

Energy-Efficient Area Coverage in Bistatic Radar Sensor Networks

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Abstract—In this paper we study area coverage in bistatic radar sensor networks (BRSN), which is composed of a collection of transmitters and receivers. Coverage in BRSN is much more difficult than that in traditional sensor networks as the sensing area of a bistatic radar depends on the positions of its component transmitter and receiver, and is in general of an elliptical shape. We first investigate the geometrical relationship between the *c-coverage area* of a bistatic radar and the distance between its component transmitter and receiver, based on which we reduce the number of candidate bistatic radars from all transmitter-receiver pairs. Then we reduce the problem dimension by transforming the *area coverage problem* to *point coverage problem* by employing intersection point concept. Finally we propose an efficient algorithm to solve the *Point Coverage Problem*, which thus solves the *area coverage problem*. We perform extensive simulations to validate our analysis and the performance of the proposed algorithm.

I. INTRODUCTION

Coverage has been widely recognized as one of the fundamental problems in wireless sensor networks [1]–[5]. It is concerned with the quality of sensing about the physical region, and thus has different implications in different scenarios. For monitoring applications, sensors are designated to detect events (targets) in the surveillance region as many as possible to maintain the coverage requirement. Traditional sensors detect the energy or signal emitted by targets in a passive way, which places restriction to highly-accurate target detection. Alternatively, radars have been employed for a long time to detect targets in an active way, which can guarantee reliability and accuracy.

Typically, a radar consists of a transmitter and a receiver: the transmitter sends signals of radio wave at a desired power level, and the receiver collects the signals reflected by targets. According to the locations and collaboration of the transmitter and receiver, radars are classified into three categories [6]: i) a *monostatic radar*, which is referred to a radar where the transmitter and receiver are co-located; ii) a *bistatic radar*, meaning that the transmitter and receiver are separate, being able to be located at different locations; iii) a *multistatic radar*, pointing to the case where the transmitter can collaborate with multiple receivers at different locations. Previous work mostly focused on the physical layer [7] to enhance detection accuracy. With the advance in miniaturization and communication, nowadays radars evolve into small-sized radar sensors, opening a new area named radar sensor networks [6]. More effort is being invested into radar network design [8]–[11]. For

example, monostatic radar networks are investigated in [8], [11], and node placement and dynamic frequency selection are investigated for target detection in bistatic radar networks [12].

We in this work study the network protocol design for coverage requirement in bistatic radar sensor networks (BRSN). The coverage in BRSN has not been studied though it has been extensively investigated in traditional sensor networks [1], [2], [4], [13], [14]. A traditional sensor is commonly assumed to have a disc or a probabilistic sensing (detection) model. The problem boils down to how to deploy sensors or activate sensors upon deployment as few as possible to ensure coverage requirement. For example, Kasbekar [15] designed a distributed and coordinate-free algorithm to provide *k*-coverage based on disc sensing model. Under the probabilistic sensing model, Hefeeda [16] aimed at activating a subset of deployed sensors to construct approximate triangular lattices.

Though bearing some similarity, coverage problem in BRSN has two unique characteristics. First, a BRSN is composed of a collection of transmitters and a set of receivers. A transmitter and a receiver form a bistatic radar when they adopt the same channel. We have to allocate channels for candidate transmitters and receivers to form bistatic radars so that we can obtain desirable network topology. Second, the sensing area of a bistatic radar not only depends on the location of the transmitter but also on the location of receiver, and typically has an elliptical shape, as shown in Fig. 1. This is far from the disc or probabilistic sensing models in traditional sensor networks. Therefore, existing works on coverage in traditional sensor networks can not be applied here.

In this paper, we try to fill an important gap by studying energy-efficient area coverage in bistatic radar networks. We formulate the problem as a *Minimum Weight c-Area Coverage Problem*. This problem is extremely difficult to address since we have to jointly optimize channel allocation for transmitters and receivers and bistatic radar selection while the desired area coverage is guaranteed. We first reduce the problem dimension by transforming the *c-area coverage problem* to *c-point coverage problem*, and then propose an efficient algorithm to solve the *Minimum Weight c-Point Coverage Problem*.

