Abstract—Unmanned aerial vehicles (UAVs) have been recognized as the possible revolution in the fifth-generation (5G) wireless networks. In this work, we consider a scenario where a UAV base station (UAVBS) communicates with legitimate user equipments (UEs) in the presence of eavesdroppers (EDs). Specifically, a UAVBS travels around UEs in turns to send commands and collects information from UEs. To guarantee the data transmission rate, the millimeter-wave (mmWave) communication is integrated into the UAVBS system. Two problems are mainly resolved for the proposed system, namely radar-aided beamforming design and physical layer security (PLS) problem. With the assistance of the radar equipped on the UAVBS, the location of the UEs can be obtained before the beamforming is designed to solve the beam selection problem. In addition, the power allocation is optimized using the difference-of-two-convex-function (D.C.) programming algorithms. In order to safeguard data transmissions against such EDs, the PLS communication system is proposed by considering the location of the UAVBS. We derive the path planning algorithm for the UAVBS to avoid the data transmission with the EDs using the disciplined convex and concave programming (DCCP) algorithm. Extensive computer experiments validate the effectiveness of our proposed location-aware PLS communications in the UAVBS system.

Index Terms—Location-Aware Beamforming, Physical Layer Security, UAV Base Station.

I. INTRODUCTION

Unmanned aerial vehicles (UAVs) have been widely researched for various applications in some specific situations such as communication, rescue, and military applications [1]. UAV base stations (UAVBS’s) promise diverse benefits for tasks such as post-disaster rescue and services in the depopulated area. A UAVBS with a wide-view camera is capable of quickly reaching the desired destination and searching for wide-range targets. As compared to traditional fixed base stations on the ground, UAVBS’s carrying with specific equipment are able to support emergency communication reconstruction after extreme disasters, such as floods, fires and earthquakes.

Despite the potential perspective of UAVBS systems, considerable research efforts are still required to materialize the benefits promised by the existing UAVBS’s. One primary problem is that the limitation on the mobile data transmission. In order to meet the demand for extremely high data rates and low latencies, millimeter wave (mmWave), as one of the most exciting key features of 5G networks, is expected to support extremely broadband connectivity with high reliability and low latency for increased data rates [2]. However, the mmWave system usually requires high overhead for beam training, which actually relies on the transmitter/receiver locations. Motivated by this observation, radar-aided communication system was proposed to guide the beam selection problem [3].

Furthermore, UAVBS’s are power-hungry systems due to the small energy capacity, and the heavy propagation loss of mmWave exacerbates the problem of low energy. To cope with these challenges, low-complexity hybrid analog/digital precoding scheme has been widely employed. Hybrid precoding involves a combination of analog and digital processing, thereby improving the efficiency to support more data transmission and meet the explosive data communication demand. Meanwhile, to guarantee the quality of service (QoS) for each user equipment (UE), power allocation is also an important problem for multi-user wireless networks [4].

On the other hand, the communications of UAVBS’s are vulnerable to malicious attacks due to the inherent wide-area broadcast. As a result, security problem has been a critical challenge in the implementation and operation of the future networks when an active eavesdropper (ED) exists on the ground. To cope with this issue, physical layer security (PLS) communications attract great research attention in recent years. As compared to traditional code-based cryptographic techniques, PLS can guarantee the data transmissions without requiring secret keys and complex algorithms, thereby improving the communication efficiency. The pioneering works in [5], [6] assumed the EDs to work in a half-duplex mode, where the ED can only passively receive signals. Thus, the PLS cannot be guaranteed in the specific scenarios such as full-duplex mode. One of the safest methods for the data transmission of UAVBS’s and UEs is to avoid the signal transmission with EDs. In this way, the received strength at ED is too weak to be recognized and decoded.

In summary, the contributions of this work can be elaborated as follows:

1) A radar-aided UAVBS system is proposed for emergency tasks, where multiple UEs are deployed on the ground to communicate with a delivering UAVBS.

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The hybrid precoding is employed for a UAVBS’s to reduce the number of RF chains. The power allocation is designed to guarantee the QoS of each UE.

2) The PLS is considered by optimizing the UAVBS’s path planning using DCCP-based algorithm. The received signal can be minimized such that the PLS is guaranteed by exploiting the path planning. Moreover, we verify the effectiveness of the proposed algorithms by various computer simulations.

