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Strategy Used to Solve Coverage Problem in Wireless Sensor Network

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Abstract-

The study of Wireless sensor network is challenging in that it requires an enormous breadth of knowledge form. They are rapidly growing area for research and commercial deployment. Wireless sensor networks address a broad range of applications related to heathcare, industrial, area , surveillance and environmental monitoring. One of the most active research area in wireless sensor network is that of coverage.This paper presents effective coverage strategy for wireless sensor network. This mainly focus on two coverage strategies which are compared. In this paper we compare Delaunay triangulation and square grid coverage strategy on different parameters.

Keywords-coverage problems, delaunay triangulation, sensor nodes,square grid,wireless sensor networks.

I. INTRODUCTION

Wireless Sensor Network Have Inspired Tremendous Research Interest Since The Mid 1990s. Advancement In Wireless Communication Have Enabled The Development Of Low-Cost,Low-Power, Multifunctional, Tiny Sensor Nodesthat Can Sense The Environment, Perform Data Processing And Communicate With Each Other Unthered Over Short Distances. These Nodes Are Characterized By Being Very Small In Size With Limited Energy Usually Supplied By A Battery. They Communicate Via Built-In-Antenna Over Rf Signals.Sensor Nodes Can Be Placed On Predetermined Positions Or Randomly Deployed.These Networks Typically Used To Monitor A Field Of Interest To Detect Movement,Temperature Changes,Precipitation Etc.

One Of The Active Research Field In Wireless Sensor Network Is That Of Coverage. Coverage Is Usually Interpreted As How Well A Sensor Network Will Monitor A Field-Of-Interest. It Can Be Thought As Measure Of Quality Of Service.There Are Several Issues That Need To Be Addresed.Coverage Problem Is Regarding How To Ensure That Each Of The Points In The Region To Be Monitored Is Covered By Sensors.In Maximising Coverage Sensors Need To Be Placed Not Too Close To Each Other So That The Sensing Capability Of The Network Is Fully Utilised And At The Same Time They Must Not Be Located Too Far From Each Other To Avoid The Formation Of Coverage Holes.They Must Be Placed Close Enough So That They Are Within Each Other Communication Range.

II. RELATED WORK

Despite the wealth of Previous research studies conducted separately on sensor network and coverage of sensor network and coverage of sensor network which are surveyed i.e joint consideration of those two concepts for WSN is so common. J. Naskath, Dr.K.G.Srinivasagan, S.Pratheema[3] focuses on the sensor replacement problem in WSN consist of mobile sensors. Gao Jun Fan and Shi Yao Jin[4] presented a survey of coverage problem where two challenges are described, namely, maximizing network lifetime and network connectivity. Ridha Soua, Leila Saidane, Pascale Minet[5] proposed an approach to use a mobile robot to assist the initial sensor deployment and to improve sensing coverage and connectivity of monitored area H. Mahboubi, J. Habibi,A. G. Aghdam [9] efficient sensor deployment algorithms are presented that helps to increase coverage in a mobile sensor network. C.F Huang,Y.C Tseng[14] proposed solutions to two versions of thecoverage problems. H. Chizari, T.Poston [16] have proposed a new measurement scheme, based on DT, which gives detailed information about the areasbetween sensors, distance between them. This information can improve understanding sensors of the coverage properties of different coverage promising algorithms, and comparison among them.

III. COVERAGE SCHEME

Here this scheme focuses on the coverage strategies we used to achieve the maximum coverage .These coverage strategies are categorized into three groups:-

1.Force Based
2.Grid Based
3.Computational Geometry Based

A. *Force Based*: Force based deployment strategies rely on the sensors mobility, using virtual repulsive and attractive force, 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; where repulsive and attractive forces are equal thus they end up canceling each other. In [7] the sensors and objects in the ROI exert virtual repulsive force that pushes sensors away from the objects and also from each other so that their sensing areas are not overlapping. The sensors will keep moving until static equilibrium state is reached. The static equilibrium state is reached based on the fact that the total energy is reduced with time. Although this method does ensure full coverage and full connectivity, but it extremely depends on mobility, which is a high power consumption task**.**

B. ***Grid Based*** **:** Grid based deployment strategies used to determine sensors positions. Grid based is the sampling method in which coverage is estimated as ratio of grid points covered to total number of grid points in the ROI. The cost of this method is determined by number of grid points, name and amount of sensors deployed. The accuracy of the estimation is determined by the size of each grid, the smaller the size the more accurate the estimation is. There are three types of grids commonly used in networking; [8]
(a) Triangular Lattice
(b) Square Grid
(c) Hexagonal Grid
Triangular lattice is the best among the three kinds of grids as it has the smallest overlapping area hence this grid requires the least number of sensors[17]. Triangular Lattice is shown in figure 2(a).Square grid is shown in figure 2(b). Square grid provides fairly good performance for any parameters. Hexagonal grid is the worst among all since it has the biggest overlapping area, shown in figure 2(c).

