Performances Analysis of Coverage Problem in Wireless Sensor Network by using Particle Swarm Optimization (PSO) and Deployment Strategy

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Abstract— *In sensor networks, coverage problem is a critical issue as it is an important aspect in measuring the quality of service (QoS) of the wireless sensor networkin this paper; we introduce a new algorithm in a sensor network to optimize coverage using deployment strategies and particle swarm optimization (PSO). PSO is carried out to find the optimal deployment of the sensor nodes that gives the best coverage.The optimization algorithms are search technique where our aim is to search for an optimal solution to a problem in order to achieve one or more objectives. In this paper we are trying to minimize the coverage holes and maximize the coverage area.*

Keywords— *Wireless sensor Network, Particle Swarm Optimization, Voronoi Diagram, Gird, coverage problem.*

I. INTRODUCTION

Wireless Sensor Network is a group of low-power, low cost, small size and multifunctional wireless sensor nodes that work together to sense the physical conditions of the environment perform simple data processing by collecting data and organizing the data and communicate wirelessly over a short distance . The WSN is built of few to several hundreds or even thousands of sensors of nodes, where each node is connected to one (or sometimes several) sensors. Each sensor network node has typically several parts such as: an electronic circuit for interfacing with the sensors, a microcontroller, radio transceiver with an internal antenna or connection to an external antenna and an energy source. There are two types of wireless sensor network these are structured and unstructured WSN. In structured WSN there are new and scarcely distributed nodes. There is often pre-planned deployment of nodes and network can easily be maintained. Whereas in unstructured there is dense collection of nodes and deployment of nodes is in ad-hoc manner. Network maintenance in unstructured is difficult and complex. WSNs measure environmental conditions like temperature, humidity, pollution levels, sound pressure, direction and wind speed etc.

In WSN there are certain issues including network lifetime, connectivity, coverage, and scheduling and data aggregation. Scheduling and data aggregation are energy conservation measures for efficient WSN lifetime. Conserving of energy in scheduling is done by turning off the sensors whenever possible while in data aggregation energy is conserve by reducing the energy which is used in transmitting the data. Coverage problems and Connectivity is due to limited sensing range of the sensor and communication range. To overcome connectivity problem, the sensors are to be placed close to each other so that they does not cross the restricted communication range. Whereas to ensure the coverage problem concerns that each points in the region of interest (ROI) is covered by the sensors. In order to minimize the coverage problem, the sensors should not be placed too close each other so that the sensing capability of the network is not fully utilized and also not too far from each which result in forming coverage holes (area outside sensing range of sensors).Coverage is one of the key factor for quality of service (QoS) in evaluation of WSN.

II. LITERATURE REVIEW

AmitabhaGhosh, Sajal K. Das (2008) et al. has studied that Sensing coverage and network connectivity the most fundamental problems in wireless sensor networks. By finding an optimal deployment node strategy would minimize communication overhead, reduce computation, minimize the cost, recover from node failure and also provide high degree of coverage with network connectivity which can face the challenges. Both coverage and connectivity together can be treated as measure of quality of service in a sensor network which tells that how well each point in the region of interest is covered and how accurate is the information gathered by the nodes. So it is concluded that by using resource constrained there is maximizing of coverage as well as network connectivity and also it becomes non-trivial problem(in which atleast one of the value of variable is non-zero in the equation).There is also comparative study of several state-of-the-art algorithms and techniques which aim to both coverage and connectivity[1]

Nor Azlina Bt. AbAzi,zAmmar W. Mohemmed, Mohammad Yusoff Alias(2009) et al. has discussed that coverage problem in wireless sensor network is the crucial issue, where high coverage rate ensure good QOS of WSN. In this paper new algorithm is proposed by using Particle swarm optimization and Voronoi diagram to achieve the optimized sensor coverage. In this algorithm PSO is used because PSO is used to find the optimal deployment of the sensor that will provide best coverage and Voronoi diagram is used to evaluate the fitness function of the solution. The result shows the good coverage with better time efficiency. In this paper there is comparison of two techniques these are PSO_VORONOI and PSO_GRID. Both PSO_GRID and PSO_VORONOI are used for solving the coverage problem in WSN but PSO_GRID when network is small and execution time is not taken into consideration whereas in PSO_VORONOI is used where there is large size of network in greater rate of interest and where execution time is taken into consideration. But in grid quality of solution isobtained [2].

