A SURVEY ON OPTIMAL DYNAMIC DEPLOYMENT AND SCHEDULING OF RELAY NODES IN WIRELESS SENSOR NETWORKS

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Abstract - Wireless sensor network (WSN) consists a group of nodes that are equipped with a small and low power batteries with functions of communication and sensing data to monitor various environmental conditions at different field of locations. The major challenge in WSNs is to achieve a maximum coverage and connectivity perfectly with optimal number of nodes. Connectivity and coverage the two most fundamental issues in WSNs, which have a significant impact on the performance and the capability of WSNs. Random deployment some nodes may get imbricate this will cause unbalanced structure. In the existing system maximum coverage problem is resolved by using the static node deployment strategy in the particular area or a field. Loss of just a single sensor node might obstructs the stability and the reliability of the entire network. Network lifetime extends and also reduces the cost due to optimized deployment strategy, sleep scheduling mechanism and coverage radius. In this paper, we discuss the coverage problem from different perspectives, describe the evaluation metrics of coverage control algorithms, analyze the relationship between coverage and connectivity, compare some simulation tools, and discuss major research challenges and existing problems in this particular area.

Index Terms - WSN, mobile node, k-coverage.

I. INTRODUCTION

The abrupt changes in sensor technologies, micro-electromechanical systems since last decade the modern networking and wireless communication technologies has increasingly elevate the emergence and development of modern WSNs [2], [3]. After emergence the concept of IoT the WSNs are currently become a hot research field, because WSNs and thenext generation networks extend the ability of people to access information, communicate physical information of the objective environment through with transmission networks which will provide people with the most direct, effective and authentic information.

A significant issue increasingly observed recently is the coverage problem, which emphasis on how well sensors are deployed in the physical space.QoS (Quality of Service) of any WSN networks is closely related to coverage with energy consumption is a one of the performance parameter of sensor networks due to this it is possible to get an energy from external sources such as solar cells and wind energy. WSN nodes are often dropped, thrown or place randomly in sensor fields, in these type of scenarios the external power supply sources often demonstrate a non-continuous behavior so that an energy buffer is needed and even no power supply at all. As we know in many cases the energy is a very critical and important resource and must be used very carefully. Therefore, energy conservation is a key issue in the design of WSN based systems. Each sensor node have a limited energy resource so we need to utilize the sensors optimally so as to increase the lifetime of the network.

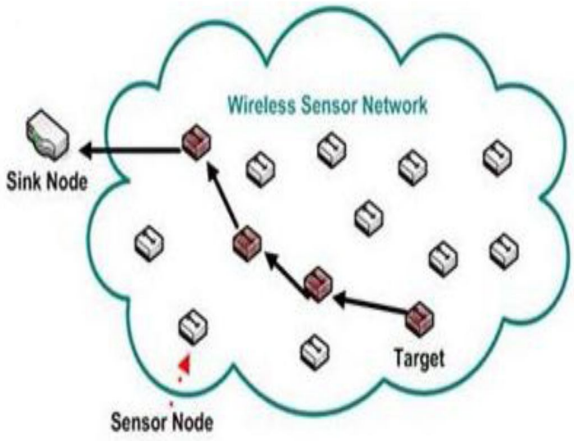


Fig.1

Problem of conserving energy in WSNs which must keep the initial coverage QoS use three different approaches. Optimal coverage deployment is the first one approach. The second approach is for sensors those are goes into sleep mode plan a schedule of active sensors that enables other sensors during the sleep or off modes. The third approach is regulating the sensing range of sensors for energy conservation.
In this paper, we analyze coverage and connectivity issues primarily based on coverage deployment strategy, Artificial Bee Colony Algorithm, and efficient coverage area.
In Section 2, we introduce the basic knowledge of coverage concepts, such as node properties, Basic structure of a sensing node,and sensing models.
Section 3 coverage deployment strategy is described. Recent research issues about static coverage and dynamic coverage are described here as well as the solution to optimize coverage deployment.

Section 4 discusses artificial bee Colony Algorithm through some examples. It is a very efficient solution of energy conservation to coverage problem.
Finally, in Section 5, a simple conclusion is given.