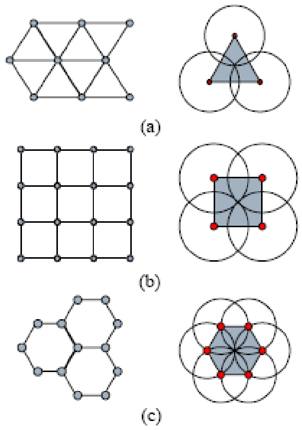
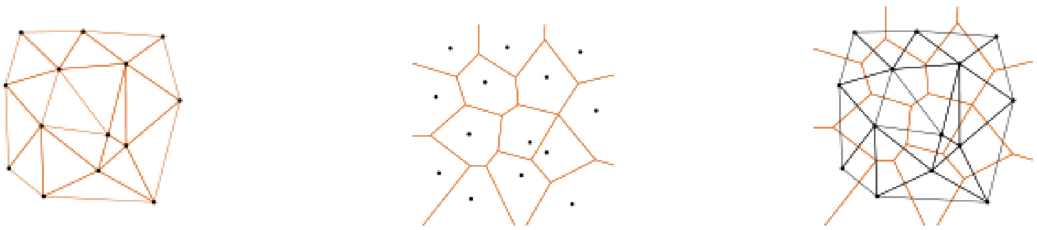


FIG 1: TYPES OF GRIDS (A) TRIANGULAR LATTICE (B) SQUARE GRID (C) HEXAGONAL GRID

C.***Computational Geometry Based*****:** Computational geometry is frequently used in WSN coverage optimization,[10] the most commonly used computational geometry approach are (a) Voronoi diagram (b) Delaunay triangulation. Voronoi diagram is partition of sites in such a way that points inside a polygon are closer to the site inside the polygon than any other sites, thus one of the vertices of the polygon is the farthest point of the polygon to the site inside it. Therefore Voronoi diagram can be used as one of the sampling method in determining WSN coverage; with the sensors act as the sites, if all Voronoi polygons vertices are covered then the ROI is fully covered otherwise coverage holes exist.

Delaunay triangle is formed by three sites provided if and only if the sites[11] circumcircle does not contain other sites. Delaunay triangulation is the dual of voronoi diagram. Voronoi diagram and Delanay triangulation are used in to estimate the worst and best case coverage. This work focuses in finding the maximal brech path-a path where an intruder can go through with the least probability of being detected,and the maximal support path-a path with highest coverage.



(a) (b) (c)

Fig 2.(a)Delanay triangulation, (b) Voronoi Diagram, (c) Voronoi diagram with Delanay triangulation.

IV. IMPLEMENTATION AND PERFORMANCE

Wireless Sensor Networks greatly benefit from simulation before deployment, since some of these networks may contain thousand of nodes. Network simulation is a relatively fast way to obtain an estimate of network performance and tuning. This section describes about the simulation environment i.e Matlab in which the research implementation work is done **.**

***A.DELAUNAY TRIANGULATION COVERAGE STRATEGY*:** It is frequently used in WSN coverage optimization. A Delaunay triangle is formed by three sites provided if and only if the sites' circumcircle does not contain other sites .Delaunay triangulation is used in to estimate the worst and best case coverage [13].The complexity of the approach using computational complexity of computational geometry methods are controlled by the number of sensors/sites (*N*) and the algorithm used.The lower bound for the computational complexity of constructing Voronoi diagram is Ω (*N* log*N*). As for the Delaunay triangulation there are several construction algorithms with computational complexity as low as *O (N logN)*.

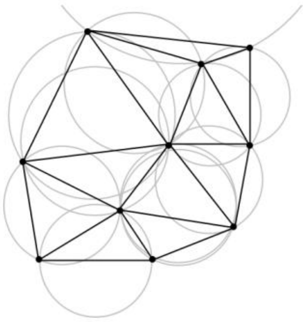


Fig 3:Circumcircles of Delaunay triangles

*B. **ASSUMPTIONS FOR DELAUNAY TRIANGULATION***:
In the sensor network the following properties are assumed.
1. Delaunay triangulation is implemented in 2D.
2. Distance between sensors is computed by distance Formula equation Sqrt(x2-x1) ^2+ (y2-y1) ^2.
3. Sensor communicate, if distance is <=R, where R is sensing range.
4. The sensor nodes sense information continuously and send the information continuously to the next node towards the head.