Qinghai Bai(2010) has discussed that Particle swarm optimization(PSO) is a heuristic global optimization method and also an optimization algorithm, which is based on swarm intelligence. PSO is introduced from the social behavior of bird and fish flock . Because of it easy implementation and adaptive nature of the particle it is widely used and developed. This paper consist comparison study of basic PSO and improved PSO. Improved PSO is examined based inertia weight, increase coverage problem, selection and blending with other intelligent optimization algorithms like Ant colony, Simulated Annealing (SA) etc. Various advantages and disadvantages of PSO have also been discussed[3].

Dian Palupi Rini, Siti Mariyam Sham suddin, Siti Sophiyati Yuhaniz (2011) has studied that Particle swarm optimization(PSO) consists of a swarm of particles, where particle represent a best solution . Particle will move through a multidimensional search space to find the best position in that space where the best position may possible to the maximum or minimum values. In this paper all the basic and modified variants of PSO are listed and review of the different methods of PSO algorithm based on these variants are taken into consideration. It provide advantages and disadvantages of basic variants and also how to overcome them and it briefly describe the modified variants of PSO. The basic variants support controlling the velocity and the stable convergence. On other hands, modified variant PSO help the PSO to process other conditions that cannot be solved by the basic PSO[4].

Haitao Zhang and Cuiping Liu(2012)has studied thatlarge extent the effectiveness of the wireless sensor networks depends on the area covered by the sensor deployment scheme since Good network node deployment not only reduces the node redundancy but also reduce network costs and prolong the service life of the network .The effective node deployment help in achieving: maximum coverage, provide good connectivity

and energy saving performance which work as key factor in coverage of sensor nodes deployment. There are three sections in this paper which explain the complete deployment process. Firstly the existing deployment method are discussed and summarized. There are basically two existing deployment methods : static deployment and dynamic deployment. Second section describes various performance indexes of node deployment. There are three performance indexes these are: coverage area, network lifetime and connectivity. Third section consists of node deployment models. There are three deployment models, these are: Perceptual Model, Coverage ratio Model and energy consumption mode[5].

PallaviSahu, Sunil R.Gupta(2012) et.al has studied coverage with connectivity properties in large wireless sensor networks (WSN). Since Coverage is determined as the quality of service of the networks so its main research interest in wireless sensor network. There are common strategies used in solving coverage problem in WSN. The strategies can be categorized in to three groups; computational geometry based approach, grid based, force based. In computational geometry most commonly used approach is Voronoi diagram. Voronoi diagram can be used as one of the sampling method which helps in determining WSN coverage in which the sensors act as the sites and if all Voronoi polygons vertices are covered then the Region ofInterest is fully covered otherwise coverage holes exist. Force based deployment strategies depends on the sensors mobility, using virtual attractive and repulsive forces the sensors are force to move away or towards each other so that full coverage is achieved and finally Grid are used in two ways in WSN deployment; either to measure coverage as used in VFA or to determine sensors positions[6].

Isa Maleki, Seyyed Reza Khaze, MarjanMahmoodiTabrizi, Ali Bagherinia(2013) has discussed that for creating the optimized coverage in WSNs it is possible to increase the network lifetime. So to gain the optimized coverage hybrid of the PSO and DE algorithms for area coverage is proposed which will increase the lifetime of the network. Network lifetime in hybrid algorithm can achieve based on two factors that are suitable distribution. To show efficiency of the hybrid algorithm is better, it is compared to PSO algorithm and according to the results received from the simulations, it is depicted that hybrid algorithm is better. So by using this algorithm find better solutions and more optimized solution[7].

