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An Implementation of Wireless Sensor Network Using Voronoi_PSO (Particle Swarm Optimization)

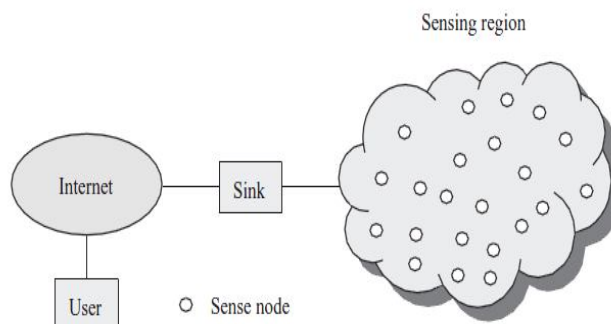
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Abstract : Today's increasing area of research is Wireless Sensor Network (WSN). Correct placement of nodes is one of the major challenge in Wireless Sensor Network. One of the most active research fields in wireless sensor networks is that of coverage. Coverage is usually explained as how well a sensor network will monitor a field of interest. In the research work we are using a strategy known as VORONOI_PSO (Particle Swarm Optimization) to solve the coverage problem. VORONOI DIAGRAM is the basically a deployment strategy. In this deployment strategy area is covered by using VORONOI Diagram which contains VORONOI polygon which is often known as VORONOI cell. Each VORONOI cell contains one sensor node in it. VORONOI DIAGRAM is the node deployment technique which is used to cover irregular areas. A new methodology has been designed to overcome the problem of VORONOI by using the PARTICLE SWARM OPTIMISATION (PSO) technique. The Optimization algorithms are search approaches which are carried out to search an optimal solution to a problem, in order to fulfill objectives. In this the coverage problem gets improved by finding the optimal coverage depending on optimal placement of nodes which improve the overall output.

Keywords: WSN, Coverage, PSO, VORONOI, VORONOI_PSO.

I. INTRODUCTION

Due to a recent development in the technology, there is a growth in wireless sensor network which is composed of large figure of homogeneous & heterogeneous sensor nodes which operates in wireless fashion to achieve common objective. Homogeneous nodes are oftenly used over heterogeneous nodes because of less complexity and better manageability. Within its radio communication range, each sensor nodes communicates with another nodes.



Sensor: Sensor is a transducer. It converts physical phenomenon e.g. light, heat, vibration, motion, and sound into electrical signals.
Sensor Network: Sensor network consists of a large number of sensor nodes and nodes deployed either inside or very close to the sensed phenomenon.
Sensor Nodes (motes): Sensor nodes are battery operated nodes with limited computing and processing capabilities. Sensor nodes with limited energy can sense their own residual energy and have the same architecture; Sensor nodes works together to form a network for monitoring the target region. Through the co-operation of sensor nodes, the Wireless Sensor Networks collect and send various kinds of message about the monitored environment (e.g. temperature, humidity, etc.) to the sink (base) node, which processes the information and reports it to the user

Base Station (BS): Base station is a node with high computing capabilities. Base Station without energy restriction is far away from the area of sensor nodes. All above given terminologies works together as all sensor nodes are immobile in nature. They use the direct transmission or multi-hop transmission to communicate with the Base Station. Sensor nodes sense environment at a fixed rate

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and always have data to send to the Base Station.

II. COVERAGE PROBLEM

Coverage problem is caused by three main reasons: not enough sensors to cover the whole Region of Interest (ROI), limited sensing range and random deployment. As sensors are operated using confined power supply some of them die out resulting in inadequate sensors to fully cover the Region Of Interest. A sensor's sensing range is restricted to a certain radius due to which sensor cannot cover the region outside its sensing range which results to the coverage problem.[1]

Coverage can be classified into three categories: Area coverage, Point Coverage and Barrier Coverage.

A. Area Coverage

The most critical problem in area coverage is the coverage kind of an area by the sensors. The main objective of area coverage in Wireless Sensor Networks is to cover an area (also referred sometimes as region) at each point in the region need to be monitored by at least one sensor and also to direct the environment completely.