C. ***ALGORITHM FOR DELAUNAY TRIANGULATION:***
Delaunay triangulation can generated by the following steps.
Step 1:
□ Send a *hello* message within the distance by using distance formula.
□ Upon receiving the *hello* message, acknowledge the sender alone with the location information of the current node.
Step 2:
Connect *u* with the neighbor nodes in form of triangle. Let this graph be *G*1.
Step 3:
Two nodes connect only if the other node lies within the sensing range of the node. The resulting graph *G* is almost Delaunay triangulation. After step 2, the graph *G*1 is a non planar graph. It may contain some non-Delaunay edges, which may cause edge crossing. After removal of the edge crossing in step 3, almost Delaunay triangulation graph *G* is achieved, which is planar but still it may contain some non-Delaunay edges.
The algorithm is very simple. After the execution of the algorithm each node will need to remember only the neighbors that have edges with it in the graph and forget the other neighbors.

*D**. SQUARE GRID BASED COVERAGE STRATEGY***: Grid points are used in two ways in WSN deployment either to measure coverage as used in VFA or to determine sensors positions. Coverage percentage as stated before is ratio of area covered to the area of ROI. Grid is among the sampling method commonly used such as in [15]. The coverage is estimated as ratio of grid points covered to total number of grid points in the ROI. The cost of this method is determined by number of grid points; *n*×*m* and amount of sensors deployed; *k*..

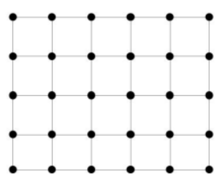


FIG 4: SQUARE GRID

E. ASSUMPTIONS FOR SQUARE GRID BASED COVERAGE STRATEGY :
In the sensor network the following properties are assumed.

1. Square Grid is implemented in 2D.
2 Sensor sensing range is equal to size of grid.
3. Formula used to compute distance is 2*R.
4. Sensor communicate if distance is <=R, where R is sensing range.
5. The sensor nodes sense information and send the information continuously to the next node towards the head.

F. ALGORITHM FOR SQUARE GRID BASED COVERAGE STRATEGY:

Square Grid Coverage strategy can be generated by the following steps.

Step 1:

 Send a *hello* message within the distance by using distance formula.

 Upon receiving the *hello* message, acknowledge the sender alone with the location information of the current node.

Step 2:

Connect a node with the neighbor nodes in form of square.

Step 3:

Two nodes connect only if the other node lies within the sensing range of the node. The resulting graph *G* is almost Square grid.

The algorithm is very simple. After the execution of the algorithm each node has static position. In some situation square grid suffers from horizontal and vertical misalignment

***G. RESULT AND ANALYSIS*:**

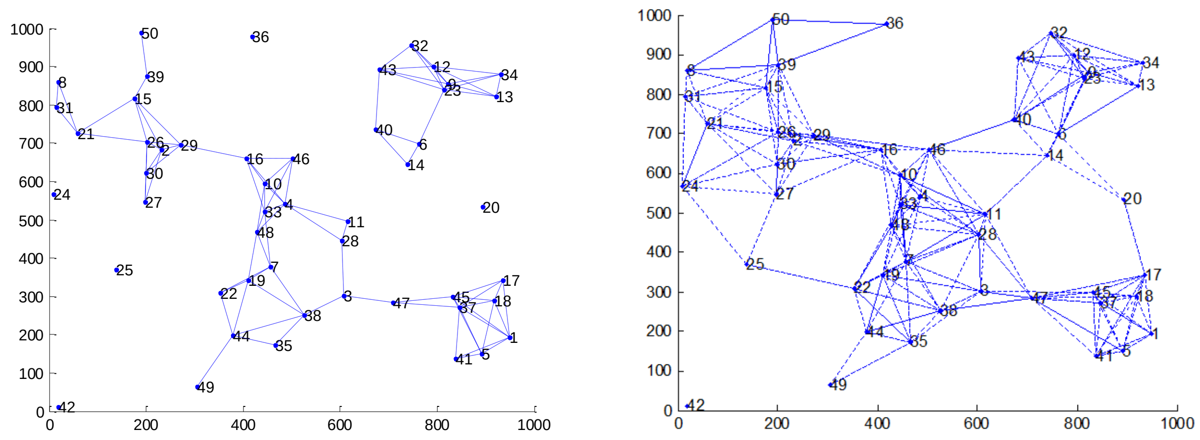
1 .THEORETICAL COMPARATIVE ANALYSIS OF COVERAGE STRATEGIES:

