Maximising Throughput and Lifetime through Effective Sensor Deployment Schemes

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Abstract - WSN are ad-hoc mobile networks in which sensors have limited resources and communication capabilities. These reasons poses lots of technical challenges on sensor deployment scheme because it affect the cost and detection capability. The objective of this paper is to deploy sensors (indoor environment) in sensing field to ensure both sensing coverage and network connectivity with a minimum coverage gap and overlap and to increase the lifetime of sensors by adjusting the deployment layout of nodes through an efficient sensor placement. NS 2.31 is used as a simulation tool. The simulation results shows that the Modified Adaptive Triangular(MATRI) deployment algorithm provides better sensing coverage and network connectivity in terms of throughput and increased lifetime of sensors.

***Key Words* - Sensor deployment, coverage, connectivity, lifetime, MATRI.**

1. INTRODUCTION

Recent advancement in wireless communications and electronics has enabled the development of low-cost sensor networks. The sensor networks can be used for various application areas (e.g., health, military, home). A wireless sensor network (WSN) typically consists of small devices called sensor nodes that are capable of sensing, gathering, storing and transmitting information. An important research problem in WSNs is the coverage problem. As a solution mobile sensor can be used for network coverage improvements. Random deployment is the most practical way in placing the sensor nodes. When the target region is subject to severe change in condition or no a priori knowledge is available, random deployment is often desirable to achieve a relatively satisfactory coverage. Differing from the random deployment scheme, the incremental placement strategy is a centralized, one-at-a-time approach to place the sensors. Each deployed node is responsible for communicating its local information back to the base station for utilization in the next iteration. This implies that each node has to maintain bidirectional communication with the sink. The demerits of this approach are obvious. Since the sensors are deployed one by one, there exists a lot of work in the computation of a new location and thus the deployment time is very long, which can significantly increase the network initialization time. Besides, this algorithm is not scalable and is computationally expensive. In this paper, goal is to maximize the coverage degree of the area by considering the total moving distance of sensors.

2. RELATED WORK

The emerging wireless sensor networks provide an inexpensive and powerful means to monitor the physical environment. Such a network is composed of many tiny low power nodes, each consisting of actuators, sensing devices, a wireless transceiver, and possibly a mobilizer [1]. Deployment algorithms [2] and its merits and demerits are discussed. The movement-assisted deployment [3] deal with moving sensors from an initial unbalanced state to a balanced state. It is not easy to encompass the influence of obstacles and the preferential areas in movement-assisted sensor deployment.

Sensing field is modeled as a grid point [4] and discusses how to place sensors as same grid points to satisfy certain coverage requirements. The sensors are deployed one by one in incremental deployment algorithm [5] there exists a lot of work in the computation of a new location and thus the deployment time is very long, which can significantly increase the network initialization time. Besides, this algorithm is not scalable and is computationally expensive. To provide high coverage within a short deploying time and limited movement [6]. The Virtual Force Algorithm (VFA) [7] divides a sensor network into clusters. Each cluster head is responsible for collecting the location information of the nodes and determining their targets.

In order to maximize coverage area and minimize coverage gaps and overlaps by adjusting the deployment layout of nodes close to equilateral triangulation to be the optimal layout to provide the maximum no-gap coverage [8]. To apply the concept of ideal layout to have the maximum coverage by less number of movements of sensor nodes and smaller movement distance [9]. Two-layered heterogeneous sensor networks where two types of nodes are deployed in the network: basic sensor nodes and cluster head nodes [10]. A cluster head node organizes the basic sensor nodes around it into a cluster. The energy consumption [11] and estimated lifetime based on a clustering mechanism with varying parameters are related to the sensing field.

3. MATRI ALGORITHM

One of the important goals of the algorithm is to maximize the coverage area. To design a maximum coverage algorithm for a given number of nodes type or choice of node layout is our important factor. Figure 3.1 shows the perfect node layout for the maximum no-gap coverage. In order to find the ideal node layout for the maximum coverage, the Delaunay triangulations describe the layout of the network. Let ‘N’ be a set of ‘n’ nodes, which are randomly thrown into the plane, and T be a Delaunay triangulation of N such that no other nodes in N are inside the circumcircle of any triangle in T.

