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Various Node Deployment Strategies in Wireless Sensor Network

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ABSTRACT

One of the key issues in Wireless Sensor Networks (WSNs) is Node Deployment. Coverage and extension of node life time are some of the important aspects of node deployment. There are different deployment strategies used based on requirements and the environment in which the nodes are placed. In this paper, existing deployment methods are analyzed and discussed, classification is carried out on various deployment methods. Various node deployment strategies are discussed. The placement strategies used in those paper, main metrics used for calculation and the solution given in the previous works are discussed here.

Keywords: node deployment; coverage; energy; connectivity; wireless sensor networks.

1. INTRODUCTION

The nodes used in WSN has the following are deployed based on the following criteria minimum cost, less power consumptions. Sensors are very limited in computation and communication. Sensors monitor changes in the environment, in which they are placed and send the observed data to gateway nodes where the user can access the data. One way of having deployment is a random way when a large number of sensors are scattered over the region that has to be monitored. This type of random scattering are carried out in places where we it is hard to deploy sensors manually, in places such as battle field the nodes might be air dropped. In other cases the nodes can be deployed carefully by some placement technique.

In sensor node once the nodes are deployed they are not taken care thereafter. Nodes stay in remote location, and it is very difficult to replace the batteries of the sensors. If the power source is drains out, the entire network may not work properly. Increasing the lifetime of the sensor are very essential.

To get maximum coverage from a sensor node is one of the biggest challenges. Coverage includes network connectivity; this is also linked with energy consumption on each node.

WSNs can be deployed deterministically or dynamically. Various researches have been carried out on sensor deployment under different performance metrics. A Good node deployment strategy not only cuts of cost of network by reducing the number of nodes, but also increase the life time of nodes in the network.

2. LITERATURE REVIEW

2.1 Static Deployment

In static deployment, once sensor nodes are placed they do not change throughout the lifetime of WSN. The best locations of the nodes are chosen according to the optimization strategy.

Static deployment implements both deterministic node deployment and the random node deployment. In deterministic deployment first the area is surveyed and then network node positioning is carried. In deterministic deployment, the paper [1] proposes a metric to measure the performance, called lifetime per unit cost, this measures the sensors efficiency in every node. A Cost measure unit called, Lifetime per unit is obtained by the network lifetime divided by the number of deployed sensors. The approach in this paper is carried out as follows. First, a greedy method is used to optimize the placement of sensors. Second, a numerical approximation is used to determine the optimal number of sensors.

In [14] focus is on redundant node elimination. It performs a coverage area calculation of each sensor by a distributed calculation. Relative location information, of the nodes are used to get coordinate information.

Paper [15] implements hierarchy level of node deployment. Proper planning is done for node deployment and the nodes are carefully placed. Here a data model is used. This model is based upon the amount of data generated per unit area. This gives us a solution about how much is the minimum number of nodes required given the lifetime of sensor nodes, the initial energy the sensor nodes have and the area they have to cover.

In paper [16] an extensive discussion about various methods of node placement techniques is carried on. It categorizes them in to static and dynamic. It states that optimization in node placement is required to get proper coverage. Node repositioning is done in dynamic deployment technique. This suggests that static is more suitable when cost of the nodes are not an issue and other factors of the deployment are known well in advance.

This states the requirement that multi node repositioning and node placement in 3D model requires further more attention and is identified has an open research area. As most of the deployment is techniques published are considering only 2D region.

We learn that sensors should be placed more uniformly as their sensing range or there is increase in path loss exponent, and when the event arrival rate increases more sensors should be deployed, or their power consumed for sensing is very less. Most of the surveys considered in this paper falls under static deployment.

2.2 Dynamic Deployment

The dynamic deployment the location of sensor nodes may keep changing throughout the lifetime of WSN. To maintain maximum performance the nodes themselves move automatically to a proper location. Initially the nodes may follow Random deployment, and later a lot of deployment algorithms are used for deployment and rearrangement of nodes. Some of the dynamic deployment algorithms are Virtual force algorithm [9], virtual force oriented particles algorithm [10], simulated annealing algorithm [11], swarm optimization algorithm [12] and simulated annealing genetic algorithm [13]. There are various dynamic deployment algorithms, though this survey sticks with just static deployment strategies.