Notations: Uppercase boldface and lowercase boldface letters are used to denote matrices and vectors, respectively. $I_N$ denotes the identity matrix with size $N \times N$. $|A|$ stands for the L2 norm of $A$ while $|A|$ denotes the absolute value of real number $A$. $A$ denotes the estimator of $A$, where $A$ can be a matrix, vector, or scalar. $A^T$ and $A^H$ denote transpose and conjugate transpose of $A$, respectively. Finally, $\nabla f(A)$ represents the gradient of function $f(A)$. The inner product between vectors $x$ and $y$ is defined as $\langle x, y \rangle = x^H y$.

II. SYSTEM MODEL AND PROBLEM FORMULATION

A. System Overview

The block diagram is depicted in Fig. 1, where one rotary-wing UAV equipped with mmWave base stations travels among UEs. Specifically, in order to realize the communication function of the UAVBS, $N_{RF}$ RF chains and $N_t$ antennas are equipped on UAVBS that transmits $Z$ data-streams to $Z$ UEs as well as $M$ EDs equipped with $N_r$ receive antennas at each time slot. In a practical system, the number of RF chains is typically much smaller than the number of antennas, i.e., $N_{RF} \ll N_t$. For the purpose of realizing the radar sensing function of UAVBS, the UAVBS is equipped with a mono-static phased-array radar that shares the communications antenna. Thus, we assume the UAVBS has prior knowledge of the positions about UEs and EDs.

To construct a connection, a UE firstly scans the space periodically until it is identified by the UAVBS. Furthermore, a UAVBS is assumed to communicate with $Z$ UEs and locate them simultaneously. The horizontal positions of the $z$-th UE and the UAVBS are denoted by $p_z = [x_z, y_z]$ and $p = [x, y]$, respectively. Finally, there are $M$ EDs localized at $p_m = [x_m, y_m]$.

B. Large-Scale Fading

The horizontal distance between the UAVBS and the $z$-th ground equipment, i.e., UE or ED, is given by

$$G_z = \sqrt{(x - x_z)^2 + (y - y_z)^2}. \quad (1)$$

We employ the low altitude platforms (LAPs) developed in [7]. The air-to-ground (A2G) pathloss between the UAVBS and the $z$-th ground user can be written in dB as

$$L_z^{dB} = \eta_{LoS} - \eta_{NLoS} + \frac{1 + a \exp(-b \arctan(h / d_z) - a)}{20 \log(d_z) + C_{LAP}}, \quad (2)$$

where

$$d_z^2 = h^2 + G_z^2, \quad (3)$$

$$C_{LAP} = 20 \log(f) + 20 \log(4\pi/c) + \eta_{NLoS}, \quad (4)$$

with $a, b, \eta_{LoS}, \eta_{NLoS}$ being the environment parameters, $d_z$ is the actual distance between the UAVBS and the $z$-th UE, $h$ is the altitude of UAVBS, $f$ is the transmitted radio frequency and $c$ is the speed of light.

C. Channel Models

In the proposed system, we assume that only one data stream is designated to each scheduled UE for transmission. Denoted by $s_n$ the $n$-th symbol of $Z$ data-streams to be transmitted, $s_n$ has unit power with $E[ss^H] = \frac{1}{Z} I_Z$, where $s \in \mathbb{R}^Z$ is the vector of transmitted symbols.

We consider a mmWave propagation environment with a restricted number of scatters. Consequently, the $z$-th user’s channel can be represented as

$$H_z = \sqrt{\frac{N_r N_t}{L_z}} \sum_{l=1}^{L_z} \alpha_{z,l} \cdot a_r(\theta_{z,l}) \cdot a_l^H(\theta_{z,l}) \quad (5)$$

where $\alpha_{z,l}$ is the complex gain of the $l$-th path of the $z$-th user. Besides, $\theta_{z,l}$ and $\phi_{z,l}$ are the corresponding angles of departure and arrival (AODs/AOAs) of the $l$-th path of the $z$-th user, respectively. Finally, $a$ is the array response vector. Assuming a uniform linear array (ULA) with $M$ antenna elements considered in this work, the array response vector $a$ is given by

$$a(\varphi) = \frac{1}{\sqrt{M}} \left[1, e^{j\frac{2\pi}{\lambda}d \sin(\varphi)}, ..., e^{j(M-1)\frac{2\pi}{\lambda}d \sin(\varphi)} \right]^T \quad (6)$$

where $\lambda$ is signal wavelength, $\varphi$ is the directional angle, and $d$ is the antenna spacing, respectively.

