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Rasmi Ranjan Patra
Dept of Mathematics, Utkal University, Vani Vihar., Bhubaneswar, Odisha,India,
rasmiranjanpatra@gmail.com

Prashant Kumar Patra
College of Engineering and Technology, Biju Patnaik University of Technology, Odisha, India.,
prashantkumarpatra@gmail.com

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Coverage and Connectivity Improvement Algorithms for the Wireless Sensor Networks

Rasmi Ranjan Patra
Dept of Mathematics,
Utkal University, Vani Vihar.,
Bhubaneswar, Odisha,India.

Prashant Kumar Patra,
College of Engineering and Technology,
Biju Patnaik University of Technology,
Odisha, India.

***Abstract*—In this paper we study the increase of coverage and connectivity in a sensor network with a view to improving coverage, while preserving the network's coverage. We also examine the impact of on the related problem of coverage-boundary detection. We reduce both problems to the computation of Voronoi diagrams and intersectional point method prove and achieve lower bounds on the solution of these problems and present efficient distributed algorithms for computing and maintaining solutions in cases of sensor failures or insertion of new sensors. We prove the correctness and termination properties of our distributed algorithms, and analytically characterize the time complexity and the traffic generated by our algorithms. Our algorithms show that the increase coverage & Connectivity in wireless sensor density.**

Key notes: Connectivity, coverage, nodes, wireless sensor networks, survey, lifetime, mobile, irregular sensing area, Voronoi diagrams.

I. INTRODUCTION

Wireless sensor networks gain more and more attention as an instrument for fine-granular measuring of a physical parameter in a given area. A wireless sensor network is a group of wireless sensor nodes of which each contains at least one sensor and a wireless RF communication unit. In the last years, research communities have developed several different wireless sensor network platforms, such as the Motes [1] or Smart-Its [2], [3]. Mentionable business is already being generated through this emerging technology [4]. The sensor nodes are normally distributed over a certain area to give information on relevant physical parameters or events. The measurements taken are then locally interpreted or forwarded to a base-station for further data processing. To forward the data in such a sensor network, the nodes normally perform multi-hop routing. Different methods and strategies to optimize this data-flow process have been proposed and compared against each other [5]. In general, a multi-hop network tries to find a route between a source and a destination to forward the information. As a theoretical minimum, at least one route must exist to perform data transport. If two nodes in this route are not able to communicate to each other because they are too far away to send/receive RF-signals the network is segmented. This can happen due to environmental conditions – e.g. higher noise on the channel, the failure of nodes or simply by wrong set-up of the sensor network. The installation process of wireless sensor networks can therefore be a very exhausting task. Wireless sensor networks can easily consist of several hundreds of nodes that have importance of nodes. Some might be redundant because they sit right next to a partner node – others might obtain a critical position being the only data relay for a large separated group.

In recent years, wireless sensor networks have attracted significant attention due to their integration of wireless, computer, and sensor technology. Wireless sensor networks consist of a multiplicity of nodes that are equipped with processing, communicating and sensing capabilities, and use ad-hoc radio protocols to forward data in a multi-hop mode of operation. Each node in such a network has limited energy resources, hence, minimizing energy usage in wireless sensor networks becomes important. The majority of literature on wireless sensor networks involves minimizing communication since this is the dominant operation in time. In [6] it is reported that to send 1 bit 100 m away uses the same energy as 3000 instructions on a microprocessor. Representative work on energy conservation strategies have included aggregating data at nodes to shorten subsequent transmissions [7], probabilistically routing traffic to spread load across network nodes and prolong stored energy [8], putting sensors to sleep when they are not needed [9], and activating only geographically localized wireless sensors [10]. In terms of the computation efficiency of sensor networks, there has been research on sorting [11] and on computational problems in distributed sensor networks [12]. It is clear that the uneven characteristics of wireless.

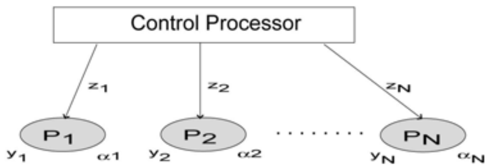


FIG-1.Control Processor for various processes

sensor networks functionality require a rethinking of integrated distributed processing algorithms and protocols. The following section describes a methodology for wireless sensor networks that combines both the communication and measurement aspects of the network.