III. TECHNIQUES AND METHODS

A. Coverage Problem

Coverage can be classified into three classes namely: - area coverage, point coverage and barrier coverage.

Area coverage:-Area coverage is how to cover an area with the sensors. The objective here is to maximize the coverage percentage. *Coverage* Where the coverage percentage is defined as the ratio of area covered by at least one sensor to the total area of ROI. Coverage problem can also be seen as a minimization problem. From the minimization point of view, the objective is to make sure the total area of the coverage holes in the network is as small as possible. Main focus in this work is area to be covered.

Point coverage: - Point coverage is the coverage for a set of points of interest. This type of coverage concentrates on how to cover a set of targets or hotspots in an area, instead of the whole area as in area coverage.

Barrier coverage: - Barrier coverage is about covering the barrier of an area. The barrier coverage focuses on decreasing the probability of undetected penetration to a protected area. Therefore, the sensors need to be deployed along the area's border.

B. Node deployment Technique

The methods used in solving coverage problem in sensor network duringdeployment stage are divided into three categories: - grid based force based, and computational geometry based**.**

1) ***Force Based:***

Force based deployment method depends on the sensors mobility, usingattractive forces and virtual repulsive the sensors are force to move away or towards each other so that full coverage is achieved. The sensors will keep moving until equilibrium state is achieved; whereattractive

forcesand repulsive are equal thus they end up cancelling each other.

2) *Computational geometry:*

This technique is frequently used in Wireless Sensor Network coverage optimization, the most widely used computational geometry approach are Voronoi diagram. Voronoi diagram can be used as one of the sampling technique in determining WSN coverage. The Voronoi diagram is named after GreogryVoronoi who was a German mathematician. Voronoi diagram records information about the distances between sets of points in any dimensional space.

3) Grid Based:

Grid based deployment strategies determine the sensors positions. This deployment strategy is the sampling method in which coverage is estimated as ratio of grid points covered to total number of grid points in the Region of Interest. The cost of this method is determined by following factors:-name, amount of sensors deployed and number of grid points. The accuracy of the estimation is determined by the size of each grid, the smaller the size the more precise the estimation is. There are three types of grids commonly used in networking;

(a) Hexagonal Grid
(b) Triangular Lattice
(c) Square Grid

Grid point is used in two ways in Wireless Sensor Network deployment; either to determine sensors positionsorto measure coverage as used in VFA.

C. *Ant colony Optimization(ACO)*

Ant Colony Optimization (ACO) is a technique for designing metaheuristic algorithms for combinatorial optimization problems.ACO algorithms are the combination of a priori information about the structure of a promising solution with a posteriori information about the structure of previously obtained good solutions.

D. Honey bee

It is an optimization algorithm which carried out both local and the global search to find out an optimized solution by using its natural foraging behavior.

E. Genetic Algorithm(GA)

Genetic Algorithm(GA) belong to the larger class of evolutionary algorithms (EA), that generate solutionsoptimized using strategy inspired by natural evolution, such ascrossover. Mutation, mutation, inheritance

F. Particle Swarm Optimization(PSO)

PSO was introduced by James Kennedy and Russell Eberhart in 1995. PSO algorithm can be used to work out the complex optimist problems.This social behaviour of this organism is duplicated by PSO using swarm ofagents called particles. Particle neighbourhood in PSO had been studied from two perspectives; global neighbourhood (gBest) and local neighbourhood (lBest). In gBest the particles are fully connected therefore the particles search is directed by the best particle of the swarm. Whereas in lBest the particles are connected to their neighbours only and their search is conducted by referring to the neighbourhood best. Particle swarm optimization algorithm starts with a populating the particles whose positions will represent the potential solutions for the problem and velocities will determine the next move, are randomly initialized in the search space.The search for optimal position (solution) is performed by updating particle velocities (vid) and positions (xid) by:

vid = w*vid + c1*rand()*(pid - xid) + c2*Rand()*(pgd -xid)
xid = xid +vid

• w is inertia which is used to control the effect of the previous velocity in the current velocity.
• c1 and c2 are the correction factors which are used to control the effect of the “best” factors of particles; pid and pgd.
•rand() and Rand() are two independent random numbers in the range of [0.0,1.0].
• (pid) is the best position found so far by the particle and (pgd) is the best position found by the neighbouring particles.