In area coverage the best coverage takes place when the main focused area is covered by the least number of the sensors completely. Area coverage is often used for the areas in which the probability of events exists in all coordinates. Also the existence of the inessential sensors in this model cause the multi coverage which lead to the high density of the network.[1].

B. Point Coverage

It is a sub group of the area coverage method. Point coverage is when the total area is not covered by the sensors but just some points are covered. In point coverage only the points which are applicative are covered. Medium numbers of the sensors are spread around the goals and then are activated according to specific scheduling in relation to specific responsibilities and send the collective information to the Base Station. In this the main objective is to cover a set of points (target) with known location that need to be monitored and identified by some specific points which must be controlled are considered. The target coverage strategy is centered on verifying the exact locations of sensor nodes which guarantees efficient coverage approach for a limited number of targets.

C. Barrier (path) coverage

In barrier coverage total area is not covered by the sensors. This model is appropriate for penetration diagnosis applications. The coverage operations take place in such a manner that if the penetration takes place from the width of the under coverage area, the sensors must diagnose them. In barrier coverage the main goal is to maximize or minimize the probability of undetected penetration through the region (sensor network).

III. TECHNIQUES OR METHODS

Strategies used in solving coverage problem in Wireless Sensor Networks are analyzed during deployment of nodes. The strategies are classified into three categories these are: grid based, force based and computational geometry based.

A. Force Based

Force based deployment strategies depends on the sensors mobility, using attractive and virtual repulsive forces the sensors are force to move away or towards each other so that full coverage is attained. The sensors will keep moving until equilibrium state is gained; where attractive and repulsive forces are equal thus they end up cancelling each other.

B. Computational geometry

It is frequently used in Wireless Sensor Networks coverage optimization, the most often computational geometry approach used is Voronoi diagram. It can be used as one of the sampling method in determining Wireless Sensor Networks coverage; in which the sensors behave as the sites, if whole of the Voronoi polygons vertices are covered then the Region Of Interest is fully covered otherwise there exist the coverage holes. Let $A = \{p_1, p_2, \dots, p_i, \dots, p_n\}$ be a set of points in a two-dimensional Euclidean plane. These points are known as sites. A Voronoi diagram decomposes the space into regions close to each site, such that all points in the region around p_i are closer to p_i than any other point in A . Consider two points p_1 and p_2 . Let $R_X(p_1, p_2) = R_{12}$ be the perpendicular bisector of the segment $p_1 p_2$. Then every point x on R_{12} is equidistant from p_1 and p_2 and it can be seen by drawing

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the triangle (p1, p2, x) as depicted

C. Grid points

They are used in Wireless Sensor Networks deployment in two ways: either to determine sensor positions or to measure coverage. In Grid based sensor networks Region Of Interest is divided into square grids and the sensors can only be placed at the center of the square. The cost of grid based deployment is determined by number of grid points, name and amount of sensors deployed. There are commonly three types of grids used in networking to achieve the maximum coverage these are:

- 1) square grid
- 2) triangular lattice
- 3) hexagonal grid

One of the best kinds of the grid among three kinds of grid is Triangular lattice since it has the smallest overlapping area and hence the grid requires the least number of sensors.

IV. SWARM INTELLIGENCE

A swarm is a large number of homogenous, simple agents interacting locally among themselves, and their environment with no central control to allow a global interesting behavior to emerge. Swarm-based algorithms have recently emerged as a family of nature-inspired, population-based algorithms that are capable of producing low cost, at fast rate, and robust solutions to several complex problems. Swarm Intelligence (SI) can therefore be defined as a relatively new branch of Artificial Intelligence that is used to model the collective behavior of social swarms in nature, such as ant colonies, honey bees, and bird flocks. Although these agents (insects or swarm individuals) are relatively unsophisticated with limited capabilities on their own, they are interacting together with certain behavioral patterns to cooperatively achieve tasks necessary for their survival. The social communications among swarm individuals can be either direct or indirect. Examples of direct interaction are through visual or audio contact, such as the air dance of honey bees. Indirect interaction takes place when one individual changes the environment and the other individuals respond to the new environment (new path), such as the pheromone trails of Ants that they deposit on their way to search for food sources. This type of indirect interaction is referred to as stigmergy technique, which means communication through the environment. The Area of research presented in this depth paper focuses on Swarm Intelligence. This paper discusses the most popular model of swarm intelligence inspired by ants' pheromone behavior for solving travelling salesman problem.

