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Efficient Partial Coverage in Wireless Sensor Networks

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Abstract— **The objective of this paper is to determine sensing coverage with minimum number of sensors in a sensor network. We focused on partial coverage problem that aims to cover monitored region using few number of sensors. In this paper we study the connected coverage problem with a given coverage guarantee. We first introduce the k-coverage problem after that we analyze the partial coverage problem. For minimum number of sensors we have worked on partial coverage. We introduce an algorithm which gives a subset from a given set of sensors which guarantees the θ-coverage (0<θ<=1).**

Keywords— **Area coverage, sensor network, tiny OS**

I. Introduction

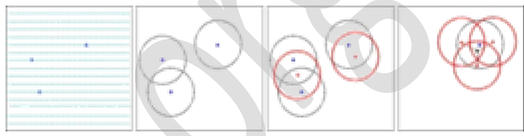
One of the main applications of wireless sensor networks is to endow with proper coverage of their deployment regions. A wireless sensor network covers its deployment region if each point in its deployment region is within the coverage ranges of at least k- sensors. In this paper, we assume that the sensors are deployed as either a Poisson point process or a uniform point process. In a square or disk region, and study how the probability of theθ-coverage changes with the sensing radius or the number of sensors. Our results take the complicated boundary effect into account, rather than avoiding it by assuming the toroidal metric as done in the literature.

II. Preliminaries

THE K-COVERAGE PROBLEM AND SOLUTION APPROACH

(k-Coverage Problem): Given n already deployed sensors in a target area, and a desired coverage degree $k \geq 1$, select a minimal subset of sensors to cover all sensor locations so that every location is within the sensing range of at least k different sensors. It is assumed that the sensing range of each sensor is a disk with radius r, and sensor deployment can follow any distribution.

An efficient approximation algorithm for solving the k-coverage problem is proposed.



(a) (b) (c) (d)

Fig 1: Modeling k-coverage as a set system (X, R).
(a) shows the points which constitute X .
(b) shows three subsets of R that are associated with three highlighted points in (a).
(c) shows a hitting set $\{c_1, c_2\}$ that 1-covers three subsets in (b)
(d) shows one 3-flower 3-covers one subset in R.

PARTIAL SENSOR COVERAGE

Let's introduce the concept of partial sensor cover, which is different from the *full sensor cover* in the literature in which the chosen sensors cover the complete monitored region.

For a given coverage promises θ with $0 < \theta \leq 1$, *the partial sensor cover* is a set of sensors along with minimum cardinality that covers minimum θ percentage of the total region. It is also termed to as *the* θ*-cover*. A special case of partial coverage is the full sensor coverage while $\theta = 1$.
To deal out the covered areas the monitored region can be partitioned into a number of equal-size blocks.

This leads to the *evenly partial* sensor *cover*, which is a set of sensors with minimum cardinality such that each of the blocks in the monitored region is θ-covered. In some applications, it may still be inadequate to have the monitored area been either completely or partly covered. Reason is the communication graph induced by the sensors in the partial or full cover might not be associated, while the sensed data by the sensors in the network have to be transmitted to the base station throughout the sensors.
Thus, it is required that the sensors in a partial or full sensor cover be capable to communicate together so that the sensed data can be transmitted to the base station. If the communication graph induced by a full (partial or evenly partial) sensor cover is connected, the sensor cover is defined as a connected, full (partial or evenly partial) sensor cover.

III. METHODOLOGIES

In recent years, incredible effort was given worldwide to do research and development on wireless sensor networks covering the monitored region, preserving network connectivity, maximizing energy efficiency and network lifetime.

Amongst them the recent progress of the full coverage and connectivity problem was surveyed. The closest work to ours is the problem of selecting the minimum number of sensors to activate from a set of randomly deployed sensors for k-coverage.

We propose new algorithms to attain k-coverage in dense sensor networks. In such networks, covering sensor locations approximates covering the whole area. However, it has been revealed before that selecting the minimum set of sensors to activate from an already deployed set of sensors is NP-hard. We recommend an efficient approximation algorithm that achieves a solution of size within a logarithmic factor of the optimal.

The problem of choosing the minimum number of sensors is to trigger from a set of already deployed sensors for k-coverage. This is the proof of NP-hard problem since it is an extension of the dominating set problem. This work presents a centralized algorithm that works by iteratively adding a set of nodes which maximizes a measure called k-*benefit* to an initially empty set of nodes. We present a randomized k-Coverage Algorithm that works by deploying n number of sensors in a target area , and a desired coverage degree k>=1, select a least subset of sensors to cover up all sensor location such that every location is within the sensing range of at least k different sensors.

IV. OBSERVATIONS

For a given monitored region R, a set S of sensors, a coverage guarantee θ, and the sensing range r of each sensor, the minimum number of sensors for the θ-coverage problem is Nopt(θ) ≥ θC(R)πrs^2 , where 0 < θ ≤ 1.It is obvious because each sensor covers at most πr^2 area. Notice that this observation only provides a lower bound on the number of sensors required for the θ-coverage problem. It, however, does not ensure that the communication graph induced by these sensors is connected.

Lemma 1: For a coverage guarantee θ with 0 < θ ≤ 1, a set S of sensors with sensing range rs and communication range rc, assume that a given a monitored region R has been connected θ-covered, then, no sensing void can partition the covered area in R if rc ≤ 2rs. In other words, there is only one covered area.