II. BASIC DEFINITIONS AND CONCEPTS

Here in this section we elaborate the basic concepts of connectivity and coverage. We describe sensor node properties, sensing models, centralized and distributed algorithms and the indicators related about the coverage quality. Solutions related about connectivity and coverage issues in WSNs involve a lot of basic assumptions and theories.

A. Nodeproperties:

Definition1 (Fixed node). Fixed node means the sensor node do not move once they are deployed. In wireless adhoc sensor networks, a fixed node has the ability to collect data, send or receive messages, process data and do other type of computations such as count the number of bits during sending and receiving the data.
Definition2 (Mobile node).A mobile node has the ability to move almost it consist all the features of the fixed nodes. A mobile node can act as a router when any of the node failure occur and the network may cause to be divided into different segments or create holes in the original coverage area.
Definition 3 (Coverage & k-coverage).For coverage and k-coverage we are assuming the number of sensor nodes, such as N= $n_1,n_2,n_3,\ldots\ldots n_t$ in a 2D area 'A'. each sensor is deployed at coordinates (x_i,y_i) inside the area 'A' with a sensing range of r_i which is usually called sensing range at any point x is said to be k-covered or k-coverage.
Definition 4 (Connectivity).If two sensing nodes are successfully communicated with each other inside the area 'A' it means node n_1 and node n_2 are fully connected.

B. Basic Structure of a Sensor Node

There are four major components of a sensor node: sensing unit, transceivers, power supply and processing unit[ ] as shown in fig. 2 In WSN these sensor nodes may vary in their sizes, sensing capabilities, transmission ranges, computing and power supplies. All these nodes are use to be small sizes and they can easily to fit in cubic mms or cms in the form of a single module.

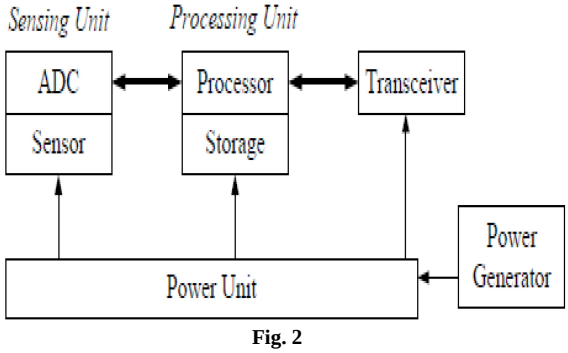


Fig. 2

Sensing units are further composed of two basic subunits; actual sensors and the analog to digital converters (ADCs). The sensors senses the environment and provide the analog information to ADC, which converts it into digital form and feeds to the processing unit. The sensing units can vary from a traditional thermometer, hydrometer to very specialized accelerometer and strain sensor. These sensing units work at their own sample rates or specified by the applications. For example, a typical sampling rate of an accelerometer is 100Hz, while the frequency to sample temperature is much lower. There is a wide range of sampling parameter that leads to different transmission rates to relay data from different type of sensors.

C. Sensing Models

Generally in WSN environments several models are used depending upon the theoretical and physical characteristics of the sensing nodes also they are based upon applications needs and working environments. Usually two facts are common when we are discussing the sensing models [1].
(1) If the distance between the sensing nodes increases the sensing ability would be decreases.
Sensing ability improves during a specific period of a time if the noise effects reduces in burst measurements.

D. The binary disc sensing model

In the binary disc sensing model a node is capable of sensing from points lie within its sensing range and not to sense from any point beyond the limit. Radius 'r' is a sensing radius is considered where each node is restricted within a circular disk of radius 'r'.

$$D_{xy}(S_i) = \{ 1 \text{ if } d(si,p) < r$$
$$0 \text{ otherwise}$$

E. The probabilistic sensing model

The probabilistic sensing model is a more actual perception, which can be taken as an extension of the binary disc sensing model [3]. The probabilistic sensing model is an extension of a binary disc sensing model it provide more accurate observations. This model show the behavior of a sensing devices and their ranges such as infrared and ultrasound sensors.