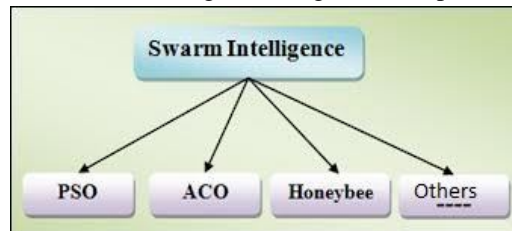


Figure 2: Types of Swarm Intelligence

V. PARTICLE SWARM OPTIMIZATION

Particle swarm optimization is a heuristic global optimization method put forward originally by Doctor Kennedy and E Berhart in 1995. It is an algorithm developed from swarm intelligence and is based on the research of bird and fish flock movement behaviour. While search for their food, the birds are either scattered or go together before they locate the place where they can find and eat the food. While the birds are doing search for food from one place to another, there is always a bird from group of birds that can smell the food very well, i.e. the bird is aware of the place where the food can be located, having the resource information for better food. Because they are distributing the information for data, especially the good information at any time while searching the food from one place to another, conducted by the better information, the birds will eventually flock to the place where food can be found. As far as concern of particle swam optimization algorithm is concerned, solution swarm is compared to the bird swarm, the birds' roaming from one place to another is equal to the development of the solution swarm, better information is equal to the most optimist solution, and the food resource is equal to the most optimal solution during the whole course. The most optimal solution can be worked out in particle swarm optimization algorithm by the cooperation of each individual. PSO determines search path according to the velocity and current position of particle without more complex evolution operation. Due to its many advantages

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including its simplicity and easy implementation, the algorithm can be used widely in the fields such as function optimization, the model classification, machine study, neural network training, the signal procession, vague system control, automatic adaptation control and etc.

Each particle i in the swarm holds the following information: (i) the current position x_i , which represents a solution to the problem, (ii) the current velocity v_i , (iii) the best position, the one associated with the best objective function value the particle has achieved so far $pbest_i$, where this objective function value is calculated using a function $f(\cdot)$ that evaluates the desirability of a solution, and (iv) the neighborhood best position, the one associated with the best objective function value found in the particle's neighborhood $nbest_i$. The choice of $nbest_i$ depends on the neighborhood topology adopted by the swarm, different neighborhood topologies have been studied in this.

A. PSO parameters

Velocity, inertia weight, learning factor and the largest iterative number are initialized. Array of particles are initialized with random position and velocity vectors.

B. Find the distance of the interest point to its nearest sensor. Fitness is evaluated for every particle at its current position using Euclidian distance as:-

$$1) (x_1, x_2)^2 - (y_1 - y_2)^2 \leq r^2$$

2) (x_1, y_1) (x_2, y_2) are the two points

3) sensing range r .

C. Minimize the fitness value; ideally the fitness value should be equal to zero, where the distance between the interests points with their nearest sensors are within the sensors' sensing range. If the fitness of the particle is lesser than that of the best particle, then the particle would be the best particle for the next move, and the fitness of this particle is taken as best fitness.

D. Each particle is made to modify its current position, current velocity, the distance between current position and $pibest$, the distance between current position and $pgbest$.

E. If the next position of the particle is best, then the particle chooses a new position, otherwise, the same algorithm is continued.

F. This process is repeated in iterations, until all the particles communicate with each other and generate maximum coverage. [2]

VI. PROPOSED ALGORITHM

The proposed PSO algorithm involves the deployment of randomly uniform nodes. The area is divided into fixed radial zones and the PSO algorithm is initialized followed by the adjusting of velocity values. Using the fitness function, the fitness value is predicted as the selection process for old and new bats begin. If the set number of iterations is not reached, new sets of fitness values are predicted again using the fitness function. Otherwise the, Voroni divided zone is optimized. The algorithm stops after all parameters have been evaluated. This process is illustrated by the flowchart below:

The basic steps in performing this dissertation are:

Step 1:- There is random deployment of nodes in the required region of interest. Based on these nodes a network is formed in form of mesh topology.