To this end, we adopt the Saleh-Valenzuela (SV) channel model with $L_z$ scatter for the channel of the $z$-th user, and each scatter only contributes one single propagation path, as shown in [8].
D. Hybrid Beamforming

In our proposed hybrid precoding scheme under the UAVBS system, let $\beta = [\beta_1, \beta_2, \ldots, \beta_Z]^T$ be the transmitted power vector, where $\beta_z$ is the transmitted power over $z$-th UE, and $\sigma_n^2$ be the noise power at $z$-th UE. Following the similar expressions in [8], we concentrate on modeling the digital and analog precoding process. Denoted by $F$ of $N_{RF} \times Z$ the digital precoder for $Z$ UEs, where $F = [f_1, f_2, \ldots, f_Z]$. Similarly, we model the corresponding analog precoder as $V$ of $N_t \times N_{RF}$. Furthermore, assuming that the UEs are all low-cost terminals that perform analog beamforming only in decoding. For notational simplicity, we denote by $g_z^H$ the effective analog beamforming gain vector observed by the $z$-th UE, i.e.,

$$g_z^H = w_z^H H_z V,$$  \hspace{1cm} (7)

where $w_z$ of length $N_r$ is the analog beamforming vector employed by the UE with the power constraint of $|w_z|^2 = 1$.

Finally, the resulting channel capacity of $z$-th UE can be computed as

$$R_z = \log_2 \left( 1 + \frac{\beta_z |g_z^H f_z|^2}{\sum_{i=1,i \neq z}^{Z} \beta_i |g_i^H f_i|^2 + \sigma_n^2} \right),$$  \hspace{1cm} (8)

E. Location-Aware Physical Layer Security

As the ED exists in the system, the UAVBS must avoid the data transmitting with ED. Recalling Equation (2), the received signal power should satisfy the following constraint:

$$\beta_{ED} - L_{ED} \leq T_{ED}$$  \hspace{1cm} (9)

where $T_{ED}$ is the minimum power that the EDs can receive and decode the signal, and $\beta_{ED}$ is the transmitted power from the UAVBS.

Therefore, we can carefully design the path panning of the UAVBS to minimize the transmitted power for the EDs to avoid the eavesdropping. As derived in [7], the maximal height of the UAVBS can be obtained for a given threshold $L_{ED} = L_{ED}$ using the following criterion:

$$\frac{\partial d_z}{\partial h} = 0,$$  \hspace{1cm} (10)

where the critical point at the radius-altitude curve changes its direction. In this way, the restricted area for the UAVBS can be obtained.

Meanwhile, the QoS of each UE should satisfy the minimal required capacity, i.e.,

$$R_z \geq \lambda_z,$$  \hspace{1cm} (11)

where $\lambda_z$ is the threshold for each UE.

III. RADAR-AIDED DOWNLINK TRANSMISSION

In this section, we discuss the downlink transmission for the radar-aided UAVBS system. The location of the UEs can be obtained by the equipped radar on the UAVBS. Thus, the analog beamforming design can be optimized by leveraging the location of the UEs.

A. Analog Precoder Design

The mobile scenario is illustrated in Fig. 1. For $i$-th instant, the positions of the UAVBS and UEs are denoted by $p_i^G \in \mathbb{R}^2$ with altitude $h$ and $p_i^G \in \mathbb{R}^2$, respectively. At most of time, the altitudes of the UAVBS are constants.

Once the location parameter $p$ is obtained, the angle $\theta_{z,i}$ of the $z$-th UE relative to the UAVBS can be represented as

$$\tan \theta_{z,i} = \frac{h}{|p_{z,i}^G - p_{z,i}^G|},$$  \hspace{1cm} (12)

By assuming that the speeds of the UEs remain unchanged in a relatively short time slot, the predicted location of the $j$-th instant is expressed as

$$\hat{p}_{z,j} = p_{z,i}^G + \Delta T v_{z,i}^G,$$  \hspace{1cm} (13)

where $v_{z,i}^G$ is the given velocity of the $z$-th UE at the $i$-th instant.

