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Analysis of *k*-coverage in Homogeneous Wireless Sensor Networks

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ABSTRACT
Recently, wireless sensor networks have attracted a lot of attention. They are being used in many fields like security and surveillance, disaster prevention, agriculture, and traffic monitoring. Such environments may consist of many low cost nodes, each having the ability of gathering, storing, and dealing with environmental information and communicating with neighboring nodes via wireless links. One of the fundamental problems in sensor networks is the coverage problem, which reflects the quality of service which is provided by a particular sensor network and how well a sensor network is monitored or tracked by sensor. The coverage concept is depending from several points of view due to a variety of sensors and a wide-range of their applications. In this paper, simulation is performed to determine the degree of coverage of for a sensor network in terms of k-mean coverage. All sensor nodes with same sensing range are deployed for the simulation. Simulation is performed on MATLAB. Simulation results shows as degree of node is greater than one then that node will goes into sleep mode so that particular region must be covered by at least one sensor node which is in active state which result in less energy consumption and also show that as we increase the number of nodes the degree of the nodes also get increase.

KEYWORDS
Coverage, Wireless sensor network, k-coverage, Energy, Base station

1. INTRODUCTION
In recent times there has been increasing interest in the area of wireless sensor networks. The WSN built by "nodes" – from a few to several hundreds or even thousands, where each node is bind to one sensors .These nodes are characterized by being very small in size with limited energy usually supplied by a battery. They communicate via built-in antennae over RF signals. These networks are typically used to monitor a field of interest like changes in the movement, temperature, precipitation, etc. Sensor nodes measures environmental parameters through observing, processing and sharing the data to the user. Success of the WSN is defined as how sensor nodes cover the whole network with minimum amount of energy. However, for achieving complete coverage more number of sensor nodes are needed which increase the energy utilization of the network. Efficient WSN uses only limited number of sensor nodes for providing full coverage one of the most active research fields in wireless sensor networks is that of coverage.

Coverage is usually interpreted as how well a sensor network will monitor a field of interest. It can be a measure of quality of service. Based on the entity to be covered using the network, coverage have been classified with respect to Area, Target and Barrier. Area Coverage aims to cover the entire intended area; Target coverage concerns about particular predetermined points in the area whereas Barrier coverage about moving objects.

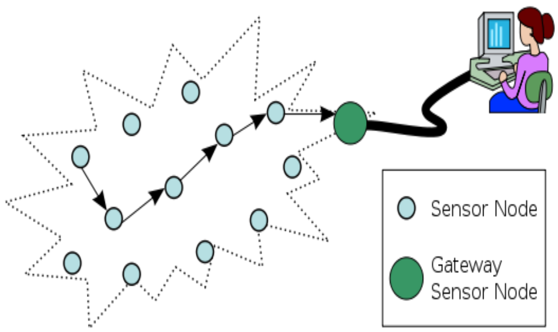

Fig1. Overview of Wireless Sensor Network

In general a WSN consists of one or more base Stations(or sinks) and a large number of sensor nodes that organize themselves into a wireless network and work together to sense the environment and do simple data processing and communicate in wireless manner over a short distance. Depending upon the application and the environment, nodes deployed or placed either randomly or in a predefined path over a geographical area. The purpose of deploying a WSN is to collect relevant data for processing/reporting. There are two types of reporting: event-drive and on-demand. A sensor collects data periodically or continuously depending on the nature of the application and forwards the data to a node called the base station (BS) which provides the necessary connections to infrastructure networking. A sensor node is equipped with a device that supports connectivity between two nodes or between a node and the Base station. Sensor nodes have three modes of operations. First one is the active mode; in this sensor senses the environment and communicates with other sensors. Second is the sleep mode, in this sensor cannot monitor or transmit data. In off mode, the nodes are turned off and do not perform any task. A sensor can change itself to active mode from sleep mode and vice versa whenever it receives suitable signal from the other sensors or from the base station. A Sensor node has the ability to move their own and several resource restrictions such as limited memory, battery power, and signals processing, communication and computation capabilities so; it can sense only a small part of environment.

The rest of the paper is structured as follows. In section 2, we briefly review about the coverage. Section 3 describes about the system models. In section 4 we provide brief description about network preliminaries. Section 5 describes the simulation parameters and assumptions made. Section 6 presents the experimental setup and simulation results. Section 7 concludes this paper by describing the summary of results obtained.

