Abstract - Wireless sensor networks are networks used to collect an environmental information in an area using sensor nodes with low power. The sensors sense various informations in different ways. So tha the sensors are expected to have different sensing models. Probabilistic coverage protocol (PCP) that can employ different sensing models. In this paper our coverage protocol is combined with K-coverage in order to increase the coverage area and to minimize the energy consumed by the sensor networks. For k-coverage case an efficient approximation algorithm DRKC (distributed randomised k-coverage algorithm) is used to achieve low power consumption. Our algorithm can be implemented in a distributed manner with a local information and a low message complexity. Simulation results show that the distributed algorithm converges faster and consumes much less energy than the previous centralized algorithms.

Key words - Sensor networks, coverage in sensor networks, probabilistic coverage, coverage protocols.

I. INTRODUCTION

In Wireless Sensor Networks (WSN) the sensor nodes are usually battery-powered. The energy consumption must be minimized in order to extend working time of sensor network. Because the power consumption of nodes determines the lifetime of the wireless sensor network. In this paper the coverage and connectivity problems in wireless sensor networks have been discussed. Many current coverage and connectivity protocols continue to assume the disk model for analysis. A distributed coverage and connectivity maintenance protocol has been proposed that explicitly accounts for the probabilistic nature of communication and sensing ranges. The protocol guarantees a target packet delivery rate in the network, while ensuring the monitored area is covered with a probability exceeding a given threshold, activates fewer nodes, consumes much less energy, and significantly prolongs the network lifetime.

Generally some protocols are needed to schedule activation and deactivation of nodes while keeping the coverage and connectivity quality. The protocols maintaining the area covered are referred to as Coverage Protocols while the protocols assuring the communication quality between nodes are referred to as Connectivity Protocols. The proposed Probabilistic Coverage Protocol, works for the disk sensing model used in [2], [3]. But in this paper we combine PCP with k-coverage in order to reduce energy consumption in the wireless sensor network.

Further more a fully distributed version of the algorithm is designed and implemented for k-coverage. The Simulation results show that the distributed algorithm converges faster and consumes much less energy than previous centralized algorithms.

II. RELATED WORK

Coverage in sensor networks has received significant research attention, see [11] for a survey. We summarize the most relevant works in the following sections.

A. Coverage Using the Disk Sensing Model

The studies in [5], [6] provide necessary and sufficient conditions for coverage in various environments and they do not propose specific coverage protocols. In [12], optimal deployment patterns for different ratios of the communication and sensing ranges are proposed. Exact sensor placement is difficult in many realistic environments. Several distributed coverage protocols have been proposed for the disk model, including [2], [4], [7].

B. Coverage Using Probabilistic Sensing Models

Probabilistic coverage with various sensing models has also been studied in [8]. The work in [9] analytically studies the implications of adopting probabilistic and disk sensing models on coverage. But probabilistic k-coverage model is not yet well defined.
III. OVERVIEW OF PCP

It has been seen that covering an area with disks of same radius \( r_s \) can optimally be done by placing disks on vertices of a triangular lattice. Optimality means the minimum number of disks required. The PCP is used to activate a subset of deployed sensors to construct an approximate triangular lattice on top of the area to be covered. By activating any sensor in the area, PCP can start. This sensor is known as an activator. This sensor activates six other sensors located at vertices of the hexagon centered at activator sensor. Each activated sensor, activates other sensors at its vertices of its own hexagon. This process continues till all the activated sensors form a virtual triangular lattice over the whole area. PCP is used to bring the connectivity between the nodes in sensor networks.

We refer maximum separation between active nodes as the distance between the vertices of the triangular lattice and it is denoted by \( s \). The value of \( s \) is determined from the sensing range \( r_s \) of sensors. Because the lattice is constructed in a distributed manner, it is said to be approximate. Also it is controlled by the sensor deployment.

IV. DRKC: DISTRIBUTED RANDOMISED K-COVERAGE ALGORITHM

Here PCP protocol is combined with the distributed k-coverage algorithm. We have a centralized algorithm and distributed algorithm for the k-coverage problem. Once sensors are deployed an algorithm is run to determine if sufficient coverage exists in the area. A centralized algorithm is run on one or more nodes in a centralized location usually near the data sink. A distributed or localized algorithm is run on nodes throughout the network. Distributed algorithms involve multiple nodes working together to solve a computing problem while localized algorithms imply that many or all of the nodes run the algorithm separately on the information each has gathered. They both spread the workload out more evenly than the centralized algorithm, however since it is being run on many more nodes throughout the network the distributed/localized algorithms may be more complex than the centralized algorithms. Figures 1 and 2 demonstrate centralized and distributed strategies, the shaded sensors are the ones that are running part or all of the algorithm.