From the theory of the ML estimation, the likelihood function $p(r_i|\theta_z)$ can be maximized to obtained the optimal $\theta_z$. Following the channel model implemented in [8], the analog precoder in transmitter can be designed as

$$V = [v_1, v_2, \ldots, v_Z],$$  \hspace{1cm} (14)

where each element is formulated as

$$v_z = [1, e^{j \kappa d \sin \hat{\theta}_z}, \ldots, e^{j (N_r - 1) \kappa d \sin \hat{\theta}_z}],$$  \hspace{1cm} (15)

with $\kappa = \frac{2}{\lambda}$ being the wavenumber and $d$ being the distance between two adjacent antennas. The analog precoder $w_z$ at the receiver can be obtained in the same manner.

B. Digital Precoder Design

In the previous stage, the analog precoders in both receiver and transmitter can be acquired by taking the advantage of the localization information. In the sequel, digital precoding will be implemented to eliminate the interference among different UEs. More specifically, the digital precoder is designed as the pseudo inverse of the effective channels using the zero-forcing algorithm:

$$F_{RF} = G^H (GG^H)^{-1},$$  \hspace{1cm} (16)

where $G_z$ is the collection of effective channels, represented by $[g_1, g_2, \ldots, g_Z]^H$.

To satisfy the normalization constraint, i.e., $|V \cdot f_z| = 1$, power normalization is performed on each $f_z$ derived from $F = [f_1, f_2, \ldots, f_Z]^H$,

$$f_z^* = \frac{f_z}{|V \cdot f_z|}.$$  \hspace{1cm} (17)
C. Location-Aware Power Allocation for PLS

For given precoders and locations of the UEs, we now investigate the QoS-aware power allocation by using the D.C. programming technique in this section.

Since the channel between UAVBS and UEs suffers from large path-loss, which makes the large-scale fading dominant. With the prediction and estimation of the motion parameters of the UEs, the UAVBS can obtain the received power of the $z$-th UE, i.e.,

$$P_{z, db} = P_{db} - L_z,$$

where $L_z$ is the pathloss derived using Equation (2).

Considering the large-scale fading caused by the distance between UAVBS and UE. Rewrite Equation (8), the capacity of the $z$-th UE is formulated as

$$R_z = \log_2 \left( 1 + \frac{\beta_z}{L_z} \cdot |H_z f_z|^2 + \sigma^2_{n,z} \right),$$

where $\beta_z = 10^{P_{db}/10}$, $P_{db} = 10^{P_{db}/10}$, and $L_z = 10^{L_z/10}$.

Considering the QoS requirements for each UE, the sum-rate maximization problem is formulated as follows:

$$\max_\beta \sum_{z=1}^Z R_z(\beta) \quad \text{subject to} \quad C_1: \sum_{z=1}^Z \beta_z \leq P; \quad C_2: R_z(\beta) \geq \lambda_z, z = 1, \ldots, Z.$$ 

where the total transmit power is constrained by $P$ as shown in $C_1$, and $C_2$ ensures that the QoS for the $z$-th UE with a minimum required data rate $\lambda_z$.

Following the procedures in [9], the problem above can be cast as a D.C. programming problem:

$$\max_\beta f(\beta) - g(\beta)$$

Observing from Equation (21), both $f(\beta)$ and $g(\beta)$ are concave in $\beta$, i.e., Equation (21) is a difference of two convex (D.C.) function. For $z = 1,2,\ldots, Z$ define vector $e_z \in R^Z$ by $e_z(z) = 0$ and $e_z(i) = \frac{1}{\ln 2 |Z|} \cdot |g_i H f_i|^2$, $i \neq z$. The gradient of $g$ at each $p$ is represented as:

$$\nabla g(\beta) = \sum_{z=1}^Z \frac{1}{\sigma^2_{n,z}} + \sum_{i=1, i \neq z}^Z \frac{\beta_i}{L_i} \cdot |g_i H f_i|^2, e_z$$

Starting from a feasible $\beta^{(0)}$, the optimal $\beta^{(n+1)}$ at the $n$-th iteration is generated as the optimal solution of a convex problem:

$$\max_\beta f(\beta) - g(\beta) - \langle \nabla g(\beta^{(n)}), \beta - \beta^{(n)} \rangle,$$  

which can be efficiently solved by any existing convex programming software, such as CVX. The computational complexity of Equation (23) is $O(Z^3)$ in each iteration [9].