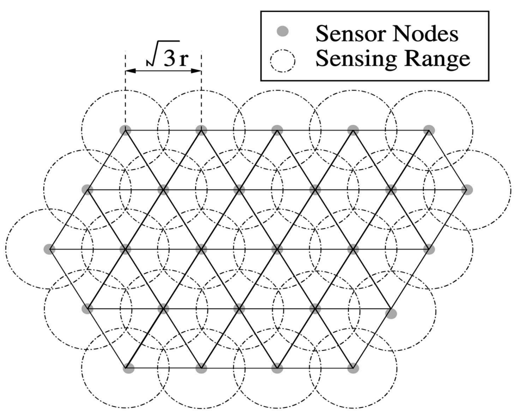

Figure 3.1 The perfect node layout for the maximum no – gap coverage

If all Delaunay triangles are equilateral triangles with edge length $\sqrt{3}$ r, then the coverage area of n nodes is maximum without coverage gap. Since the entire working area can be decomposed into a large number of Delaunay triangles, that the no-gap coverage area in any Delaunay triangle is maximized when the lengths of all of its edges equal $\sqrt{3}$ r, then the maximum coverage area of n nodes can be obtained. The moving strategy in TRI algorithm is that if the horizontal distance between two neighbors is longer than $\sqrt{3}$ r, then the sensors will move toward each other to shorten the gap between them. On the contrary, they will move away from each other to reduce the coverage overlap.

- MATRI algorithm aims to locate all sensors in one cluster.
- Within each cluster, one of the nodes is nominated by cluster head node randomly and will move to the nearest desired location, which is one of the vertices of one of the Delaunay triangles.
- Each node has its neighbor’s information and location information in its neighbor table.
- Sensor compares its current neighbor number to the neighbor number it suppose to have.
- All nodes will be in the same cluster which results in connectivity of the network.

4. RESULTS AND DISCUSSION

Table 4.1 Simulation parameters

PARAMETERS	VALUES
Sensing field	1000m * 1000m
Sensing range	150m
Communication range	250m
Maximum number of nodes used	50
Propagation model	Two ray ground
Energy	0.1 mJ

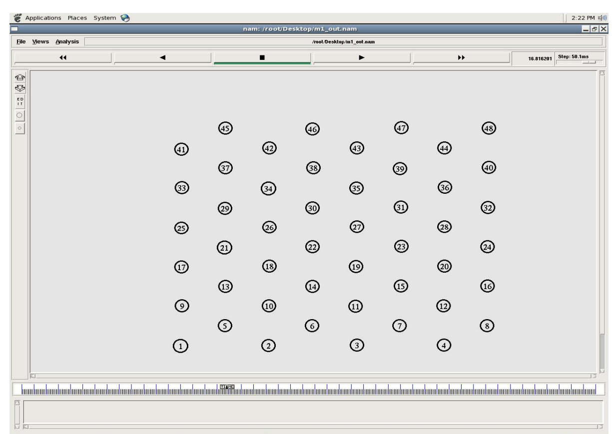

Figure 4.1 Triangular placement model

Figure 4.1 shows the layout of triangular placement model. Sensors are deployed in triangular model due to that minimum coverage gap and overlaps are attained.

