs Aiming to achieve performance comparable to fully digital Beamforming, but with far less complexity and power consumption. In addition, we remove the association problem between users and BS, and present its performance. In short, our contribution can be described as follows:

To fully exploit the benefits of distributed BS and Improve communication quality under severe path loss and interrupt losses are usually in mm-wave communication, we consider a UAV relay-assisted mm-Wave Large Scale MIMO System with Hybrid Beamforming architecture. Specifically, UAV based relaying Sum rates as indicators can significantly improve performance Also expand the coverage area. Simulation results Demonstrates that UAVs can signal relay-based architecture Receivable totals cannot exceed the data rate Optional one without relaying UAV for mm-wave Communications.

Performance and. to achieve better trade-off between Complexities in UAV Enabled Communications, a Multiuser Hybrid beamforming scheme has been prepared, which Signify reduces implementation overhead, and effectively minimizes inter-user interference. Compatible performance is very close to that achieved by full digital beamforming, and performs better [55] proposed in the existing scheme.

To formulate an optimization problem that Best user association scenarios such as sum-rate composite UAV relay-assisted mm-wave massive MIMO systems can be maximized under multiple Barriers to communication, i.e. quality of service, Maximum available bandwidth that each BS can do Support, maximum number of links, power on limit which can transmit a BS initialization signal and Maximum data rate constraints are considered. We show through the simulation that our proposed solution does almost optimal.

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