3.NODE DEPLOYMENT STUDY

Paper [1] measures life time per unit cost by the following methods. Utilization efficiency of sensors is measured using the above said unit cost measurement, the lifetime per unit cost η is calculated by dividing the network lifetime L by the number of deployed sensors N.

$$\eta = E[L]/N$$

Deploying a large number N of sensors causes inefficient use of network. Similarly, deploying minimum number N of sensors [2] causes more energy consumption for reporting. Therefore, the number and placement of sensors should be chosen carefully.

This paper [1], introduces a new metric called lifetime per unit cost of a wireless network. This paper reveals that deploying either an extremely large or an extremely small number of sensors is inefficient in terms of lifetime per unit cost. This paper also states, the last sensor must be placed very near as possible to the gateway node, which will to reduce the reporting energy consumption.

In the paper [1], analyzes the lifetime per unit cost of an event-driven WSN, which in organized in linear fashion. This paper with its calculated lifetime per unit cost metrics states that deploying either an quite large or an small number of sensors is inefficient. The number of sensors to be deployed is optimized and maximizes lifetime per unit cost, by the node placement. This also states that the last sensor node should be placed as close as possible to the gateway node in order to reduce the reporting energy consumption. It also states that that the optimal number of deployed sensors increases with the event arrival rate and decreases with the sensing power consumption.

The next step is Optimization of sensor placement is minimization of both the wasted energy and the reporting energy. Greedy algorithm [3] is applied to minimize the reporting energy consumption. This is made on the assumption that energy consumption of every sensor is the same.

In [3], a two-tiered WSN design is used to determine the location of base station by an algorithmic method. This maximizes the node lifetime. The upper and lower bounds of the sensor lifetime are also analytically derived by exploring some intrinsic properties of WSNs. This paper demonstrates the efficiency of topology control as a fundamental process for maximizing network lifetime of WSNs.

In the two-tiered WSN algorithm is discussed in [3], some nodes are designated as specially, which are known as first-tier nodes. The first tier node calls the application node interfaces with the base-station. The minimum enclosing circle found for the application nodes is shown in Figure 1, as redrawn from [5].

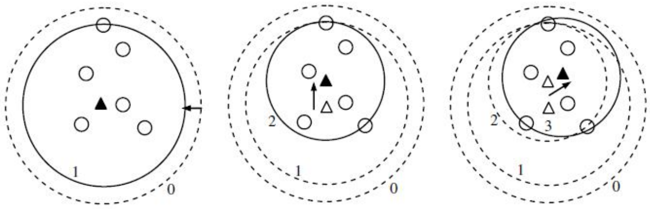

Figure. 1. Finding the minimum enclosing circle for six application nodes [3]. The data-node (black triangle) is placed at the center of the smallest disk that contains all application nodes (small circles).

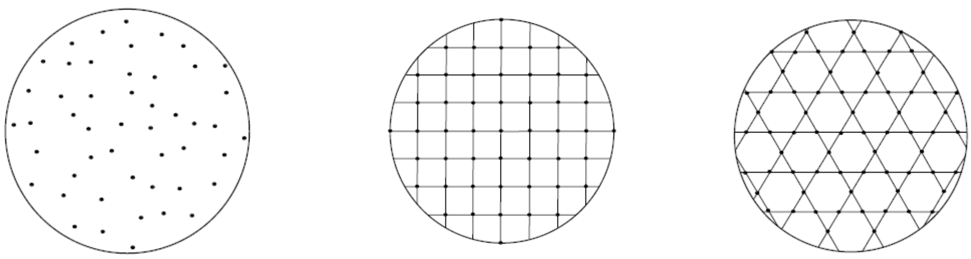

Figure 2(a) Random **Figure 2(b)** Square grid **Figure 2(c)** THT Node deployment

In paper [6] three models of deployments are taken into account: 1. A uniform random Figure 2(a), 2. A square grid Figure 2(b), and 3 A uniform pattern-based Tri-Hexagon Tiling (THT) Figure 2(c) node deployments. In this paper a simple energy model is used to know about the energy consumption for the above three deployment strategies. Area covered by each sensor, energy consumed by each sensor and worst-case delay as metrics.

This paper [6] states that THT is far better node deployment strategy, though it amounts to overhead cost for planning ahead. With the considered metrics for performance, THT performs better than other strategies, when energy consumption and worst-case delay are taken as factors. When area coverage of as sensor is taken as a performance factor, a square grid is observed as a better solution than other two strategies. Though the paper analyzes are based upon certain assumptions. It clearly states that THT is a better deployment method.