F. Centralized/distributed algorithms

To determine the existing desired coverage area, once the sensors are deployed an algorithm is run. Usually in a centralized algorithm, a central source or cluster receives data from each sensor node, which results in a excessive energy in communication. But on the other hand the distributed algorithm each sensor node decide its own working mode by the neighbors, this run it throughout the network [4]. On the basis of the simulations centralizedalgorithmsdecrease communication energy and the detection accuracy but increase the processing energy. Overall for large scale

networks distributed algorithms are more appropriate as compared to centralized algorithms.

G. Coverage control algorithms evaluation metrics

For the network usability and effectiveness it's very important to know to evaluate the performance of coverage and its algorithm. The main elements for evaluating the performance are as follows:

1. Number of active nodes:the main objective of a wireless sensor networks is to cover up a maximum coverage area with fewer number of nodes. In other words, using less number of active nodes and consumes the less energy consumption.
2. Coverage relates to QoS:Different network tasks such as transmission of data between source and sinks, coverage area, network sensing ability is the basisstandard of evaluating the algorithm. The QoS of coverage decides the completion of these network tasks.
3. Energy efficiency control: In a series of monitoring the tasks, maintain the energybalance of a network is a critical issue for this purpose coverage control algorithms are required.
4. Communications overhead:Communication overhead depends upon the number of bits transferred between the source and the transmitter which consumes the sensor node energy. Coverage control algorithms have a greater advantage with low cost in the process of communication.
5. Scalability of a Network:In wireless sensor networks the topology dynamically changes, coverage control algorithms should be able to scale the different dynamics of the network.
6. Node deployment strategy for coverage:In the sensing field maximize the coverage is a great research challenge in the field of WSN with optimal number of resources and with maintaining the lower cost, especially when the monitoring area or a region is unknown and possibly with some obstacles. Many simulation results indicates the optimal deployment strategy can find results with certain degree of coverage with minimal number sensing nodes [5].

III. STATIC COVERAGE

Static coverage is mainly concern about optimal placement of antenna in many domains like 2D or 3D environments for several applications. Different coverage formulations naturally arise in multiple domains [7].

Efficient Coverage Area

Static network must be deployed in a predefined shape and the sensor locations are also predefined and identical in different areas for achieving a deterministic coverage in more critically monitored areas [6].The Efficient coverage area ratio (ECAR) and the maximum net efficient coverage area (ECA) in wireless sensor networks, the entire field are completely and continuously covered by sensor nodes with some significant effects on energy preservation. In this way, the given analysis formulation is based on the assumptions are as follows:

1. A sensor's sensing ability is omni-directional, that is, its coverage range is a disk whose radius is r and whose area If a sensor is in omni-directional way, the coverage is a round disk whose radius is r and area is A where $A=\pi r^2$
2. All sensors in the sensing area the power of the sensors are equal and uniform therefore the radius r of all sensors are same and equal.
3. All sensors are in the same plane in the sensor field.

The Efficient Coverage Area (ECA) and the Ratio of Efficient Coverage Area (RECA) are defined as follows:

Efficient Coverage Area (ECA): Efficient Coverage Area ECA A_{ECA} is the coverage area that is overlapping coverage field F_s Area A_z subtracted from node N_1 with coverage range $D(\pi r^2)$ likely,

$$A_{ECA} = D\text{-}A_z = \pi r^2 - A_z$$

Ration of Efficient Coverage Area (RECA):

$$R_{ECA} = 1 - Az / \pi r^2$$

As shown by (a) in Fig. 1, in order to realize full seamless coverage, a point in Circle C_1 is at least between Point A and Point B, which are intersecting points of Circle C_2 and Circle C_3. As shown by (b) in Fig. 3