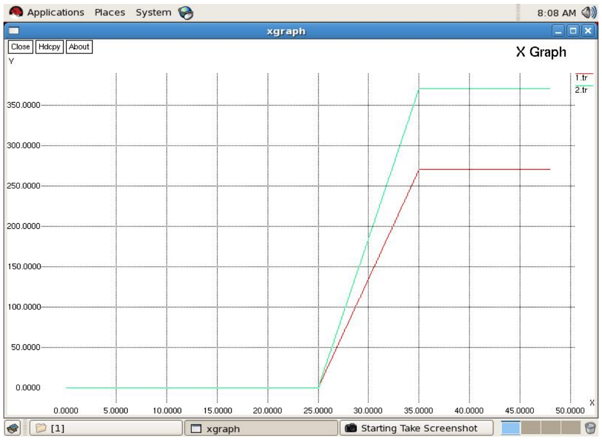

Figure 4.2 Throughput comparison for Adaptive triangular deployment and MATRI with 25% mobile sensor

Figure 4.2 and 4.3 shows the throughput comparison for ATRI and MATRI of 48 nodes with 25% mobile sensors in sensing field. The moving strategy in ATRI algorithm is that if the horizontal distance between two neighbors is longer than $\sqrt{3}$ r, then the sensors will move toward each other to shorten the gap between them. On the contrary, they will move away from each other to reduce the coverage overlap in the presence of obstacles.

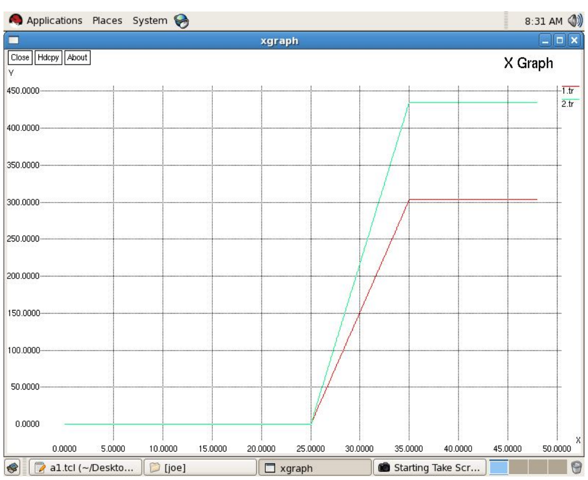

Figure 4.3 Throughput comparison for Adaptive triangular deployment and MATRI with 50% mobile sensor

MATRI algorithm aims to locate all sensors in one cluster. Based on the information in neighbor table, a node will find the cluster. Within each cluster, one of the nodes is nominated by cluster head node. Higher the throughput better is the connectivity in the network The deployment strategy guarantees maximum possible coverage of the network.

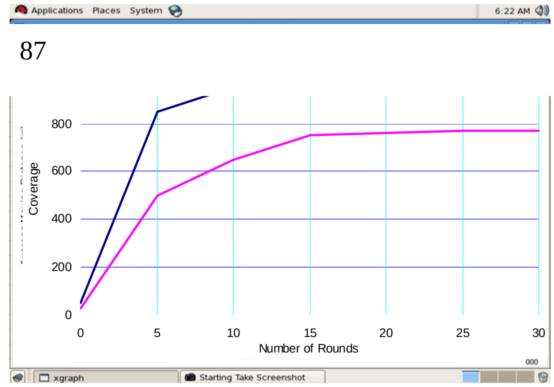

Figure 4.4 Total coverage area versus number of rounds for ATRI and MATRI

Figure 4.4 shows the total coverage area of ATRI and MATRI algorithm. We can see that the total coverage of ATRI algorithm increases before round 20 and then goes smoothly. But by simulating MATRI algorithm, total coverage area increases before round 10.

