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A Survey on Coverage Problem in Wireless Sensor Network

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Abstract: A wireless sensor network (WSN) is a composed group of a small tiny battery-equipped device capable of sensing, communication and computation which can be scattered over a vast region for the purpose of detecting or monitoring region perfectly. Sensing coverage and network connectivity are two of the most fundamental problem in WSNs. In WSN is usually defined as a measure of how well the sensing field is monitored or sensors are able to observe the physical space. Connectivity can be defined as the ability of the sensor to reach the data sink. Finding an optimal deployment strategy that provides high degree of coverage with network connectivity is extremely challenging. Therefore, maximizing network coverage as well as maintaining network connectivity using the resources constrained node is a non-trivial problem. In this survey article, we classify the coverage problem; analyze the relationship between coverage and connectivity and research challenges and existing problem in this area.

Keywords: Wireless sensor network; Coverage; Network connectivity; Deployment strategy.

1 Introduction

Issues related to wireless sensor network are of high importance in modern knowledge for processing and information technology and at present many scientists are doing research on these cases in various universities. Wireless sensor network are important in the case of accessing the region that user cannot enter or collect data directly [1].

Wireless sensor network are composed of a large no. of sensor deployed in a given region. All nodes collaborate to execute sensing and monitor tasks and send sensed data to sink. Wireless sensor network are used in various application such as, military activities, target acquisition, environmental activities and civil engineering. Each sensor node in WSN needs a battery as a source of energy. The lifetime of batteries determine the lifespan of the network, so the energy efficiency is an important factor for having a longer network lifetime [2].

Coverage of a sensor network reflects how well the target area is monitored by sensors. However, the sensor node limitations are causes problem such as network lifetime, coverage and connectivity. For example, to increase the coverage, more sensor nodes may be added. This means installation cost is increased, the network lifetime changes, and the data transmission route must be redesigned. Also, the connectivity of the sensor nodes needs to be concerned in order to transfer the sensing data to base station. Thus, the position of each sensor node must be planed before the sensor node deployment process [3].

This paper will be organized as follows: section 2 will describe the several issues in WSN and section 3 will describe the classification of coverage problem while section 4 finally concludes the paper.

2 Issues in WSN

There are several factors that affect the design and performance of a wireless sensor network [4]-[5].

2.1. Energy Efficiency

The best way to energy efficiency maximize the network lifetime is to balance energy consumption among the entire sensor in the network.

2.2. Security

Security in sensor network is as much as an important factor as performance. Security means provide a stronger and complete protection against illegal activities and maintain stability of the system at the same time.

2.3. Deployment

Deployment means setting up the operational sensor network in a real world environment. Sensor nodes are deployed in a area by either placing them in a predetermines location or having the nodes randomly located is known as deterministic or random placement.

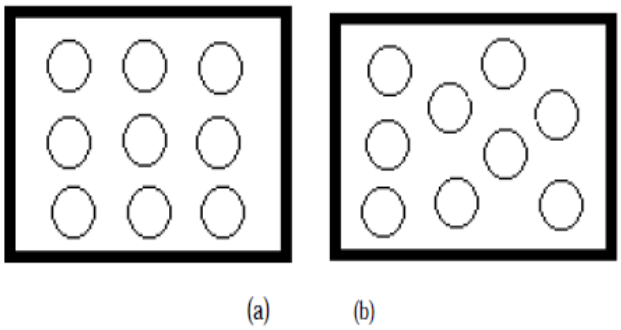

Fig.1 (a) Deterministic Deployment (b) Random Deployment

2.4. Data Management

Amount of data collected by a WSN is remarkably huge, how to manage, process and route this data is truly a challenge.

2.5. Routing

Safely and securely route the data through a high-density network is also a big question for sensor network.

3 Classification of coverage problem

The major objective of coverage problem is to efficiently cover an area or set of points or objective under various limitations. The coverage algorithm based on the subject to be covered, sensor deployment mechanism and other wireless sensor network properties. Three type of coverage have been covered in this paper.