2. PROBLEM FORMULATION

Notations:

Av(i): Node i's voronoi cell's area.
ArsB(i): Node i's sensing area (if node i is black node).
Avhole(i): The hole area in Node i's voronoi diagram area.
Aoverlapping(i , j): The overlapping area that node i's sensing area was covered node j.
Aoutside(i): Node i's sensing area that is outside the monitoring region.
We assume deployed N nodes in the network, and the node number set is {1,2,…,n}.
i=1~n, *j*=1~n.
Fig. 3. Voronoi diagram of the sensors in
Fig. 2 – circles represent the coverage disks of the labeled sensors. Note that only in the case of sensors A and R, the coverage area completely covers the corresponding Voronoi cell.

2(A).EFFICIENT COVERAGE

The connectivity (and coverage) properties of random deployments can be best analysed by using voronoi diagrams.The main aim of our algorithms is to increase coverage.we have to arrange the nodes such that the coverage should increase effectively. Change some nodes (from black node to red node) to increase coverage under the same conditions with the paper (same # red nodes & # black nodes). Use the **voronoi diagram** & optimization method to calculate which node can reduce the *Avhold (i)* as shown in figure 2.

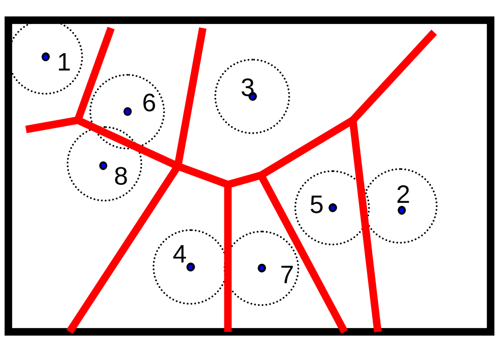


FIG-2. Circles represent the coverage disks of the labeled sensors.

Algorithms

Step1. the network has to use voronoi diagram to draw up the cell of each node.
Step2. each node has to know the hole area with its cell.
Step3. if a node i has minimize overlapping area (the overlapping area means how much area in node i's sensing area was covered by other node), we will choose it. And change it radius. (from black node to red node, rsR>rsB).

Notations:

Av(i): Node i's voronoi cell's area.
ArsB(i): Node i's sensing area (if node i is black node).
Avhole(i): The hole area in Node i's voronoi diagram area.
Aoverlapping(i , j): The overlapping area that node i's sensing area was covered node j.
Aoutside(i): Node i's sensing area that is outside the monitoring region.
We assume deployed N nodes in the network, and the node number set is {1,2,…,n}.
i=1~n, *j*=1~n.

Optimization equation :

Choose a ***node i*** to satisfy the following:

$$minimize \sum_{i=1}^{n} A_{vhole}(i)$$

$$Subject\ to\ {}^{i}A_{overlapping} = min\{{}^{1}A_{overlapping}, {}^{2}A_{overlapping}, \ldots, {}^{n}A_{overlapping}\}$$

$$c_{ij} = 1 \quad for\ all\ i,j$$

$$A_v(i) > A_{r_{sB}}(i) - A_{outside}(i) \quad for\ all\ i$$

$$c_{ij} \times [A_{r_s}(i) - A_{r_s}(j)] \neq 0 \quad for\ all\ i,j$$

$$where\ {}^{i}A_{overlapping}(i,j) = \frac{1}{2} \times \sum_{j=1}^{n} c_{ij} \times |(A_v(i) - A_v(j)) - (A_{outside}(i) - A_{outside}(j)) - \ldots$$

$$-(A_{vhole}(i) + A_{vhole}(j)) - (A_{r_{sB}}(i) + A_{r_{sB}}(j))| \quad for\ all\ i,j$$

How to calculate Aoutside(i): :