2. RELATED WORK

Wireless sensor networks (WSNs) have attracted a great deal of research attention due to their wide-range of potential applications. Sensors in a network can cooperatively gather information from an interest region of observation and transmit this collected information to a base station. In the former case, the data is sent to the base station when one or more sensors detect an event in the vicinity. In the latter case, the data is sent from the sensors to the base station based on an explicit request. An important problem addressed in literature is the sensor coverage problem. The goal is to have each location in the physical space of interest within the sensing range of at least one sensor. Since sensors may be spread in an random manner, one of the important issues in a wireless sensor network is the coverage problem. Reference [4] defines a sensor coverage metric called surveillance that can be used as a measurement of quality of service provided by a particular sensor network, and centralized optimum algorithms that take polynomial time are proposed to evaluate paths that are best and least monitored in the sensor network. The work further carry out the problem of how well a target can be tracked over a time period. While it moves along an arbitrary path with an arbitrary velocity in a sensor network. Localized exposure-based coverage and location discovery algorithms are proposed [5].Some works are targeted at specific applications, but the main focus is still related to the coverage problem. For example, sensors on-duty time must be scheduled properly to conserve energy. If sensors are randomly distributed, if some nodes share the same sensing part and task, then we can turn off some of the nodes to conserve energy and thus lifetime of the network will extend. This is possible if turning off some nodes still provide the same "coverage" .Author in [6] proposes a heuristic to select mutually exclusive sets of sensor nodes such that each set of sensors can provide a complete coverage the monitored area. Author in [7] proposes a probe-based density control algorithm to put some nodes in a sensor-dense area to a doze mode to ensure a long-lived, robust sensing coverage. A coverage preserving node scheduling scheme is presented in [8] to determine when a node can be turned off and when it should be rescheduled to become active again. In this work, we consider a more general sensor coverage problem. Given a sensors deployed in a particular area and we want to determine if the area is sufficiently k-covered, in the sense that every point in the particular area is covered by at least k sensors, where k is a predefined constant. As a result, the works in [6,7] can be regarded as a special case of this problem with $k = 1$. Applications requiring $k > 1$ may occur in situations where the stronger environmental monitoring is necessary, such as military applications. In paper [9], a novel solution is proposed to determine whether a sensor network is k-covered. The sensing range of each sensor can be a unit disk or a non-unit disk. In this paper, we propose a simple solution to determine the degree of coverage of a sensor network.

3. SYSTEM MODELS

3.1 Sensing Range

The range of sensor node by which it can sense a particular or targeted area.

Sensor S is used to cover an area A, within the sensing range of s.

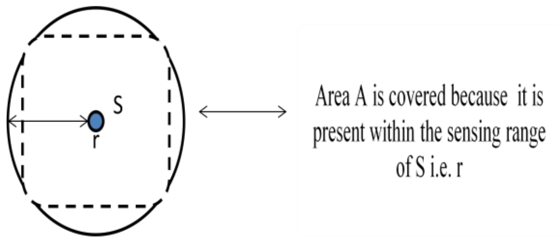

Fig 2: Area within sensing range

3.2 Communication Range

The range of sensor through which it can communicate with another sensor.

3.3 Degree Of Coverage

When sensor s covered an area, then the mean or degree of coverage of that particular area is one because it is covered by only one sensor within the sensing range.

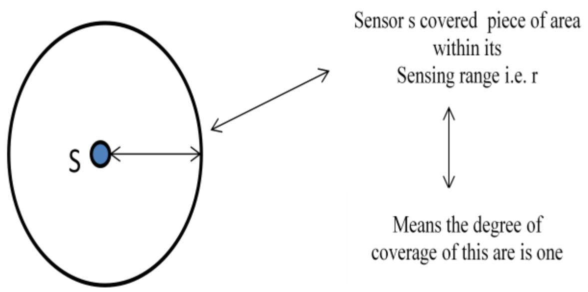

Fig3: Sensor S within its sensing range

4. NETWORK PRELIMINARIES FOR THE PROPOSED WORK

Simulation is performed in MATLAB. In simulation network nodes are deployed in uniform random distribution. The network is a homogenous network in terms of energy. Energy model is used as LEACH. If one sensor node covered a area then degree of coverage is one then if two sensor node covered a area then degree of coverage is of this area is 2. Same way how many sensors intersect with each other is equal to the degree of coverage of that intersects area. If degree of that intersects is more than two then that sensor node will goes into sleep mode o minimize the energy consumption and rest sensor nodes will be in active state and also show that as we increase the number of nodes then degree of nodes also get increase.