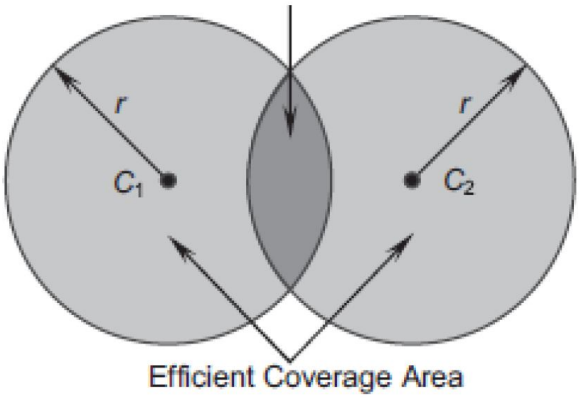


Fig. 3

Dynamic Coverage

Dynamic coverage is more complex as compared to static because in dynamic coverage all nodes have the ability to moving. The deployment of the sensors cannot determine exactly especially when the environments are unknown such as sensors may drop from the aircraft [7]or deployed in a random placement. Mobile sensors are usually desirable because they can move in a wide area and they repositioned because of the better surveillance.

IV.ARTIFICIAL BEE COLONY ALGORITHM (ABC)

As the usage and development of wireless sensor networks increases, problems related to these networks are being discovered. Dynamic deployment is one of the main issues that directly affect the performance of wireless sensor networks. An artificial bee colony algorithm is applied to the dynamic deployment of mobile sensor networks to gain better performance by trying to increase the coverage area of the network[8]. The good performance of the algorithm shows that it can be utilized in the dynamic deployment of wireless sensor networks. [10]

This approach is based on the artificial bee colony (ABC) algorithm, which was developed by considering the searching behavior of honey bee swarms [9]. ABC algorithm works well for numerical optimization problems and clustering techniques. Using the ABC algorithm is a proper approach for the sensors in the network to obtain good coverage in a 2-dimensional space.
The aim of the optimization technique is to maximize the coverage rate of the network, as given in Eq. (1).

$R = U_{ci}/A,\ i \in S$ Equation.1

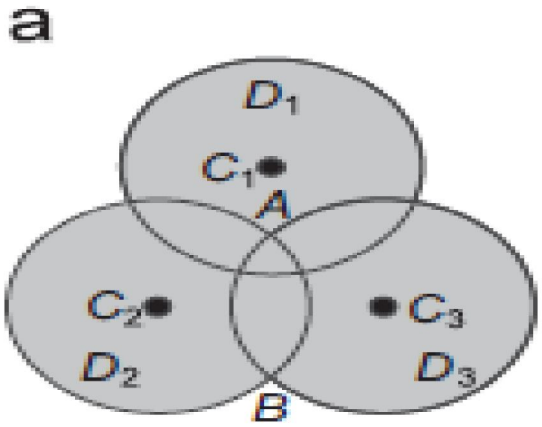


Fig.4

Where ci is the coverage of sensor i, S is the set of nodes, and A is the total size of the area of interest.
In the network's scenario, it is assumed that:

- The detection radius of the sensors are all the same (r).
- All of the sensors have the ability to communicate with the other sensors.
- All sensors are mobile.

In the ABC algorithm, the position of a food source represents a possible solution to theoptimization problem and the nectar amount of a food source corresponds to the quality (fitness) of the associated solution. Therefore, the deployment of the sensors in the sensed area (each solution of the deployment problem) refers to a food source in the algorithm. The coverage rate of the network, i.e. the total coverage area, corresponds to the fitness value (nectar) of the solution. In the ABC model, artificial bee colonies, in which the goal of the bees is to find the best solution [10], comprise 3 groups of bees: employed bees, onlookers, and scouts. A bee waiting in the dance area to determine the choice of a food source is an onlooker, and when a bee goes to a previously visited food source, it is an employed bee. A bee that carries out random searches is called a scout.

CONCLUSION

Coverage and connectivity are two of the most fundamental issues in WSNs, which have a great impact on QoS of WSNs. Many algorithms, strategies and mechanisms have been proposed by researchers around the world to solve these problems. First, a brief introduction to the basic knowledge of coverage concepts is given in this paper. Second, we take energy efficient factors into consideration, and describe the coverage and connectivity issues from three aspects: coverage deployment strategy, Artificial Bee Colony Algorithm (ABC). Finally, typical issues on coverage and connectivity in WSNs are summarized, and existing problems and challenges are discussed. We hope that our efforts can be used as a starting point of what has been done in such field so far or even do some help to future research.

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