◎ *(For Type III)*

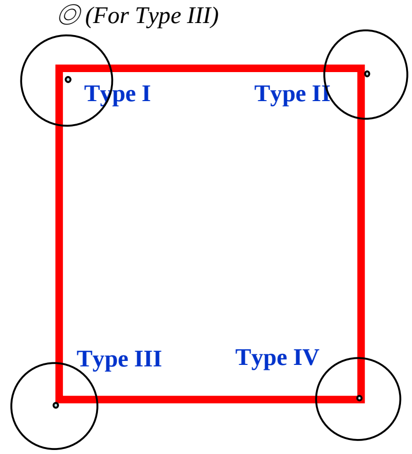


FIG-3. Voronoi diagram of the sensors in

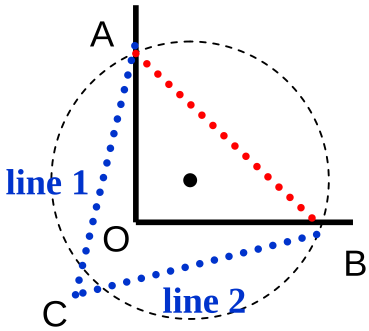


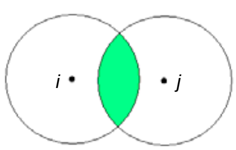
FIG-4.Single Sensor Coordinates

2(B) EFFICIENT COVERAGE

Step1. to know A & B
Step2. calculate triangle AOB.
Step3. to extend line1 & line2 from A & B, and the line |AB|=|AC|=|BC|, so the triangle ACB is regular triangle.
Step4. calculate are of arc ACB.
Step5. area of arc ACB - triangle ACB = area of arc AB
Step6. area of arc AB + triangle AOB = inside sensing area.
Step7. outside sensing area= all sensing area- inside sensing are.

FOR 3 NODES

In previous method steps, *Aoverlapping(i,j)* just adapt to calculate 2-coverage overlapping between *i & j*.
If there is overlapping area (over 3-coverage) between node *i, j, k*, it will be wrong.
◊ 3-coverage overlapping will be repeated calculate.



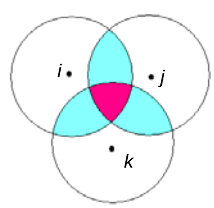


FIG-5(a).Overlapping of Two sensors
FIG-5(b).Overlapping of Three sensors

The main aim of our proposed algorithms is to increase coverage when more than 2 nodes are overlapping each other as shown in figure 5(a) and 5(b).we have to arrange the nodes such that the coverage should increase effectively. Change some nodes (from black node to red node) to increase coverage under the same conditions with the paper (same # red nodes & # black nodes). Use the **intersectional point method** & optimization method to calculate which node can reduce the *Avhold (i).* As shown in Fig 7 nodes are deployed randomly within certain specific area.Using Intersectional point method we can find out how many intersectional point pass through a node and arrange the nodes in ascending order. Then those points who have less rank occurrences having less coverage area. From the figure 7. We find out that nodes no's 3,2,8,4,7 have intersectional point 3,4,4,5,5 respectively. The other nodes no's like 1,5,6,10,9 have intersectional point of 6,6,6,6,9. So to improve coverage we increase the less coverage area nodes to more coverage area nodes as shown in figure 8 and figure 9 .For this we proposed an algorithms to optimization of sensing area to increase more coverage.

<u>Example:</u>

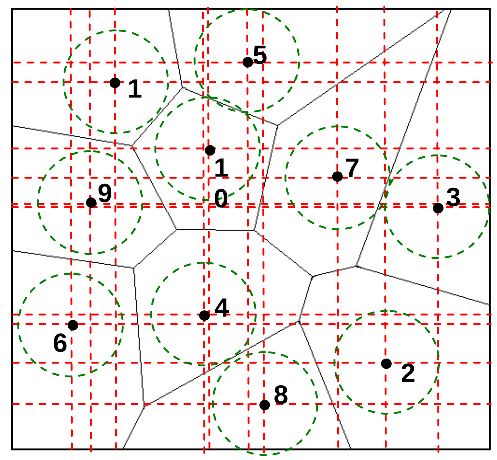


FIG-7.Randmonly deployed node with intersectional points.

<u>TABLES FOR THE VARIOUS NODES WITH INTERSECTIONS OF FIGURE-7.</u>

Number of Node	# intersectional point
Node 1	6
Node 2	5
Node 3	3
Node 4	4
Node 5	6
Node 6	6
Node 7	5
Node 8	4
Node 9	9
Node 10	6

RANK IN ASCENDING ORDER

Number of Node	# intersectional point
Node 3	3
Node 4	4
Node 8	4
Node 2	5
Node 7	5
Node 1	6
Node 5	6
Node 6	6
Node 10	6
Node 9	9