Our main contributions in this work are three fold:

- 1) We explore the geometrical relationship between the *c-coverage area* of a bistatic radar and the distance between its component transmitter and receiver, based on which we reduce the number of candidate bistatic

radars from all transmitter-receiver pairs.

- 2) We transform the *Minimum Weight c-Area Coverage Problem* into *Minimum Weight c-Point Coverage Problem* based on the intersection point concept. This funding significantly reduces the problem dimension, thus paves the way for algorithm design.
- 3) We propose a sensor activation algorithm to solve the problem. Extensive simulations are conducted to validate the effectiveness of our proposed algorithm.

The rest of the paper is organized as follows. We present preliminary knowledge and problem formulation in Section II. We transform the *Minimum Weight c-Area Coverage Problem* into *Minimum Weight c-Point Coverage Problem* and propose an efficient algorithm to solve the problem in Section III. We perform extensive simulations to evaluate the performance of the proposed algorithm in Section IV. Finally, we conclude the paper in Section V.

II. PROBLEM STATEMENT

We consider a bistatic radar sensor network (BRSN) deployed in a large region of interest (ROI) Ω . The BRSN consists of a collection $\mathcal{T}$ of transmit radar sensors (transmitter), and a collection $\mathcal{R}$ of receive radar sensors (receiver). Each transmitter $T_i \in \mathcal{T}$ can choose fixed and orthorhombic channel to avoid interference [7]. By choosing the same channel as a certain transmitter T_i , the receiver $R_j \in \mathcal{R}$ and its corresponding transmitter T_i can form a bistatic radar [12]. In view of this, we assume that one transmitter can only be connected to one receiver. We use $T_i R_j$ to denote the bistatic radar formed by T_i and R_j and denote all the bistatic radars by $\mathcal{TR}$. Without ambiguity, we also use T_i and R_j to denote the position of the transmitters and receivers.

The bistatic radars are widely used for target detection [12]. For a target located at $P \in \Omega$, the SNR that is transmitted by the transmitter T_i and received at the receiver R_j is given by [7]

$$SNR = \frac{K}{\|T_i P\|^2 \|P R_j\|^2}, \quad (1)$$

where $\|T_i P\|$ and $\|P R_j\|$ are the distances of the target from transmitter and receiver, respectively; and K is a constant related to the physical-layer parameters of the bistatic radar, such as transmit power, cross section of radar, and antenna gains of transmitter and receiver. The SNR contours of a bistatic radar are Cassini ovals with foci of transmitter and receiver [7]. For easy exploration, we assume that the constant K is identical for all bistatic radars, i.e., homogeneous bistatic radars. The homogeneous model can serve as a basis for the heterogeneous case, and will not impact the results qualitatively.

The probability that a bistatic radar detects a target at P is determined by the received SNR, given by Eq. (1). Note that the larger $\|T_i P\| \|R_j P\|$, the smaller the received SNR, thus the smaller the probability that the target at P can be detected. We thus use the product of transmitter-target and target-receiver distances as a metric of coverage. Considering the co-existence of multiple bistatic radars, the coverage $C(P)$

of a point P (where targets may appear) can be characterized by the minimum distance products $\|T_i P\| \|R_j P\|$ among all bistatic radars, i.e.,

$$C(P) \triangleq \min_{T_i R_j \in \mathcal{TR}} \|T_i P\| \|P R_j\|. \quad (2)$$

Based on (2), we give the definitions of *c-coverage* and *c-area coverage*.

Definition 1 (c-coverage): Bistatic radar sensor network is said to provide *c-coverage* to point P if

$$C(P) < c.$$

Definition 2 (c-area coverage): Bistatic radar sensor network is said to provide *c-area coverage* to ROI Ω if it provides *c-coverage* to any point P in Ω .

The value of c is decided by the requirement of applications. The smaller c appeals for more working bistatic radars. Nowadays, radar sensors can be manufactured with the size less than a coin, which brings the issue of energy efficiency. In addition, it is desirable to reduce the total number of co-active bistatic radars as the available number of channels is typically limited. Therefore, we aim at energy-efficient on-off scheduling of bistatic radars while *c-area coverage* is guaranteed, which is formally formulated as *Minimum Weight c-full Cover Problem* in the following.