Finally, since $\beta^{(n+1)}$ is the solution to Equation (23), it follows that

$$\begin{align*}
\min_\lambda & f(\beta^{(n+1)}) - g(\beta^{(n+1)}) - \langle \nabla g(\beta^{(n)}), \beta^{(n+1)} - \beta^{(n)} \rangle, \\
\text{subject to:} & f(\beta^{(n)}) - g(\beta^{(n)}) - \langle \nabla g(\beta^{(n)}), \beta^{(n+1)} - \beta^{(n)} \rangle \\
& \leq \epsilon.
\end{align*}$$

Therefore, the $(n+1)$-th solution is always better than the previous one. The iterative process terminates after $[f(\beta^{(n+1)}) - g(\beta^{(n+1)}) - f(\beta^{(n)}) - g(\beta^{(n)})] \leq \epsilon$ is achieved with a pre-defined threshold $\epsilon > 0$.

Then we can use existed software, such as CVX to resolve the formulation.

IV. DCCP-BASED PATH-PLANNING FOR PLS

A. DCCP Algorithm

The ED avoidance problem can be represented as a non-convex optimization problem, where the distance between the ED and UAVBS base station should be constrained to a minimum value. To cope with this defect, we proposed to implement DCCP algorithm for the path planning of the UAVBS. In general, the D.C. problem can be formulated as:

$$\min_x f_0(x) - g_0(x)$$

subject to: $f_i(x) - g_i(x) \leq 0, i = 1, \ldots, m$,

DCCP is a extension of D.C. programming for optimal problem. More specifically, the DCCP optimal problem can be designed as:

$$\min_x f_0(x) - \phi$$

subject to: $\phi = g_0(x)$,

$$f_i(x) \leq g_i(x)$$

In a DCCP problem, we are able to minimize a convex function, subject to non-affine equality and non-convex inequality constraints.
B. Path Planning for PLS

The path planning for PLS is considered in the sequel. We assume the UAVBS moves in a plane such that the altitude of the UAVBS is fixed as $h \bar{u}$. Recalling Equation (2) and (9), we can derive the undesirable radius of the ED for the UAVBS. Therefore, the radius $G_{ED}$ can be obtained.

The movement of the UAVBS can be modeled as a linear dynamic system. The state model can be formulated as [11]

$$s_{t+1} = As_t + Bu_t,$$  \hspace{1cm} (28)

$$y_t = Cs_t,$$  \hspace{1cm} (29)

where $t = 0, 1, \cdots, T - 1$ denotes the discrete time while $s_t \in \mathbb{R}^4$ composed of the position and velocity represents the states of the UAVBS. Furthermore, $y_t \in \mathbb{R}^2$ stands for the 2-D position output and $u_t$ is the energy consumption required to change the velocity of the UAVBS at the $t$-th time instant. For the UAVBS movement, the parameter $A$, $B$ and $C$ are defined as following:

$$A = \begin{bmatrix} I_2 & \Delta T I_2 \\ 0_2 & R^{(n)} \end{bmatrix}, \quad B = \begin{bmatrix} 0_2 \\ \Delta T I_2 \end{bmatrix}, \quad C = \begin{bmatrix} I_2 \\ 0_2 \end{bmatrix},$$  \hspace{1cm} (30)

where $I_2 \in \mathbb{R}^{2 \times 2}$ is an identity matrix and $0_2 \in \mathbb{R}^{2 \times 2}$ is a zero matrix. $\Delta T$ is the time interval between two consecutive states. In addition, $R \in \mathbb{R}^{2 \times 2}$ is the resistance damping on velocity encountered by the UAVBS. The value of $R$ depends on the environment such as the air friction of the UAVBS. For simplicity, we set $R$ as a constant matrix by ignoring the environmental difference in the sequel.

Denote by $s_0, s_1, \cdots, s_{T-1}$ the discrete samples along the planned trajectory, where $T$ is the number of samples within a period. Recalling the derivation in Equation (28), the ED-avoidance energy-efficient trajectory generation for a single UAVBS can be formulated as the following optimization problem:

$$\begin{align}
\text{minimize} & \quad \sum_{t=0}^{T-1} \| u_t \|_1 \\
\text{subject to:} & \quad C_1 : s_0 = s_{init}, s_{T-1} = s_{end}; \\
& \quad C_2 : s_{t+1} = As_t + Bu_t; \\
& \quad C_3 : y_t = Cs_t; \\
& \quad C_4 : \| u_t \|_\infty \leq P_{max}; \\
& \quad C_5 : \| y_t - y_{t-1} \|_2 \leq \gamma; \\
& \quad C_6 : \| y_t - p_{ED} \|_2 \geq G_{ED}; \\
& \quad C_7 : y_t \in \Gamma,
\end{align}$$  \hspace{1cm} (31)