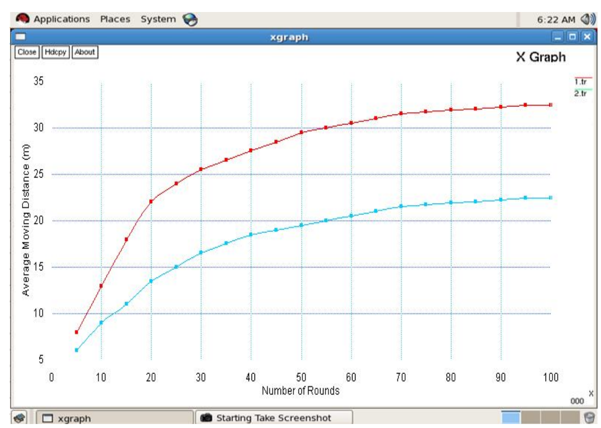

Figure 4.5 Lifetime analysis of ATRI and MATRI

Figure 4.5 shows the average moving distance when the simulation rounds range from 10 to 100. Average moving distance of ATRI will be more compared to MATRI algorithm. MATRI algorithm aims to locate all sensors in one cluster. Due to this fact, the distance moved by the sensor is less. If the moving distance is less, then there will be increased lifetime.

5. CONCLUSION

In this project the sensor deployment problem is overcome by using triangular model. The proposed MATRI algorithm gives better connectivity which is analysed with the throughput simulation result of the network. MATRI provides better sensing coverage and network connectivity with minimum coverage gap and overlap when compared to ATRI. MATRI algorithm aims to locate all sensors in one cluster. Based on the information in neighbor table, a node will find the cluster. Within each cluster, one of the nodes is nominated by cluster head node. The deployment strategy guarantees maximum possible coverage of the network.

Thus this project work concludes that compared to TRI and ATRI, MATRI gives better coverage and connectivity and increased lifetime of sensors.

6. REFERENCES

[1] I.F. Akyildiz, W. Su, Y. Sankarasubramaniam, and E. Cayirci, "A Survey on Sensor Networks", *IEEE Communication Magazine*, Vol. 40, No. 8, pp. 102-114, August 2002.

[2] P. Basu and J. Redi, "Movement Control Algorithms for Realization of Fault-Tolerant Ad Hoc Robot Networks", *IEEE Network,* Vol.18, No.4, pp. 36-44, April 2004.

[3] F. Danilo-Lem J. Wu and S. Yang, "SMART: A Scan-Based Movement-Assisted Sensor Deployment Method in Wireless Sensor Networks", *Proceedings of IEEE Informatics and Communications*, Vol. 6, pp. 2313-2324, March 2005.

[4] K. Chakrabarty, S.S. Iyengar, H. Qi, and E. Cho, "Grid Coverage for Surveillance and Target Location in Distributed Sensor Networks"; *IEEE Transactions on Computers,* Vol. 51, No. 12, pp. 1448-1453, December 2002.

[5] A. Howard, M.J.Matari c, and G.S.Sukhatme, "An Incremental Self-Deployment Algorithm for Mobile Sensor Networks", *Autonomous Robots,* Vol. 13, No. 2, pp. 113-126, September 2002.

[6] G. Wang, G. Cao, and T. La Porta, "Movement-Assisted Sensor Deployment," *Proceedings of IEEE Informatics and communications*, Vol. 8, No. 3 pp. 72-86, March 2004.

[7] Y. Zou and K. Chakrabarty, "Sensor Deployment and Target Localizations Based on Virtual Forces," *Proceedings of IEEE Informatics and communications*, Vol. 12, No. 5, pp. 122-132, March 2003.

[8] Ming Ma, Student Member, IEEE, and Yuanyuan Yang,"Adaptive Triangular Deployment Algorithm for Unattended Mobile Sensor Networks", *IEEE Transactions on Computers,* Vol.56, No. 7, pp. 946-958, July 2007.

[9] S. Poduri and G.S. Sukhatme, "Constrained Coverage for Mobile Sensor Networks," *Proceedings of IEEE International Conference on Robotics and Automation*, Vol. 42, No.5, pp. 165-172, May 2004.

[10] Z. Zhang, M. Ma, and Y. Yang, "Energy-Efficient Multi-Hop Polling in Clusters of Two- Layered Heterogeneous Sensor Networks," *Proceedings of 19th IEEE International Parallel and Distributed Processing Symposium,* April 2005.

[11] E.J. Duarte-Melo, M. Liu, "Analysis of energy consumption and lifetime of heterogeneous sensor networks", *Proceedings of Global Communications system*, May 2002.