Minimum Weight c-Area Coverage Problem (c-MWACP): Given a ROI Ω , a set $\mathcal{T}$ of transmitters and a set $\mathcal{R}$ of receivers, and a weight w_{ij} for any candidate bistatic radar consisting of transmitter T_i and receiver R_j , *Minimum Weight c-Area Coverage Problem* is to find a subset of bistatic radars with the minimum aggregate weight to provide *c-area coverage* to Ω .

III. AREA COVERAGE OPTIMIZATION

A. The candidate bistatic radar set

According to the definition of *c-coverage*, point P is covered if there is at least one bistatic radar $T_i R_j$ such that $\|T_i P\| \|P R_j\| < c$. Hence, the coverage $\lambda(T_i R_j, P)$ of a point P by a bistatic radar $T_i R_j$ can be expressed as

$$\lambda(T_i R_j, P) = \begin{cases} 1, & \|T_i P\| \|P R_j\| < c \\ 0, & \|T_i P\| \|P R_j\| \geq c \end{cases}. \quad (3)$$

$\lambda(T_i R_j, P) = 1$ means the *c-coverage* of P by $T_i R_j$, while $\lambda(T_i R_j, P) = 0$ indicates that $T_i R_j$ can not provide *c-coverage* to P . We refer to the area that $T_i R_j$ can provide *c-coverage* to as the *c-coverage area* of bistatic radar $T_i R_j$. *c-area coverage* requires that any point in Ω is within the *c-coverage area* of at least one bistatic radar. In Fig. 1, we illustrates the *8-coverage area* bounded by Cassini oval of bistatic radars $T_1 R_1$, $T_2 R_2$, $T_3 R_3$ and $T_4 R_4$ with distances between the transmitter and receiver of d_1 , d_2 , d_3 and d_4 , respectively.

The potential set of bistatic radars is $\mathcal{TR} = \{T_i R_j | T_i \in \mathcal{T}, R_j \in \mathcal{R}\}$ with $|\mathcal{T}| \cdot |\mathcal{R}|$ candidates. See Fig. 1. As the distance between the transmitter and receiver increases,

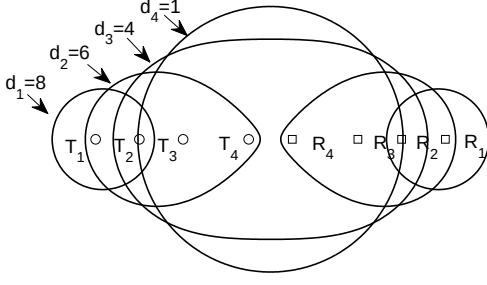


Fig. 1. The 8-coverage area of bistatic radars with different transmitter-receiver distances.

the 8-coverage area of a bistatic radar is turning from a circle to an ellipse and finally into two separate shapes. Fig. 2 shows the trend that when the distance is extremely large, c -coverage area of a bistatic radar approaches 0. Let D be a threshold of distance when c -coverage area of a bistatic radar becomes negligible. We obtain the candidate bistatic radar set (still denoted by $\mathcal{TR}$) by excluding from the potential candidate bistatic radar set the bistatic radars where the distance between transmitter and receiver is larger than D , i.e., $\mathcal{TR} = \{T_i R_j | T_i \in \mathcal{T}, R_j \in \mathcal{R}, ||T_i R_j|| \leq D\}$. Doing this will not impact the overall network much as c -coverage area of a bistatic radar is relatively small in this case, however, it can largely reduce the number of candidate bistatic radars so as to mitigate the computational complexity. D is determined by the value c , application requirement and also physical parameter of radars.

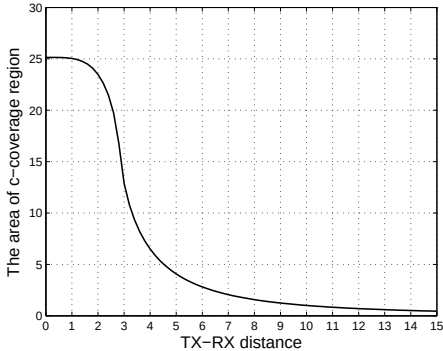


Fig. 2. The area of c -coverage region with different transmitter-receiver distances ($c=8$).