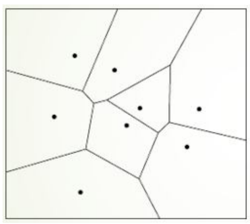

Figure 3 Voronoi Cells

In paper [7] optimizes both sensor placement and transmission structure for data gathering. The assumption made here is the nodes use joint entropy coding made by the communication which is made between sensor nodes. The optimization includes coverage limitations, and placement of nodes with optimized distortion boundary. It looks for optimal placement first in the one-dimensional case, a simple aggregation scheme is derived analytically. These results are extended to the 2-D case also.

Another type of method is discussed in paper [7], node placement is based on formation on voronoi cells Figure 3. The coverage area of sensors is created with voronoi cells. This algorithm states that significant power gains can be obtained with this node placement scheme over commonly used uniformly random placements by which a circular voronoi cells Figure 4 are developed.

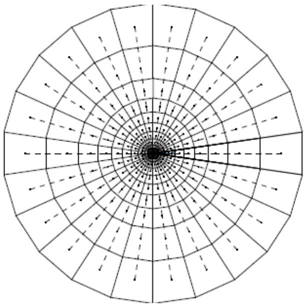

Figure 4. Uniformly placed circular voronoi cells

Paper [8] tries to compute the minimum numbers of sensors with relay the signal, it discusses about the set of sensors in the plane and the in the upper boundary of the transmission range. A balance between performance of the network, lifetime of the sensors, and the cost for designing sensor networks is taken in to consideration to reduce the number of sensors deployed. The problem is modeled by a tree structure called Steiner Minimum Tree with Minimum number of Steiner Points and bounded edge length.

The paper [8] maintains global connectivity of relay sensor in WSNs, with their transmission range is restricted. The numbers of relay sensors are reduced by a network optimization, by constructing Steiner Minimum Tree with Minimum number of Steiner Points.

This paper suggests two approximate algorithms for creating Steiner tree, one with ratio 3 and another with ratio 2.5. For the operation of the algorithm certain number of terminals in a Euclidean plane is given as input. The algorithm produces Steiner tree T which reduces the number of sensor nodes required for a WSN.

First the algorithm constructs a weighted graph. From the weighted graph a minimum spanning tree is constructed by calling a randomized algorithm. In the last step every edge of the minimum spanning tree is replaced with Steiner tree in the maximum length of the edge of the spanning tree is optimum. Thus the algorithm reduces the number of relay nodes deployed, but still maintaining a great degree of connectivity.

The comparison is table of the above discussed paper has been tabulated in the following Table 1

Table 1: An analysis of different node deployment strategies

Paper	Deployment	Tire	Metrics used	Conclusion
[1] Sensor placement for max life time	Linear	Single	Energy consumption	Neither extremely large nor extremely small.
[3] Algorithmically obtained locations	Linear	Two tire	Power and energy	Derived upper and lower boundary increases life time or sensors.
[6] Load deployment in large WSN	Random, Square grid & THT (Tri-Hexagon Tiling)	Two tire	Coverage, Energy consumption, Worst case delay	THT better deployment strategy.
[7] Power-Efficient placement	Circular Voronoi	Two Tire	Distortion	Significant power gains.
[8] Relay Sensor Placement	Minimum spanning tree structure	Single	Minimum nodes	Minimizes number of sensor in the network by using tree structure.

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4.CONCLUSION

Wireless sensor networks have wide application in combat field and various types of environment monitoring. One of the main challenges here is node deployment. We have discussed some types of node deployment technique.

In static approach, node placement is optimized to achieve coverage, and node life time. In dynamic approach nodes are repositioned after initial placement, mainly to improve the performance.

Static methods are comparatively easier, when we know a number of nodes in advance. Dynamic strategies will normally increase the cost and the management overhead.

In this paper we have discussed about node deployment strategy based upon a metric called lifetime per unit cost for a node, which tries to get maximum coverage by reducing the number of nodes. In the two-tier WSN, it tries to reduce the deployment on the number of nodes. In the three deployment strategy study namely random, square and THT, THT emerges to be a better method. In 1-D and 2-D node optimization we see significant power gain. Another technique is to reduce the number of relay sensors by creating a minimum tree known as Steiner Minimum Tree.