In this section, we present a decentralized version of our k-coverage algorithm, DRKC algorithm, is used to keep local estimates for global information.

V. DESCRIPTION OF DRKC

Normally DRKC is working in rounds of equal length. The round length is taken to be much smaller than the average lifetime of sensors. This round length is measured in real time. Every node runs DRKC in the beginning of each round independent of other nodes and a number of messages will be exchanged between nodes in order to determine which nodes will be on duty and which will sleep during the current round. This will be happened until the beginning of the next round. We denote the convergence time is the time it takes the DRKC protocol to determine active/sleep nodes.

After convergence, no changes in node state and no activation messages are exchanged until the beginning of the next round. Generally a node can be in one of three states: Active, Sleep, and Temp. In Active state, all transmission, receiving, and sensing modules are turned on, whereas all modules are turned off in Sleep state. In Temp state transmission and receiving modules are turned on. The sensing module sets its state in the immediate preceding round. This should be done in order to avoid any
coverage outage during round transitions. A round is
started by a node in the Temp state, where it
initializes the parameters (netsize, weight, and total
weight). During each round, the neighborsize variable
is updated and also its value is retained across
rounds.

After this initialization, the algorithm
iterates up to log n times in the while loop, or until it
achieves k coverage. Now the node broadcasts an
activation message to its neighbor nodes in order to
increase its own coverage to be k.

When a neighbor receives an activation
message, it will become an activator. Then the node
broadcasts a notify message to all its neighbors and
informs that it has become active. A node waits a
random period between 0 and reqcoverage×Tm, to
reduce collisions between notify messages, where
Tm is the average transmission time of a message. A
node verifies its own coverage, after receiving notify
messages. A node terminates the algorithm in the
current round and waits until the beginning of the
next round only if the node is sufficiently covered.
Else, another loop iteration is needed.

VI. RESULTS AND DISCUSSION

An efficient approximation algorithm has
been proposed which achieves a solution of size
within a logarithmic factor of the optimal. Here the
algorithm can be implemented in a distributed
manner with a local information and a low message
complexity.

- We consider the more general k-coverage (k
1) problem.
- Where each point should be within the
sensing range of k or more sensors.
- Covering each point by multiple sensors is
desired for many applications, because it
provides redundancy and fault tolerance.
- K-coverage is necessary for the proper
functioning of other applications, such as
intrusion detection, data gathering, and object
tracking.

Packet delivery ratio (PDR) measures the
percentage of data packets generated by nodes that
are successfully delivered. Packet delivered ratio is
grater in the case of pcp with k-coverage is shown in
fig 6.

End-End latency measures the average time
it takes to route a data packet from the source node to
the hub. Energy consumption measures the energy
expended per delivered data packet. Energy
consumption of sensor network using pcp with k-
coverage is less as shown in fig 5. Throughput is
defined as the number of packed at destination side at
a particular time. According to fig 4, maximum
throughput is achieved by using pcp with k-
coverage. Bandwidth used by k-coverage is also
less and it is shown in fig 3.

Fig 3. Bandwidth of pcp with k-coverage

Fig 4. Throughput performance of pcp with k-coverage
In this paper, a fully distributed, probabilistic coverage protocol with k-coverage has been proposed. In this paper this protocol is mainly used to bring the communication between the nodes. This protocol can be used with different sensing models, with minimal changes. The k-coverage problem is modelled as a set system for which an optimal hitting set corresponds to an optimal solution for k-coverage. For that purpose an approximation algorithm has been proposed for computing near-optimal hitting sets efficiently. Simulation results show that the distributed algorithm converges faster and consumes much less energy than previous centralised algorithms. So that k-coverage can be needed in several sensor network applications to converge much faster and activate near optimal number of sensors and prolong the life of the sensor networks. The probabilistic Coverage Protocol in the k-coverage case is used to give higher savings in the number of activated sensors.

REFERENCES