B. The intersection point method

We employ the intersection point concept [15] to transform the c -area coverage problem into c -point coverage, which will reduce the problem dimension and thus the computational complexity. Two bistatic radars $T_{i_1} R_{j_1}$ and $T_{i_2} R_{j_2}$ in $\mathcal{TR}$, are *intersected* when their c -coverage areas intersect. For the reason that two bistatic radars with the same transmitter or

receiver can not both be activated at the same time, we have to ensure $i_1 \neq i_2$ and $j_1 \neq j_2$. In this case $T_{i_1} R_{j_1}$ and $T_{i_2} R_{j_2}$ are termed as *disjoint bistatic radars*. Let IP be the set of all intersection points.

Theorem 1: Let C be a subset of $\mathcal{TR}$ with disjoint bistatic radars. C provides c -area coverage to ROI Ω if and only if it provides c -coverage to all points in IP .

We omit the proof due to space limitation. With Theorem 1, to guarantee c -area coverage, we only have to study the c -point coverage over a set IP of points with finite cardinality. We have the following result.

Property 1: Two disjoint bistatic radars $T_{i_1} R_{j_1}$ and $T_{i_2} R_{j_2}$ in $\mathcal{TR}$ are not *intersected* if at least one of the following conditions holds: (i). $||T_{i_1} T_{i_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_1^2}{4}} + \frac{d_1}{2}$ and $||T_{i_1} R_{j_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_1^2}{4}} + \frac{d_1}{2}$; (ii). $||R_{j_1} T_{i_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_1^2}{4}} + \frac{d_1}{2}$ and $||R_{j_1} R_{j_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_1^2}{4}} + \frac{d_1}{2}$; (iii). $||T_{i_1} T_{i_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_2^2}{4}} + \frac{d_2}{2}$ and $||R_{j_1} T_{i_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_2^2}{4}} + \frac{d_2}{2}$; (iv). $||T_{i_1} R_{j_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_2^2}{4}} + \frac{d_2}{2}$ and $||R_{j_1} R_{j_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_2^2}{4}} + \frac{d_2}{2}$; (v). $||T_{i_1} T_{i_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_2^2}{4}} + \frac{d_2}{2}$ and $||R_{j_1} R_{j_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_2^2}{4}} + \frac{d_2}{2}$; (iv). $||T_{i_1} R_{i_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_2^2}{4}} + \frac{d_2}{2}$ and $||R_{j_1} T_{j_2}|| \geq \sqrt{c} + \sqrt{c + \frac{d_2^2}{4}} + \frac{d_2}{2}$. Hereby, $d_1 = ||T_{i_1} R_{j_1}||$, $d_2 = ||T_{i_2} R_{j_2}||$, $d = \min(d_1, d_2)$

Proof: Let P be an arbitrary point on the boundary of c -coverage area of bistatic radar $T_{i_1} R_{j_1}$ such that $||T_{i_1} P|| \cdot ||R_{j_1} P|| = c$ as shown in Fig. 3. It follows that the maximal value of $||T_{i_1} P||$ or $||R_{j_1} P||$ is $\sqrt{c + \frac{d_1^2}{4}} + \frac{d_1}{2}$. The proof is omitted for space limitation. With this property, for case (i), we have

$$\begin{aligned} & ||T_{i_2} P|| \cdot ||R_{j_2} P|| \\ & > (||T_{i_1} T_{i_2}|| - ||T_{i_1} P||)(||T_{i_1} R_{i_2}|| - ||T_{i_1} P||) \\ & \geq (||T_{i_1} T_{i_2}|| - \sqrt{c + \frac{d_1^2}{4}} - \frac{d_1}{2})(||T_{i_1} R_{i_2}|| - \sqrt{c + \frac{d_1^2}{4}} - \frac{d_1}{2}) \\ & \geq c. \end{aligned} \quad (4)$$