Step 2:- Area is covered by using VORONOI Diagram containing polygon that is known as cell. Each cell contain one sensor node in it. VORONOI is the node deployment technique which is used to cover irregular areas.

Step 3:- Implement Particle Swarm Optimization

Step 4:- Calculate the fitness value for each of the eligible node. Fitness value is calculated by using fitness uncton.

Step 5:- It gives rate of change of distance and speed of a node.

Step 6:- Find the best solution. The best solution is based upon distance and position of a node.

Step 7:- Selection process gives the optimal solution for the search space and also define the feasible solution (which consist of the most optimal solution with less number of dead nodes).

Step 8:- Ignoring or eliminating all the non-feasible solution.

Step 9:- Dividing the entire area into different number of zones with respect to base station.

Step 10:- Finally there is indirect communication between of nodes with respect to base station by cluster head.

Step 11:- Define all the parameter.

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VII. RESULTS AND DISCUSSION

FOR 250 NODES

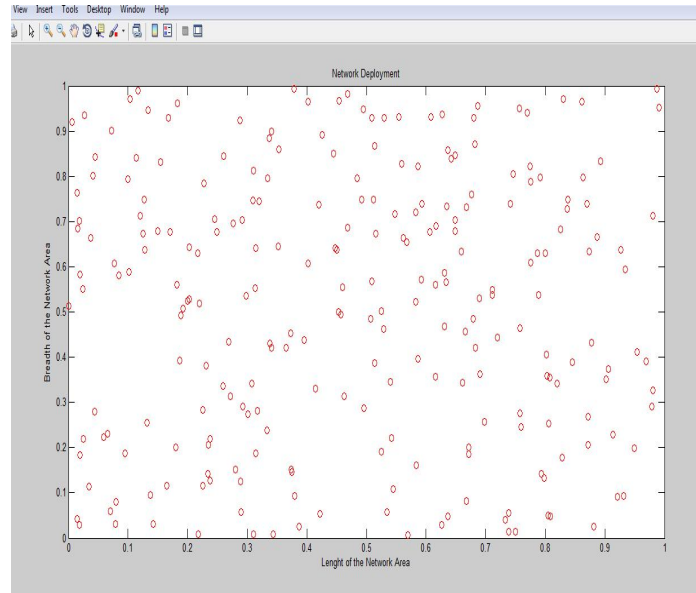


Figure 3: Random deployment of 250 nodes

In this on MATLAB editor by applying simple coding we can place 250 random nodes anywhere which can be placed anywhere at any time by running it into command window we get the graphical representation in terms of x and y axes.