TABLE 1: THEORETICAL COMPARATIVE ANALYSIS OF COVERAGE STRATEGIES

S.NO	FEATURES	DELAUNAY TRIANGULATION COVERAGE STRATEGY	SQUARE GRID BASED DEPLOYMENT STRATEGY
1	OBJECTIVE	Partion of site	SAMPLING METHOD
2	ALGORITHM	BASED ALGORITHM	Distributed Algorithm
3	COVERAGE	VORONOI BASED ALGORITHM	Better Coverage
4	SENSING RANGE	IRREGULAR SENSING RANGE	Same Size Disk
5	STRATEGY	Geometry Based	Deployment Strategy
6	COPLEXITY	O(N LogN)	O(nm)

2.***SIMULATION BASED COMPARATIVE ANALYSIS OF COVERAGE STRATEGIES*:**

2.***1 DELAUNAY TRIANGULATION SIMULATION RESULTS:***



(A) (B)

FIG 5(A): RANDOM DISTRIBUTION OF NODES FOR DELAUNAY TRIANGULATION. (B)MATLAB SIMULATION FOR DELAUNAY TRIANGULATION COVERAGE STRATEGY

As Shown In Above Fig 5(A). Nodes Are Connected In Triangle Form. There Are 50 Nodes Having Same Sensing Range. But As Shown In Figure Some Nodes Like Node No 20,25,36,42 Remain Ideal Because Of Low Sensing Range. As Shown In Fig 5(B). More Nodes Are Connected As Compared To Fig 8.The Node Number 20, 25 And 36 Is Completely Connected With Other Nodes. This Is Because Sensing Range Of Sensors Is Increased, So That Three Sensors Can Easily Link To Each Other. Node Number 42 Is Not Connected Because Distance Of Node No 42 Is Greater Than Sensing Range. But Increasing Sensing Range Results More Numbers Of Nodes Connected Than Number Of Nodes Remain Ideal. Fig 9 Shows The Achievement Of Delaunay Triangulation Coverage Strategy**.**

Table2. Simulation Result of Delaunay Triangulation Coverage Strategy

S.NO	NO. OF NODES	SENSING RANGE	IDEAL SENSOR
1	41	220	2
2	41	230	1
3	45	200	1
4	45	220	0
5	47	250	0
6	47	220	1
7	49	220	2
8	49	250	0
9	50	210	2
10	50	240	0

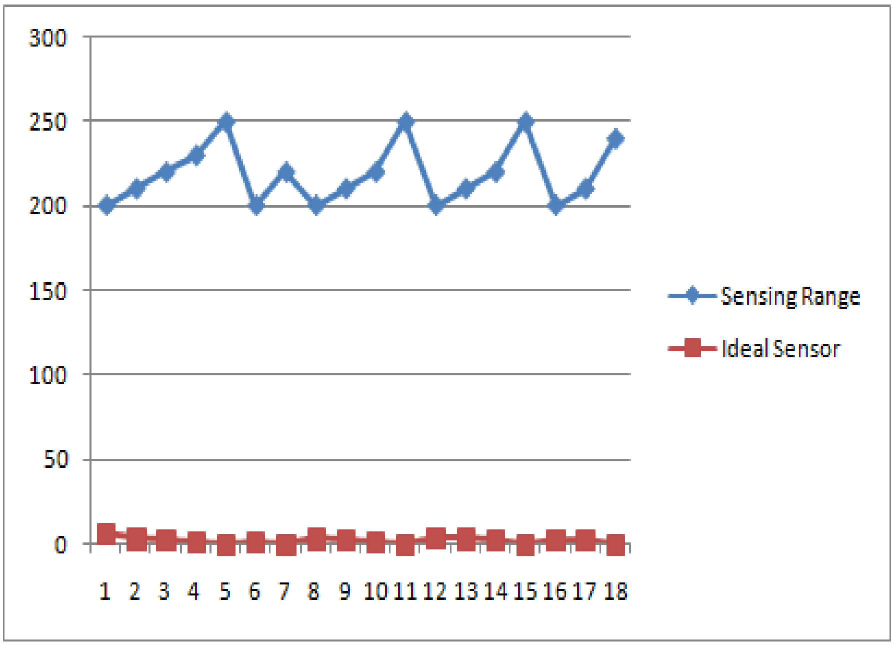


Fig 6: Graph of Delaunay Triangulation

Fig 6 shows the graph based simulation result of Delaunay Triangulation. Graph is made based on Table 3 result. It is shown in figure that if sensing range of sensors is increased than number of ideal nodes is decreased.