This shows that a point on the boundary of c -coverage area of bistatic radar $T_{i_1} R_{j_1}$ can not be on the boundary of c -coverage area of bistatic radar $T_{i_2} R_{j_2}$, which means that $T_{i_2} R_{j_2}$ has no *intersection* with $T_{i_1} R_{j_1}$. The same conclusion can be derived for the cases (ii), (iii), (iv), (v) and (vi) in a similar process. ■

With the Property 1, we can check whether two disjoint bistatic radars $T_{i_1} R_{j_1}$ and $T_{i_2} R_{j_2}$ are not *intersected* by calculating the conditions (i), (ii), (iii), (iv), (v) and (vi). If two bistatic radars have intersection points, solve the following equations to obtain intersection points, denoted by $P(x, y)$.

$$\begin{aligned} & \sqrt{(x - x_{i_1})^2 + (y - y_{i_1})^2} \sqrt{(x - x_{j_1})^2 + (y - y_{j_1})^2} = c, \\ & \sqrt{(x - x_{i_2})^2 + (y - y_{i_2})^2} \sqrt{(x - x_{j_2})^2 + (y - y_{j_2})^2} = c. \end{aligned}$$

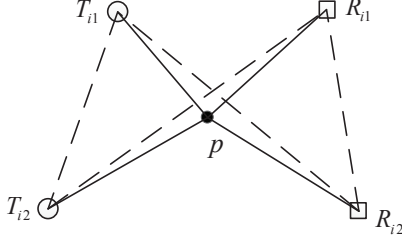


Fig. 3. Illustration of two disjoint radars.

(x_{i1}, y_{i1}) , (x_{j1}, y_{j1}) , (x_{i2}, y_{i2}) and (x_{j2}, y_{j2}) are coordinates of T_{i1} , R_{j1} , T_{i2} and R_{j2} , respectively. Note that the converse of Property 1 does not hold, since $T_{i1}R_{j1}$ and $T_{i2}R_{j2}$ may not have intersection points when these six conditions are all invalid.

C. Algorithm Design

As aforementioned, the candidate radar set is $\mathcal{TR} = \{T_i R_j | T_i \in \mathcal{T}, R_j \in \mathcal{R}, ||T_i R_j|| \leq D\}$ with D being a predefined value. The weight w_{ij} , $T_i R_j \in \mathcal{TR}$ is a function of the smaller residual energy of T_i and R_j . For example, w_{ij} can be set as

$$w_{ij} = l^{\tau_{ij}} \quad (5)$$

with l being a constant satisfying $l > 1$ and $\tau_{ij} = \min(1 - e_{T_i}/E_{T_i}, 1 - e_{R_j}/E_{R_j})$, where e_{T_i} , e_{R_j} , E_{T_i} and E_{R_j} are the current and initial energy of T_i and R_j , respectively [3]. Let $x_{ij} = 1$ if T_i and R_j are selected as a bistatic radar, $x_{ij} = 0$, otherwise. Let $\lambda_{ij}^P = 1$ if P is within the c -coverage area of candidate bistatic radar $T_i R_j$, and $\lambda_{ij}^P = 0$, otherwise.

We formulate the *Minimum Weight c-Area Coverage Problem* as the following 0 – 1 integer programming problem:

$$\begin{aligned} & \text{Minimize} \quad \sum_{T_i R_j \in \mathcal{TR}} w_{ij} x_{ij} \\ & \text{s.t.} \quad \begin{cases} \sum_{T_i R_j \in \mathcal{TR}} \lambda_{ij}^P x_{ij} \geq 1, \forall P \in IP \\ \sum_{R_j \in \mathcal{R}} x_{ij} \leq 1, \forall T_i \in \mathcal{T} \\ \sum_{T_i \in \mathcal{T}} x_{ij} \leq 1, \forall R_j \in \mathcal{R} \\ x_{ij} \in \{0, 1\}, T_i \in \mathcal{T}, R_j \in \mathcal{R} \end{cases} \end{aligned} \quad (6)$$

The first constraint ensures that each intersection point in IP is within the c -coverage area of at least one selected bistatic radar. The second and third constraints maintain that each selected transmitter or receiver can only be associated to one receiver or transmitter.