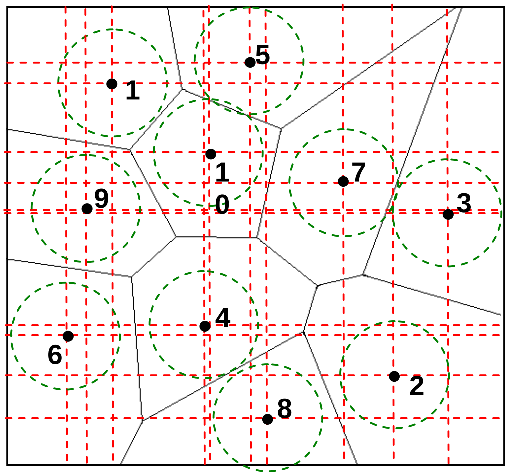


FIG-8.Before arranging the nodes

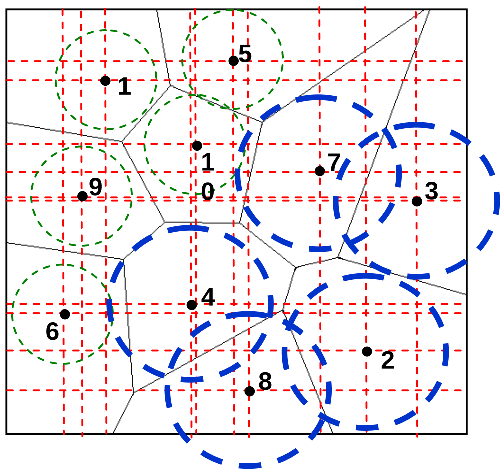


FIG.9.After arranging the nodes in ascending order of ranking,the radious increase to cover up more intersectional point to increase coverage.

ALGORITHMS

Step1. the network has to draw up dotted red line in the network.
Step2. each node has to know how many intersectional points with its sensing area.
Step3. if a node i has minimize number of intersectional points, we will choose it. And change it radius. (from black node to red node, rsR>rsB).
Notations:

$$c_{ij} = \begin{cases} 1, & i \neq j \\ 0, & i = j \end{cases}$$

Av(i): Node i's voronoi diagram area.
ArsB(i) / ArsR(i) : Node i's sensing area (if node i is black node / red node).
Avhole(i): The hole area in Node i's voronoi diagram area.
Aoverlapping(i , j): The overlapping area that node i's sensing area was covered node j.
Aoutside(i): Node i's sensing area outside of the network.
N iIP(i): the # intersectional point within sensing area.

Optimization equation :

$$minimize \sum_{i=1}^{n} A_{vhole}(i)$$

$$Subject\ to\quad A^{i}_{overlapping} = min\{A^{1}_{overlapping}, A^{2}_{overlapping}, \ldots, A^{n}_{overlapping}\}$$
$$N^{i}_{IP} = min\{N^{1}_{IP}, N^{2}_{IP}, \ldots, N^{n}_{IP}\}$$
$$c_{ij} = 1 \quad for\ all\ i$$
$$A_{v}(i) > A_{r_s}(i) - A_{outside}(i) \quad for\ all\ i, i \neq j$$
$$c_{ij} \times [A_{r_s}(i) - A_{r_s}(j)] \neq 0 \quad for\ all\ i, i \neq j$$

$$where\ A^{i}_{overlapping}(i,j) = \frac{1}{2} \times \sum_{j=1}^{n} c_{ij} \times |(A_{v}(i) - A_{v}(j)) - (A_{outside}(i) - A_{outside}(j)) - (A_{vhole}(i) + A_{vhole}(j)) - (A_{r_{sR}}(i) + A_{r_{sR}}(j))| \quad for\ all\ i$$

3. PERFORMANCE EVALUATION

The 4 graphs developed by Matlab 7.0 after putting the equation used in the algorithms. Fig 11 shows how the % of coverage will increase by applying the optimization equation. We also check in Fig 12, the increase in coverage by increasing the sensing range from 10m to 20m then to 50 m.Fig 10 and fig 13 both show how the increase in consumption of energy by increasing nodes and with increase in sensing range the energy consumption also increases.

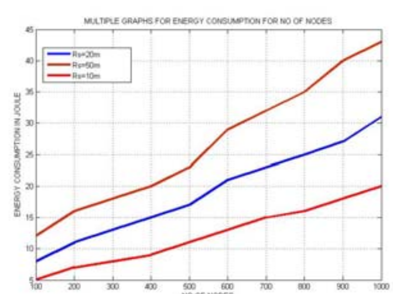


FIG 10.Multiple Graphs for energy Consumption for no of Nodes(Here we take 1000 nodes and energy consumption in Joule,Nodes having sensing ranges 10m,20m & 50m)