where $u_t$ is the instantaneous energy consumption while $P_{max}$ stands for the maximal power for one instant. $\| \cdot \|_\infty$ is the $\ell_\infty$ norm of the enclosed quantity. Furthermore, $\gamma$ is a pre-defined parameter to control the smoothness of the resulting path since $\gamma$ constrains the maximal distance between two generated trajectory points. More specifically, a smaller $\gamma$ can lead to a smoother trajectory at the cost of increased computational complexity. Thus, the value of $\gamma$ must be carefully chosen according to the real environment. In constraint $C_6$, the distance between the UAVBS and EDs is constrained. Therefore, the circle areas are approximated and represented as circles that can be converted into convex-concave constraints.

It is straightforward to show that the problem in Equation (31) is non-convex due to its non-convex constraints. However, since Equation (31) follows the DCCP formulation shown in Equation (27), Equation (31) can be solved under the DCCP framework [12]. In contrast to the conventional trajectory-generation algorithms such as Dijkstra and RRT, the proposed DCCP-based method can formulate an optimization problem with given non-convex constraints. It should be pointed out that the solution provided by the DCCP is shown to be a local optimum [12].

V. SIMULATION RESULTS

In this section, we will use computer simulation to evaluate the sum-rate performance of the proposed location-aware hybrid precoding schemes. Unless specified otherwise, we consider a transmitter equipped with a 64 UPA (i.e., $N_t = 64$), $N_{RF} = 16$ RF chains and $N_U = 16$ UEs. Moreover, 5 EDs each equipped with an 9 ULA (i.e., $N_r = 9$) are randomly deployed on the ground. The number of paths is set to $L_s = 1$ and the additive Gaussian noise power $\sigma^2 = -30$ dBm for each user. We consider the azimuth $\text{AoA}/\text{AoD}$’s uniformly distributed over $[0, 2\pi]$ while the elevation $\text{AoA}/\text{AoD}$’s uniformly distributed over $[-\pi/2, \pi/2]$, respectively. For each computer experiment, we compute the average over 100 realizations.

![Fig. 2. Sum-rate comparison for different algorithms.](image)

In Fig. 2, it shows the comparison of the sum-rate between the conventional hybrid beamforming system and the proposed radar-aided communication scheme with 16 UEs. The upper bound of the performance is labeled as “Single User” since the multi-user interference is not considered. The curve labeled as “Radar-Aided ZF Algorithm” refers to the location-aware hybrid precoding with uniform power.
allocation. By employing the proposed D.C. Programming algorithm, the sum-rate has better performance as compared to the radar-aided ZF algorithm. In contrast, the sum-rate is significantly reduced once the localization is not used as shown on the curve referred to “Conventional ZF”. The reason is that the direction of beams cannot be accurately assigned to the UEs due to high mobility of the UAVBS.

![Graph](image)

Fig. 3. The QoS as well as PLS of UEs are guaranteed using the proposed algorithms.

Inspection of Fig. 3 suggests that the proposed D.C. programming algorithm can guarantee the QoS of each UE as compared to the conventional uniform power allocation algorithm. We set the threshold to be 3 bps/Hz. In the meanwhile, the red line shows that the minimal distance of the generated trajectory between the UAVBS and EDs meets the PLS requirement when the $G_{ED}$ is given as 10 m.

Fig. 4 shows the path planning for the PLS communications. The UAVBS moves to avoid the undesirable area that may communicate with EDs. In the meanwhile, the energy consumption can be also minimized as derived in Equation (31). Using the DCCP-based algorithm, the generated trajectory is smooth enough as compared to the conventional grid decomposition algorithms.

VI. CONCLUSION

In this work, the radar-aided communication and path-planning problem are investigated for the UAVBS system. To enlarge the data transmission, location-aware hybrid beamforming system is employed on the radar-aided UAVBS to overcome the propagation pathloss of mmWave. Next, the QoS-aware power allocation algorithm is derived using D.C. programming. In addition, to guarantee the PLS communications, we propose a DCCP-based path-planning algorithm to generate the trajectory for the UAVBS to avoid the attack from existing EDs. Finally, computer simulations verify the effectiveness of the proposed algorithms.

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