The problem formulated by (6) is an NP-hard problem as one of its special case is the classical set cover problem [17]. We thus focus on approximation algorithms and propose an energy efficient c -area coverage optimization algorithm under radar network (ACO) to solve this problem. The ACO consists of two phases: the initialization phase and the activation phase, which will be elaborated in next two subsections.

1) *The initialization phase:* We execute the initialization phase at the beginning of the network operation. In this phase, we compute the candidate bistatic radar set $\mathcal{TR}$ in Step 1 and the intersection points set IP in Step 2.

Step 1: For each pair of transmitter T_i and receiver R_j , calculate their distance $||T_i R_j||$. If $||T_i R_j|| < D$, then add the bistatic radar $T_i R_j$ to the candidate radar set.

Step 2: For each disjoint pair of candidate bistatic radar $T_{i1} R_{j1}$ and $T_{i2} R_{j2}$ in $\mathcal{TR}$, confirm the validity of the conditions in Property 1. If none of these conditions holds, solve to find the coordinates of intersection points and add them to IP .

2) *The activation phase:* The activation phase executed at the beginning of each time slot, is to activate a small set of disjoint bistatic radars. The transmitters and receivers not being activated are turned into sleep mode that consumes negligible energy in each slot.

The weight w_{ij} of each candidate radar $T_i R_j$ is calculated by Eq. (5), i.e., according to the current residual energy of its component transmitter and receiver. If the transmitter or receiver of a bistatic radar does not have enough energy to operate for one slot, we assign w_{ij} with a value of ∞ ; otherwise, $w_{ij} = l^{\tau_{ij}}$, which indicates that more residual energy leads to a larger weight. The network lifetime is considered as terminated when one or more radars in the activated bistatic radar set have infinite weight. The detailed computation of c -MWACP to activate a minimum weight cover is presented in Algorithm. 1.

Algorithm 1 The sensor activation for c -MWACP

Definitions:

- Let $\overline{\mathcal{TR}}$ be the set of current available bistatic radars. Initially, $\overline{\mathcal{TR}} = \mathcal{TR}$.
- Let $\overline{IP}$ be the set of intersection points in IP that have not been covered by activated bistatic radars. Initially, $\overline{IP} = IP$.
- Let C be the set of activated bistatic radars. Initially, $C = \emptyset$.

Begin

- 1) For every bistatic radar $T_i R_j \in \overline{\mathcal{TR}}$, compute $\lambda_{ij} = \frac{\sum_{P \in \overline{IP}} \lambda_{ij}^P}{w_{ij}}$. Select $T_i R_j$ with the largest λ_{ij} . Finally add $T_i R_j$ to C , and at the same time delete $T_i R_j$ from $\overline{\mathcal{TR}}$, and P from $\overline{IP}$ if $\lambda_{ij}^P = 1$ and set $x_k = 1$.
 - 2) If $\overline{IP} = \emptyset$ or $w_{ij} > B$, then terminate the Algorithm and return C .
 - 3) Exclude the bistatic radars with component T_i or R_j from $\overline{\mathcal{TR}}$. Go back to 1).
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IV. SIMULATION

In this section, we perform simulations to demonstrate the performance of the proposed algorithm by using Matlab. As there is no previous work on this issue, we compare our algorithm with the grid-point based method (G-method), which is widely adopted for the full area coverage problem in sensor network. Furthermore, we also evaluate the impact of threshold D on computational time and aggregate weight of activated bistatic radars.

The parameters for simulation setup are given as follows. The transmitters and receivers are randomly deployed in ROI Ω and the value of c is set to be 10. Each transmitter or receiver is associated with a random residual energy varies from 0 to 1. We assign the weight of a bistatic radar by $w = 0.1^e$, where e is the minimum residual energy of the component transmitter and receiver.

A. Simulation results

We first evaluate the performance of our ACO to the well-known G-method. The main idea of the G-method is to approximate area coverage of the monitored region by guaranteeing the coverage of discrete grid points. The larger number of grid points that we choose, the more close the algorithm can approximate the area coverage. We simply employ this method in bistatic radar network by selecting the grid points and solve this point coverage problem using Algorithm. 1.