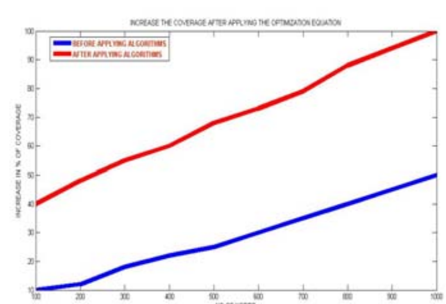


FIG11.Increase in Coverage after applying the algorithm. (Here we take 1000 nodes and % of increase in coverage)

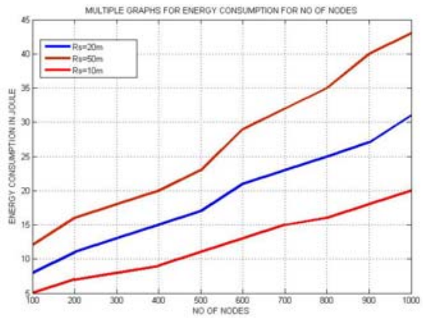


Fig 12. The multiple Graphs for various sensing ranges of the nodes.(in This Graph We take Sensing radious as 10m,20m,50m)

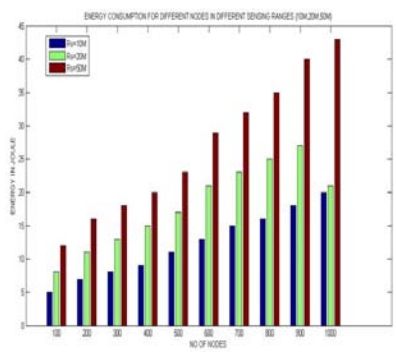


Fig 13. The Bargraph shows energy consumption with respect to the sensing Ranges.

4. CONCLUSION

Two algorithms using voronoi diagrams and intersectional point method are proposed to increase coverage in wireless sensor network using 2 nodes and using 3 nodes(which can be extended to N nodes) respectively. Since the coverage scheme proposed here is one of the fundamental ideas, there is a large horizon of possibilities for future researches on this algorithms, even these partial solutions offer reason for optimism.

5.REFERENCES

[1] Website, accessed: 4/2004. Crossbow.http://www.xbow.com/.

[2] C. Decker, A. Krohn, M. Beigl, and T. Zimmer. The Particle Computer System. In *IPSN Track on Sensor Platform, Tools and Design Methods for Networked Embedded Systems (SPOTS). Proceedings of the ACM/IEEE Fourth International Conference on Information Processing in Sensor Networks*, Los Angeles, USA, 2005. to appear.

[3] The european smart-its project. Website, accessed: 10/2005. http://www.smart-its.org.

[4] The particle computer company. Website, accessed: 10/2005. http://www.particle-computer.de.

[5] Josh Broch, David A. Maltz, David B. Johnson, Yih-Chun Hu, and Jorjeta Jetcheva. A performance comparison of multi-hop wireless adhoc network routing protocols. In *Mobile Computing and Networking*,pages 85–97, 1998.

[6] Tilak, S., Abu-Ghazaleh, N. B., and Heinzelman, W.A taxonomy of wireless micro-sensor network models.*Mobile Computing and Communications Review*, **9** (2002),28—36.

[7] Intanagonwiwat, C., Estrin, D., Govindan, R., and Heidemann, J.Impact of network density on data aggregation in wireless sensor networks.In *Proceedings of the 22nd International Conference on Distributed Computing Systems* (ICDCS'02), 2002,414—415.

[8] Shah, R. C., and Rabaey, J. M.Energy aware routing for low energy ad-hoc sensor networks.In *Proceedings of the 3rd IEEE Wireless communications and Networking Conference*, Orlando, FL, 2001, 151—165.

[9] Schurgers, C., Tsiatsis, V., Ganeriwal, S., and Srivastava, M.Topology management for sensor networks: Exploiting latency and density.ACM MobiHOC'02, 2002, 135—145.

[10] Megeurdichian, S., Slijepcevic, S., Karayan, V., and Potkonjak, M. Localized algorithms in wireless ad-hoc networks:Location discovery and sensor exposure.MobiHOC, 2001, 106—116.

[11] Bordim, J. L., Nakano, K., and Shen, H.Sorting on a single channel wireless sensor networks.In *Proceedings of the International Symposium on Parallel Architectures and Networks*, 2002, 153—158.

[12] Iyengar, S. S., and Wu, Q.Computational aspects of distributed sensor networks.In *Proceedings of the International Symposium on Parallel Architectures and Networks*, 2002, 23—30.