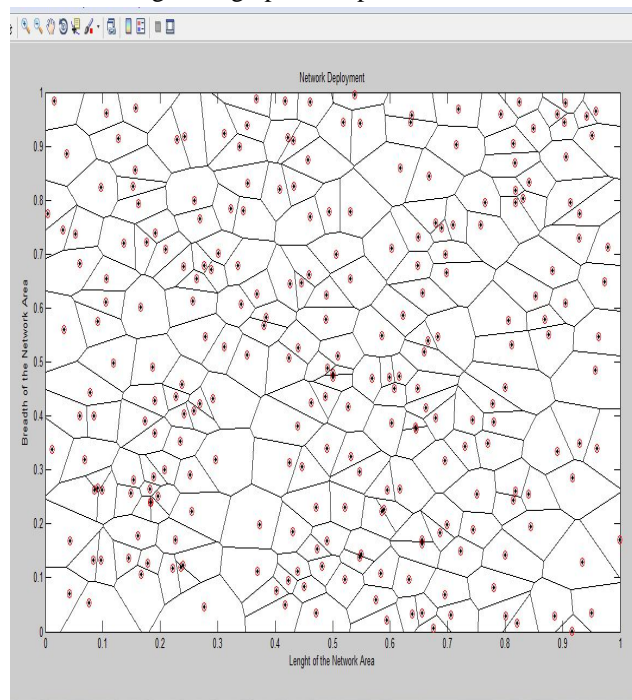


Figure 4: VORONOI diagram of 250 nodes

250 nodes are deployed on the basis of voronoi diagram to obtain maximum coverage area and minimum void .In this graphical representation we apply perform voronoi based deployment to 250 nodes, hence 250 nodes are placed on both the axes. If we run it into MATLAB editor we get this graphical result and simultaneously in MATLAB command window we get each voronoi cell contains a sensor node in it.

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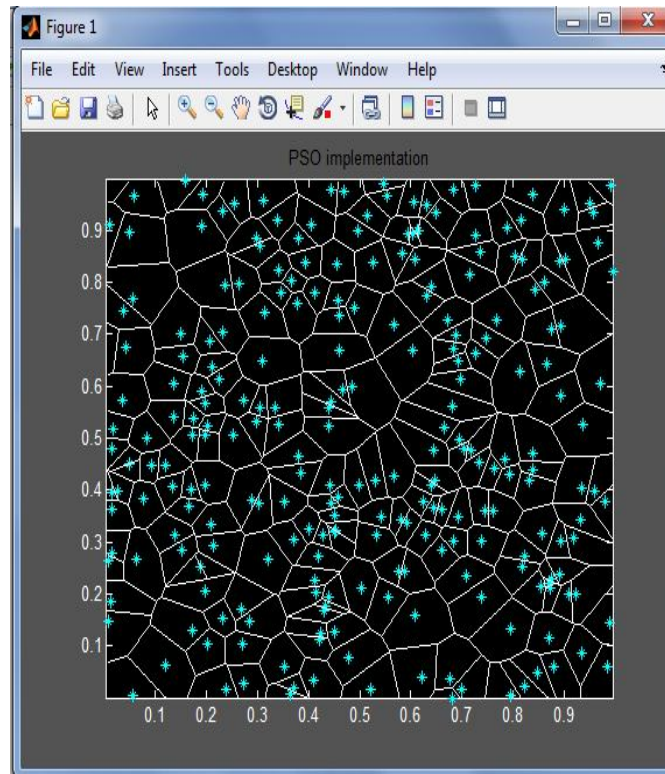


Figure 5: PSO_VORONOI diagram of 250 nodes

The above results shows the optimized placement of nodes. In this Particle Swarm Optimization is applied on Voronoi diagram. Hence there is reallocation of nodes.

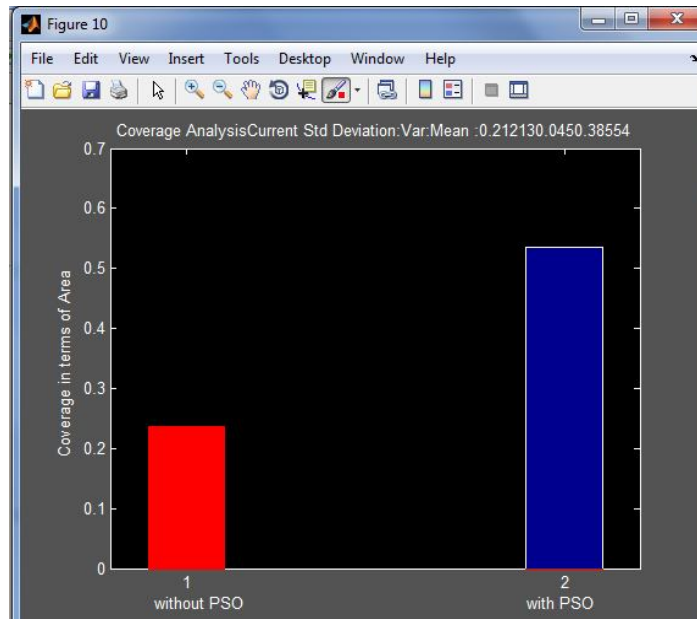


Figure 6: Bar graph of proposed and existing technology for 250 nodes

This bar graph shows the comparison between the existing technology (i.e area covered by using voronoi diagram) and the proposed technology (i.e by using PSO_VORONOI). As it is clear from the graphical result that the proposed strategy for 250 nodes is better than existing technology.