G. Proposed algorithm

Proposed algorithm that can be used for optimizing the coverage problem in Sensor

Network. The algorithm proposed here provides good coverage within a reasonable computational time. In this, the coverage problem is formulated as an optimization problem and PSO is used to find an optimum or near optimum solution to it. PSO is a meta-heuristic optimization algorithm imitating the swarm intelligence of some organisms like birds or fish. It has been successfully used in many applications. In this, PSO is used to find the optimal placement of the sensors according to a fitness function based on deployment strategy of node.

IV. RESULTS

To improve the coverage problem using PSO algorithm with voronoi diagram

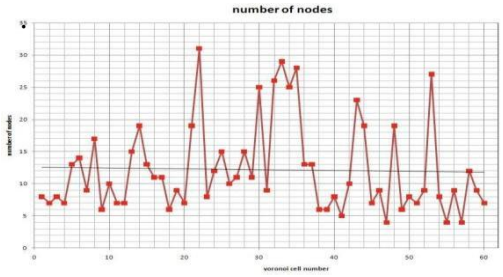

Fig 1 Number of nodes for each voronoi cell with r=2m

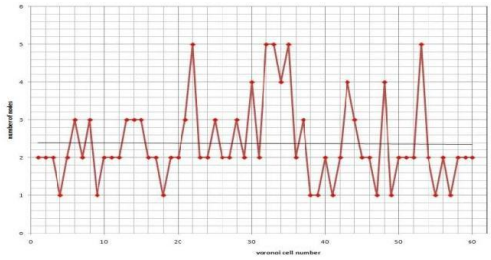

Fig 2 Number of nodes for each voronoi cell with r=5m

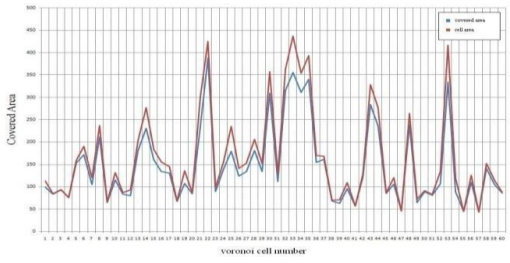

Fig 3 Covered area with r=2m

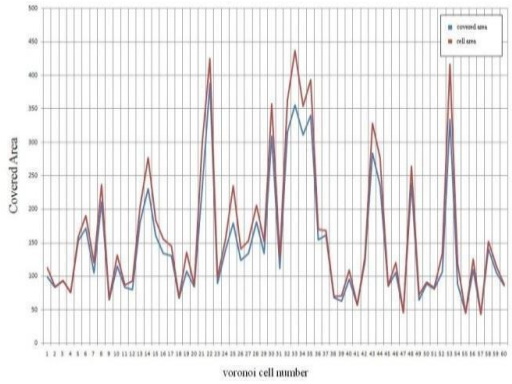

Fig 4 covered area with r=5m

V. CONCLUSION

This paper outlined the issues, goals and approaches of coverage in Wireless Sensor Network. The reviewed strategies commonly used to solve the Wireless Sensor Network coverage problem have their own cost and benefits. Sensor coverage is an important constituent for Quality of Service in applications in Wireless Sensor Network.To accommodate a large Wireless Sensor Network with dynamic topology and limited resources, coverage control algorithms and protocols perform best if they are distributed and localized.

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