2.2 ***Square Grid Simulation Results*****:** For the implementation of Square Grid Coverage Strategy square target Area A of size 1000x1000 is used and numbers of sensor nodes n is 50.Random distribution of the nodes in the target area A is assumed. The neighbors of the nodes are within the range of 2*R formula, where R is the sensing range of the sensor. A node will communicate with other node only if it lies in the range of 2*R area of the node.

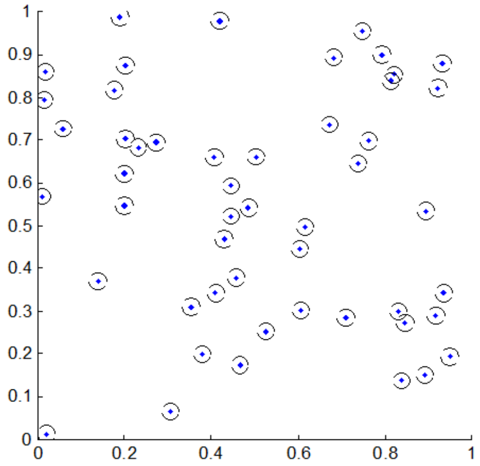


Fig7: Random Deployments of Sensors in Square Grid

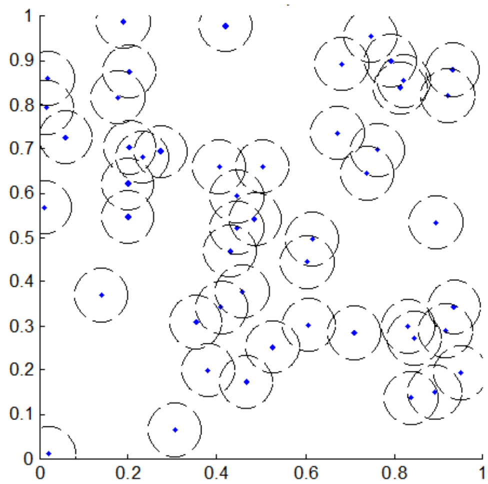


Fig 8: Square Grid Deployment Coverage strategy

Fig8 shows the communication of sensors increased as compared to fig7 by increasing sensors sensing range. But overlapping is also increased in fig8 in comparision of fig 7**.**

Table 2: Simulation Result of Square Grid Coverage Strategy

S.NO.	NO. OF NODES	SENSING RANGE	NO. OF OVERLAPPED SENSING AREA NODES
1	41	100	0
2	41	200	6
3	45	180	0
4	47	140	0
5	49	100	0
6	49	140	6
7	50	100	0
8	50	150	2

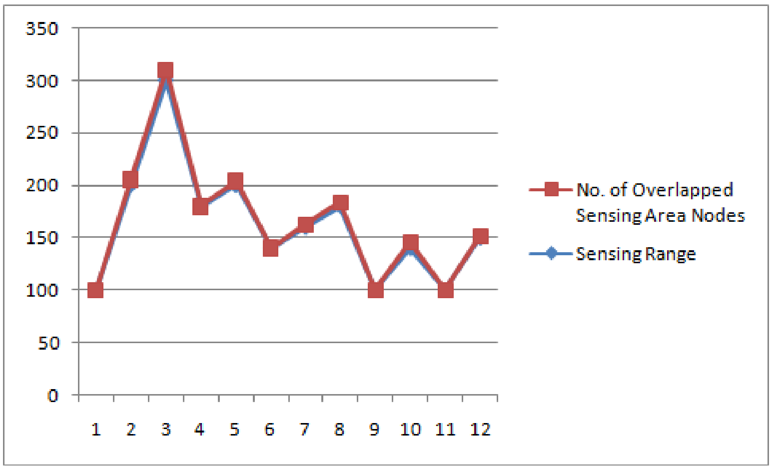


Fig9. Graph of Square grid.

Fig 9 shows graph based simulation result of Square Grid Coverage strategy. Graph is made on Table 4 result. It is shown in fig9 if sensing range of sensors is increased the number of nodes having overlapped sensing area also increased.

V. Conclusions

In this paper two coverage strategies of Wireless Sensor Network are compared on different parameters i.e sensing range and number of nodes. Almost Delaunay triangulation is more supierer coverage strategy because node are link in triangle form and if sensing range of the sensor is increased than each node can communicate with other node in the network where as square grid deployment strategy is also used in different applications but this strategy suffers Horizontal and Vertical and Random misalignments. If sensing range is increased in square grid coverage strategy than overlapping of sensing area is increased which is not desirable for valid data in coverage of region of interest.

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