In the first simulation, 200 transmitter and 250 receivers are randomly deployed in Ω with the size of $50\text{m} \times 50\text{m}$ and the threshold D is given as 12. To have a fair comparison, the number of selected grid points is set almost the same as that of the intersection points in IP . Fig. 4 depicts the simulation results of the area coverage, which shows that our ACO can completely guarantee c -area coverage to ROI while the G-method not. Thus, we validate the correctness of Theorem. 1. In addition, the performance of G-method fluctuates with operation time, showing G-method is not reliable. Note that in practice, as we do not know the accurate number of points in IP , G-method would perform even worse.

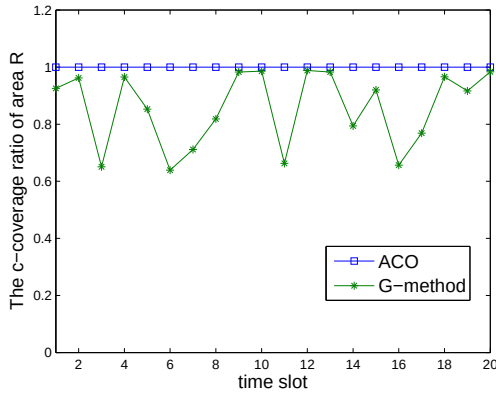
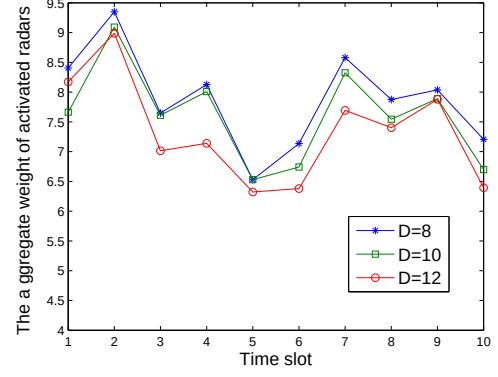


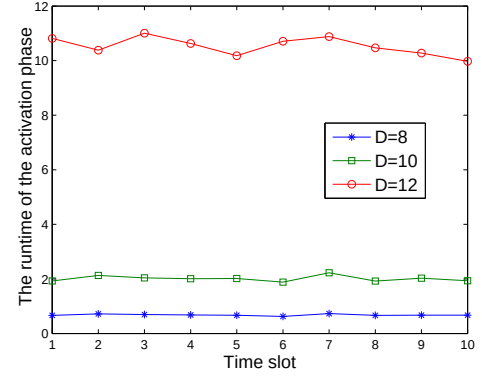
Fig. 4. The c -covered area of R

In the second experiment, we demonstrate the impact of different D , $D = 8, 10, 12$, on the performance of proposed algorithm. ROI Ω is a rectangular field of $20\text{m} \times 20\text{m}$ with 24 transmitters and 26 receivers randomly deployed. The amounts of candidate bistatic radars when $D = 8, 10, 12$, are respectively 192, 290 and 371, while the numbers of intersection points in IP are 1973, 4025, and 6453. Definitely, the numbers increase with the set value of D . Fig. 5 presents the performance comparisons under different D in terms of the

aggregate weight and runtime. We can summarise that larger D can improve the lifetime as it activate a smaller weight radar cover but will bring significant computational cost, which implies a tradeoff between the lifetime optimization and computational cost.



(a) Aggregate weight of activated radar cover.



(b) The runtime of the activation phase.

Fig. 5. Simulation results.

V. CONCLUSION

In this paper, we investigated the area coverage problem in bistatic radar sensor network. We reduced the number of candidate bistatic radars from all transmitter-receiver pairs, in order to mitigate the computational complexity. Then, we utilized the intersection point concept to transform the *Minimum Weight c -Area Coverage Problem* into *Minimum Weight c -Point Coverage Problem*, which significantly reduces the problem dimension. With these fundings, we designed an energy efficient sensor activation algorithm. Simulation results are conducted to validate the analytical results and performance of our proposed algorithm.

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