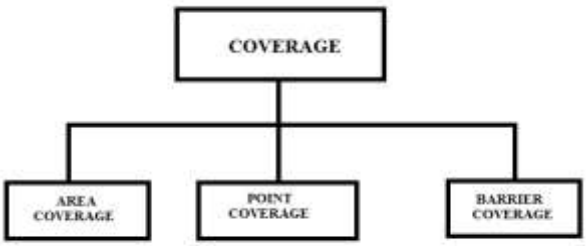

Fig.2 Different type of coverage

3.1 Area Coverage

The main objective of sensor network in area coverage is to monitor a region or entire area. Entire area also known as full or blanket coverage means that every single points within the field of interest in the sensing range of at least one sensor node. According to requirement area coverage is divided into I-coverage algorithm, k-coverage algorithm and connected based coverage algorithm.

3.1.1 I-coverage algorithm

In reference [6], determines I-coverage algorithm. In this paper analyze the possibility of one node becoming a redundant node according to the relationship of positions of different node. If a node is redundant, it will sleep. The algorithm judged the redundant nodes only considering the neighbor nodes in its sensing range, while there are still other redundant nodes in active nodes, thus, the performance of this mechanism need to be enhanced.

3.1.2 K-coverage algorithm

A location in an area A is said to be k-covered if it is within at least k sensor sensing range. Area A is said to be k-covered if every point within it is k-covered. In this k is coverage level or coverage degree. The mechanism used in this paper considers the contribution value of the network when the node from the sleep state changing to active state [7].

K-coverage is concern with covering a region by k sensor where k>=1.different application of WSN like fire detection, radiation detection and intrusion detection may require k-coverage in real time. Two following categories of k-coverage problem have been identified.

K-coverage verification: In this category k-coverage problem is formulated as a decision problem where a given area needs to be verified whether it is k-covered or not.

Selecting subset from deployed nodes for k-coverage: The problem select minimum subset from already deployed sensor nodes to activate from sleeping mode in order to maintain k-coverage in the given area [8].

3.1.3 Connected coverage problem

An important issue in WSN is connectivity. A network is connected if any active node can communicate with any other active node. In reference [9], a localized protocol, each node makes decision based solely on information about itself and its one-hop neighbor. If position information is also available-or its two hop neighbor-if position information is not available.

3.2 Point Coverage

The main objective is to cover a set of point with known location that need to be monitored. The point coverage scheme focuses on determining sensor node exact position, which

guarantees efficient coverage application for a limited number of targets.

In reference [10], propose a point mechanism and two connectivity mechanism. In the point coverage mechanism we present a method for computing the waiting time, which reduce the number of required sensors. For preserving the connectivity, virtual robust spanning tree (VRST) and modified virtual robust spanning tree (MVRST) are proposed. These mechanisms are based on making a virtual spanning tree and converting this tree to a physical tree. In order to spread out sensed data to sink from different paths and decrease the loss probability, instead of using a minimum spanning tree (MST) to connect node to sink, we use combination of distance of nodes and the no. of hops to select the edge and construct the tree.

3.2.1 Target connected-coverage problem

One of the major issues in target-coverage problem of wireless sensor network is to increase the network lifetime. This can be solved by selecting minimum working node that will cover all the target. In reference [11], propose an ant colony algorithm for this purpose. In this, we assume a homogeneous sensor network comprised N sensors randomly deployed to cover M target. Each sensor has an initial energy E where it consume some energy per time unit for sensing and for communication purpose. Among the sensor some are base station connected, known as reference sensor send the sensed information for processing. The other ordinary sensors communicate with base station through reference sensor. To prolong the network lifetime, the reference and ordinary are scheduled alternatively between active and sleep mode such that all the target are monitored continuously.