V. ALGORITHM

In this paper, we first propose the concept of partial coverage in sensor networks referred to as θ-coverage, (0 < θ ≤ 1) for further reducing energy consumption, thereby prolonging the network lifetime. We then analyze the properties of partial coverage and present an algorithm by which some selected nodes will be active that takes partial coverage and connectivity into consideration simultaneously .Other nodes will be in sleeping mode .When these node will be exhausted from the same algorithm again the nodes will be selected to give the partial coverage repeatedly. We finally conduct extensive experiments by simulation to evaluate the performance of the proposed algorithm.

The algorithm is all follows:

Input: the monitored region R , the set S of sensors, the coverage guarantee θ in percentage(%) .
Output: The set AS of active sensors if it exists.
begin
1. AS = {s}, where s is selected randomly from S;
2. construct a shortest path tree SPT rooted at s.
3.Find out the % age of area covered by the root nodes using cov(s,t,..).
/*cov (s) is the area covered by sensor s*/
4.for each node t descendent of s.
5.check flag=0? /*flag value of each sensor*/

6. if yes. compute dist(s,t)
7. if dist(s,t)>2r /*minimum distance between two nodes*/
8.flag=1
9.compute cov(t)
10.Now root is t.
11.repeat the steps 3 to 10.
12.else(dist(s,t)<2r) go to the next node & repeat from 3 to 10.
13.If there is not any descendent or flag!=0 go to the ancestor and continue from 4 to 10.
14.exit if there is not any node whose flag =0.

The entire algorithm is implemented in JAVA and the output is shown in subsequent sections.

VI. RESULTS

The results are shown in snapshots as in following.

Start Page:

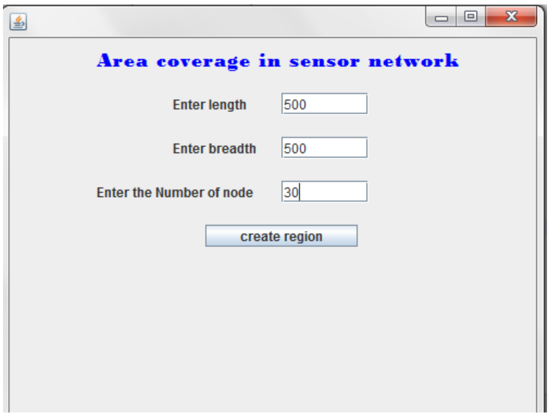


Fig2: Start page with inputs

Sensor deployment:

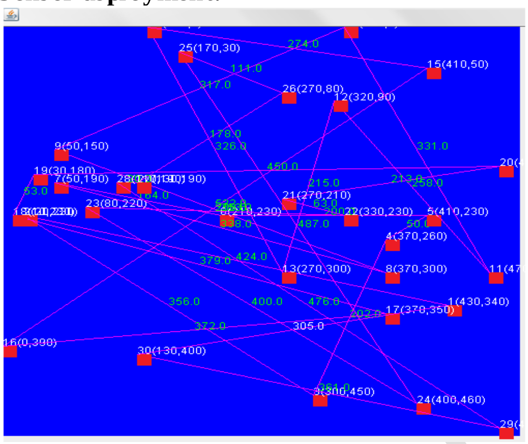


Fig3: Sensor deployment

Creating Spanning Tree

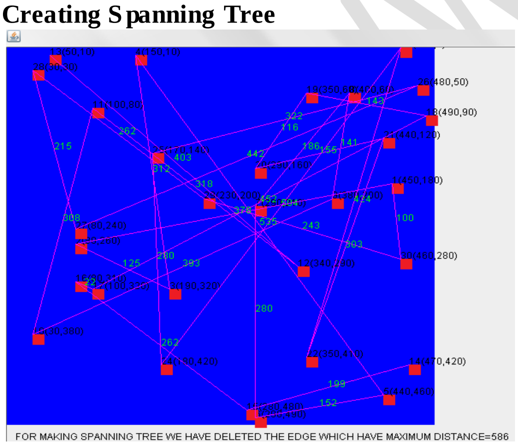


Fig4: Creating spanning tree

Active sensor with covered area

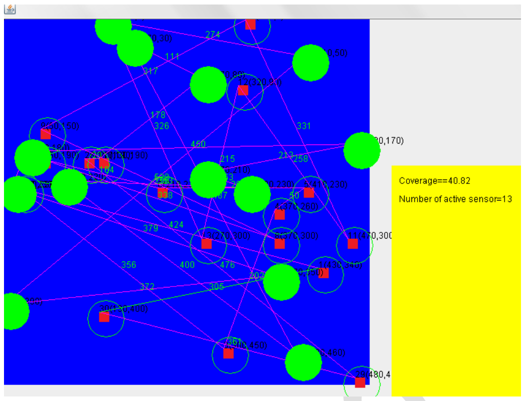


Fig5: Active sensor with covered area

VII. Conclusion

In this paper we have shown that coverage and connectivity are important metrics to characterize quality of sensor networks. A partial k-coverage algorithm is proposed to select a subset from a given set of sensors for θ-coverage (0<θ<=1). This algorithm preserves node connectivity and k-coverage property for hotspot area.

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