This paper provides basic idea of various static deployment techniques. In future work involves a detailed study of dynamic deployment strategies and proposal of new techniques in node deployment.

References

[1]. Y. Chen, C. Chuah, and Q. Zhao, “Sensor Placement For Maximizing Lifetime Per Unit Cost in Wireless Sensor Networks,” Proceedings of the IEEE Military Communication Conference (MILCOM’05), Atlantic City, NJ, October 2005.

[2]. Y.T. Hou, Y. Shi, H.D. Sherali, “On energy provisioning and relay node placement for wireless sensor networks”, IEEE Transactions on Wireless Communications, 2005.

[3]. J. Pan, L. Cai, Y.T. Hou, Y. Shi, S.X. Shen, “Optimal basestation locations in two-tiered wireless sensor networks”, IEEE Transactions on Mobile Computing 4 (5) (2005) 458–473.

[4]. F. Ye, H. Luo, J. Cheng, S. Lu, and L. Zhang, “A Two-Tier Data Dissemination Model for Large Scale Wireless Sensor Networks,” Proc. Seventh ACM Mobicom, pp. 148-159, 2001.

[5]. M. Younis and K. Akkaya, “Strategies and techniques for node placement in wireless sensor networks: A survey”, Ad Hoc Networks 6 (4) (2008) 621–655.

[6]. W. Y. Poe and J. B. Schmitt, “Node Deployment in Large Wireless Sensor Networks: Coverage, Energy Consumption, and Worst-Case Delay”, AINTEC’09, November 18–20, 2009.

[7]. D. Ganesan, R. Cristescu, B. B. Lozano, “PowerEfficient Sensor Placement and Transmission Structure for Data Gathering under Distortion Constraints”, IPSN’04, April 26–27, 2004.

[8]. X. Cheng, D. Du, L. Wang, B. Xu, “Relay Sensor Placement in Wireless Sensor Networks”, ACM/Springer Journal of Wireless Networks, 2008.

[9]. Q. Luo, and Z. M. PAN, “An Algorithm of Deployment in Small-Scale Underwater Wireless Sensor Networks”, Chinese Journal of Sensors and Actuators, Vo. 24, No. 7, 2011, pp. 1043-1047

[10]. X. Wang, S. Wang, and J. J. MA, “Dynamic Sensor Deployment Strategy Based on Virtuai Force-Directed Particle Swarm Optimization in Wireless Sensor Networks”, Acta Electronica Sinica, Vol. 35, No. 11, 2007, pp. 2038-2042.

[11]. F. Y. S. Lin, and P. L. Chiu, “A Near-optimal Sensor Placement Algorithm to Achieve Complete Coverage Discrimination in Sensor Network,”, IEEE Communications Letters, Vol. 9, No. 1, 2005, pp43-45.

[12]. Y. Liu, “Wireless Sensor Network Deployment BasedonGenetic Algorithm and Simulated Annealing Algorithm”, Computer Simulation, Vol. 28, No.5, 2011, pp. 171-174

[13]. W. H. Liao, Y. C. Kao, and Y. S. Li, “A Sensor Deployment Approach Using Glowworm Swarm Optimization Algorithm in Wireless Sensor Networks”, Expert Systems with Applications, Vol. 38, No. 2011, pp. 12180–12188.

[14]. N. Tezcan, W. Wang, “Effective Coverage and Connectivity Preserving in Wireless Sensor Networks”, Wireless Communications and Networking Conference, 2007.WCNC 2007. IEEE.

[15]. X. Liu, P. Mohapatra, “On the Deployment of Wireless Sensor Nodes”, Liu, Xin, and Prasant Mohapatra. "On the deployment of wireless sensor nodes.", Proceedings of the 3rd International Workshop on Measurement,

Modeling, and Performance Analysis of Wireless Sensor Networks, in Conjunction with the 2nd Annual International Conference on Mobile and Ubiquitous Systems. 2005.

[16]. M. Younis, K. Akkaya, "Strategies and Techniques for Node Placement in Wireless Sensor Networks: A Survey", Elsevier, Ad Hoc Networks, Volume 6, Issue 4, June 2008, Pages 621-655.

[17]. Z. Bojkovic, B. Bakmaz, "A Survey on Wireless Sensor Networks Deployment", WSEAS Transactions on Communications 7.12 (2008): 1172-1181.

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