5. SIMULATION PARAMETERS

Table 1 shows the simulation parameter

Table 1: Simulation Parameters

Parameter	Values
Simulation Round	100
Topology Size	200 x 200
Number of nodes	Random
Initial node power	Random
Nodes Distribution	Nodes are uniformly randomly distributed
Energy for Transmission (ETX)	50*0.000000001
Energy for Reception (ERX)/Sensing Energy	50*0.000000001
Energy for Data Aggregation (EDA)	5*0.000000001

6. SIMULATION RESULTS

Simulation shows the following results in different scenario

6.1 As the number of nodes increases the mean of nodes also get increased

Table 2: Mean of nodes

Mean	No. of nodes			
	50	100	150	200
0-mean	1	0	0	0
1-mean	30	42	58	56
2-mean	8	33	30	53
3-mean	9	16	34	29
4-mean	2	7	18	28
5-mean	0	2	8	19

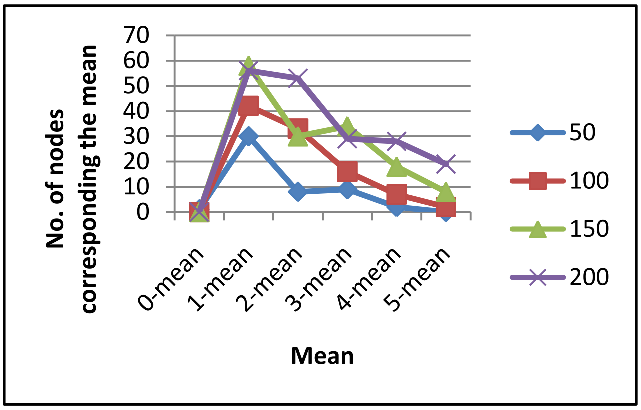

Fig2: Mean of nodes

6.2 Nodes get deployed to get maximum 1-mean, 2-mean and 3-mean

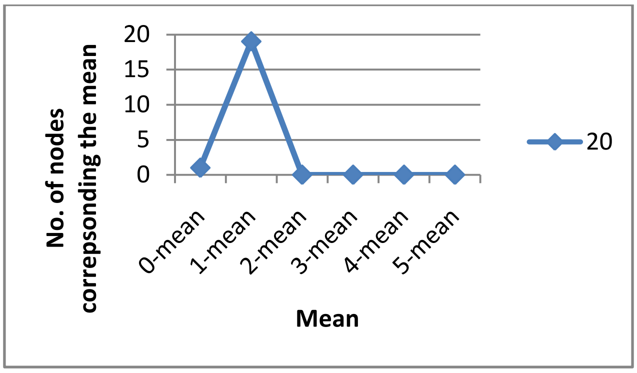

Fig3: For 1-mean

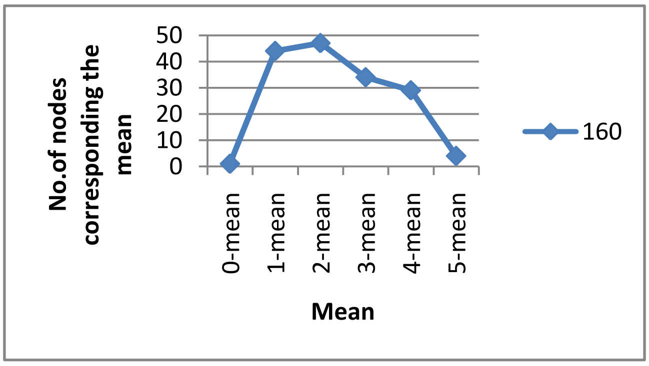

Fig4: For 2-mean

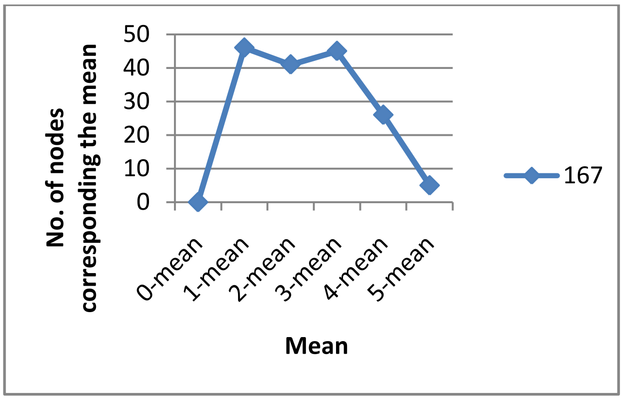

Fig5: For 3-mean

7. CONCLUSION

This paper presents the simulation result for K-mean coverage for sensor network. In coverage aware protocol K-mean value is use to set sleep mode for a node. As the K-mean value of nodes increases a node can be in sleep mode. And it increases the life time of node. And it increases the coverage of sensor node for a long time. According to results obtained, table-1 and fig2 shows that as we increase the number of nodes then the value of k-mean also gets increased. In fig.3, 4and 5, it is observed that for maximum 1-mean, 2-mean, 3-meanwe need at least 20,160,167 nodes respectively. As K-mean increase then maximum number of nodes will goes into sleep mode because of which coverage gets preserved and there is less energy consumption and rest nodes will be in active state for transferring the data. This results also show that as the degree of nodes is greater than one then these nodes will goes into sleep mode and alive for long time and network lifetime.

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