3.3 Barrier Coverage

Barrier coverage refers to the detection of movement across a barrier sensor. This is useful in application where the major goal is to detect intruders as they cross a border or as the penetrate to protected area. Barrier coverage is also known as sweep coverage.

The major goal of barrier coverage is to detect intruders as they cross a border or as they penetrate a protected area [12].

3.3.1 K-barrier coverage

A sensor network provides k-barrier coverage for ROI if all crossing path through the region is k covered. K-barrier coverage is needed due to false alarms and detection failures happen frequently for intruder detection. If the number of barrier formed is larger than the required number of barrier, we can apply sleep-wake up protocols to prolong the network lifetime. In order to form k-barrier coverage for ROI, mobile sensor should move to fill gaps between stationary sensors.

In [13], present a complete solution to detect intruders moving along restricted crossing path in rectangular areas. In this, we present an efficient distributed algorithm to construct sensor barrier on long strip area of irregular shape without any constraint on crossing paths. Our algorithm approximates the area by dividing it into horizontal rectangular segment interleaved by vertical thin strips. Each segment and vertical strip independently computes the barrier in its own area and achieves continuous barrier coverage for whole region. A strong barrier has no gaps, so that no intruders can cross the region undetected no matter what crossing path the intruders would choose.

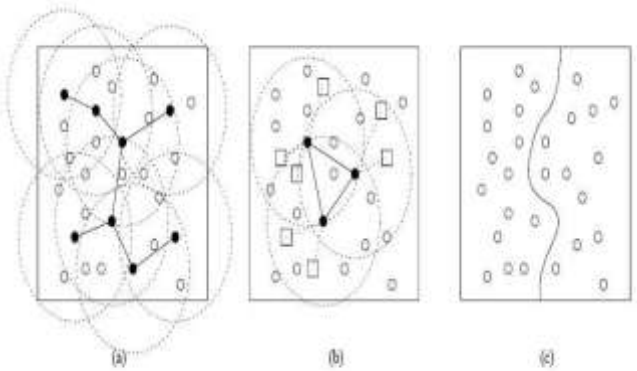

Fig.3 (a) Area Coverage (b) Point Coverage
(c) Barrier Coverage

Different coverage type and their objective corresponding to which coverage approach is used are defined in TABLE 1.

TABLE1. Different Coverage Approaches

COVERAGE TYPE	APPROACH COVERAGE	COVERAGE OBJECTIVE
Area coverage	Node Self Scheduling Algorithm	Energy efficiency, Maximum network lifetime
Area coverage	I-Coverage Algorithm	Energy efficiency, Network lifetime
Area coverage	K-Coverage Algorithm	Energy efficiency, Connectivity
Area coverage	Connected Based Coverage Algorithm	Energy efficiency, Connectivity
Point coverage	K-Connected Coverage Set (K-CCS/K-CS)	Minimum energy consumption
Point coverage	VRST and MVRST method	Less data latency
Point coverage	Disjoint Set Heuristic	Energy efficiency
Target coverage	NP-Complete Problem Heuristics Approach	Maximum network lifetime
Target coverage	Ant Colony Algorithm	Coverage ratio
Barrier coverage	Minimum Exposure Path Algorithm	Minimum exposure path
Barrier coverage	Distributed Algorithm For Disjoint Barrier	Computation cost, Low delay

Barrier coverage	Direction Barrier Coverage Algorithm	Shortest coverage path

4. Conclusion

In this paper, we categorized and describe recent coverage problem. Coverage and connectivity are two important properties of WSN. Adjusting the working direction of sensor nodes is the main method for coverage improvement. Whereas scheduling sensor node has been proposed to prolong network lifetime. There are both centralized and distributed coverage algorithm are more scalable for large area sensor network and distributed solution do not need global information, the sensor node in the distributed algorithm only exchange message with neighboring nodes. Thus, the required communication overhead for organizing the working direction is lower than centralized solution.

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