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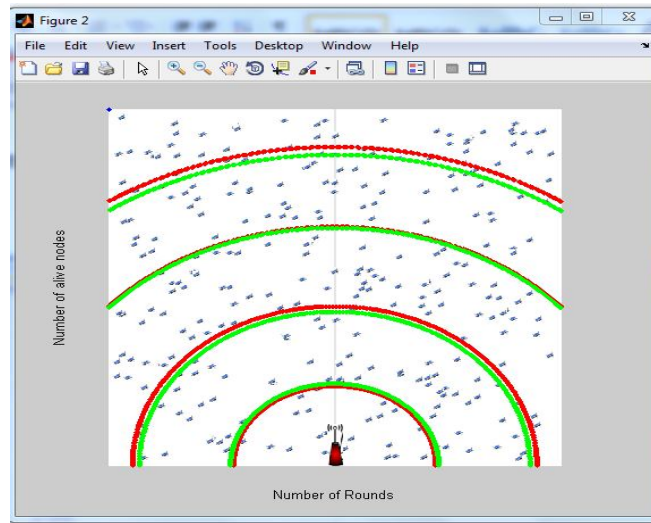


Figure 7: Zone division of area

The entire region is divided into zone with respect to base station. The region which is closest to the base station contains maximum number of eligible nodes. Nodes which contain these two properties are called eligible nodes and from these eligible nodes cluster head is chosen. Eligible nodes are the nodes which can easily able to communicate with base station. And the nodes which could not communicate with base station are not eligible nodes and they are ignored.

AVERAGE COVERAGE

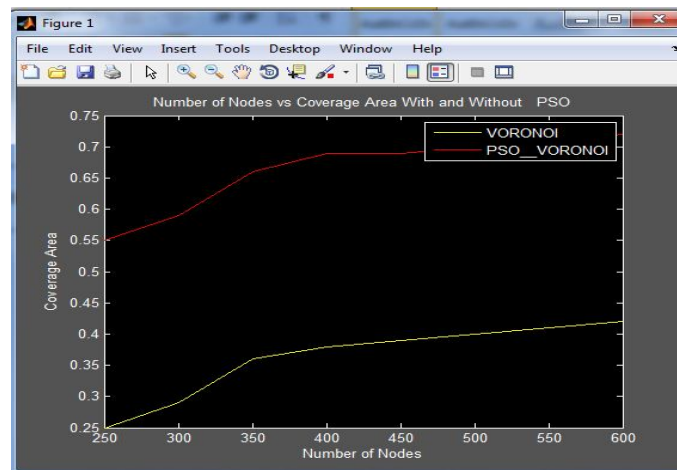


Figure 8: Comparison Of existing and Proposed Work for average coverage

The graph is plotted between coverage with PSO (along x-axis) versus number of nodes (along y-axis). Hence, from the graph we determine that average coverage area covered by proposed technology is better than existing technology.

VIII. CONCLUSION

The research work has focused on solving coverage problem in Wireless Sensor Network and found the optimum coverage area with minimum number of dead nodes. Which result in less coverage hole. To maximize the coverage area by decrease in coverage hole is quite difficult task but ,whole research is based on finding the optimal position or the optimal placement for the node which results in optimum coverage and which leads to less coverage hole. So to find the optimum position of the node with less number of dead nodes a new technique is suggested in this research work which uses VORONOI with PSO(PARTICLE SWARM OPTIMIZATION) which may result in finding optimum coverage area for sensors and reduce number of dead nodes. The proposed algorithm is implemented in MATLAB and checked by taking different number of nodes i.e by taking different scenario. Comparison has been made between original and improved algorithm shows that improved algorithm perform better than existing

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algorithm in terms of Average Coverage. In near future work can be extended and can be implemented on real time environment and also more tests for different conditions and optimizing other problems in Wireless Sensor Network.

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