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A Survey on Node Placement Strategies Imtisenla Imchen

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Abstract- The wireless sensors nodes are distributed on fields to communicate with one another to form a network. But there are certain challenges in Wireless Sensor Network (WSN). One among them is deployment of the nodes to meet the optimization of the desired design goal. Proper node placement plays a vital role in proper functioning of WSN. Energy consumption, lifetime, coverage, cost and node failure are some of the parameters that should be maintained for optimized node deployment. To provide the optimized deployment for the sensor nodes, researchers have proposed different deployment strategies. This paper outlines some of the work done by researchers and analyzes the different strategies.
Keywords- Wireless Sensor Network (WSN), Node Deployment, Energy Consumption, Lifetime, Coverage, Node Failure.

I. INTRODUCTION

Sensors [1] [8] [9] are deployed in an area either uniformly, randomly or in hybrid manner (combination of both uniform and random). The deployment choice depends mainly on the type of sensors, purpose and the environment that the sensors are working in. Uniform deployment is placement of nodes in a controlled manner. It is a preferred choice for moderate network and user friendly terrain. These are mainly used for indoor application. Random deployments are placement of nodes in an excited manner where sensors are dropped from a moving vehicle. In harsh environment [13] like battle field or disaster region, random placement of nodes is the only option of deployment. The combination of both the scheme increases the quality of service and network. WSNs have lots of applications like surveillance, security, environment monitoring, health monitoring and target tracking in military and risky environment.

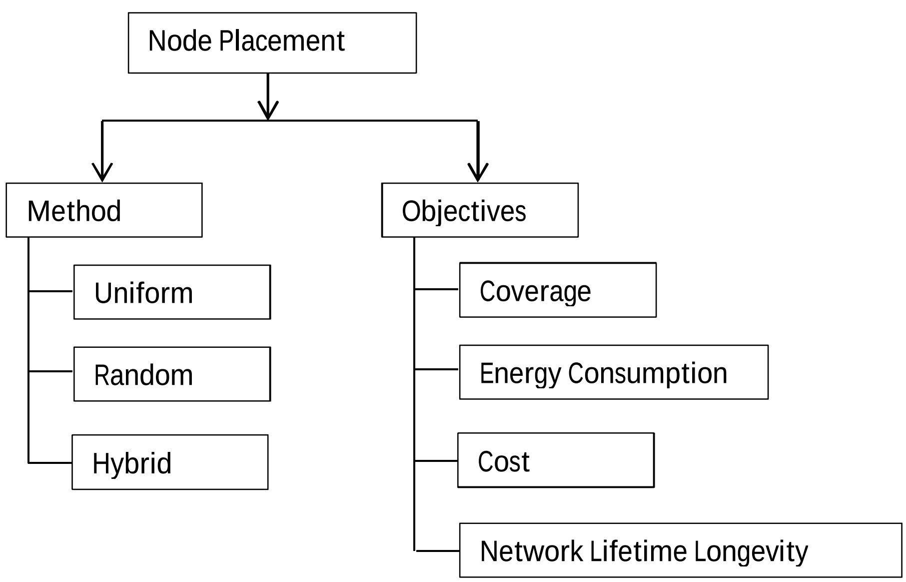

Fig. 1 Different classification of node placement in WSN.

In [15], deployment strategies can also be classified as pre-deployment, post-deployment and re-deployment. Pre-deployment and Post-deployment is improving the quality of service (QoS) during the designing of the network and after the designing of the network. Re-deployment is also a post deployment where additional nodes are added for better QOS. The networking and communication techniques [12] proposed so far for WSN generally follow a best effort service approach. In other words energy consumption, delay, jitters or throughputs are provided. On the other hand, WSN applications specifically require these types of guarantees for efficient delivery of the sensed phenomenon. Moreover, the type of application affects the QoS requirements in the network. Each stream contains information that requires different levels of QoS guarantees. Consequently, the design of WSNs requires the development of algorithms that support application-specific QoS requirements. These requirements may on energy consumption, delay, reliability, distortion, or network lifetime. Since the sensor nodes are expensive and the deployments of these nodes are more expensive, controlled node deployment is very necessary. The minimization of number of nodes with total coverage has been studied and researched by many researchers. The placement of the nodes can highly influence the WSN in terms of coverage, energy consumption, lifetime, cost and node failure.

II. PERFORMANCE REQUIREMENTS

Coverage [6][7][10][11] is one of the important issue in WSN. It has received a great deal of attention from many researchers because of its ability to optimize resources. Sensor nodes gather information from the environment within a certain range. Sensor nodes should be deployed to achieve sufficient coverage and that every point or target should be covered by at least one sensor node. Coverage affects power saving, connectivity, network configuration and number of nodes to be deployed. Under the coverage performance, number of nodes has been minimized by many researchers.

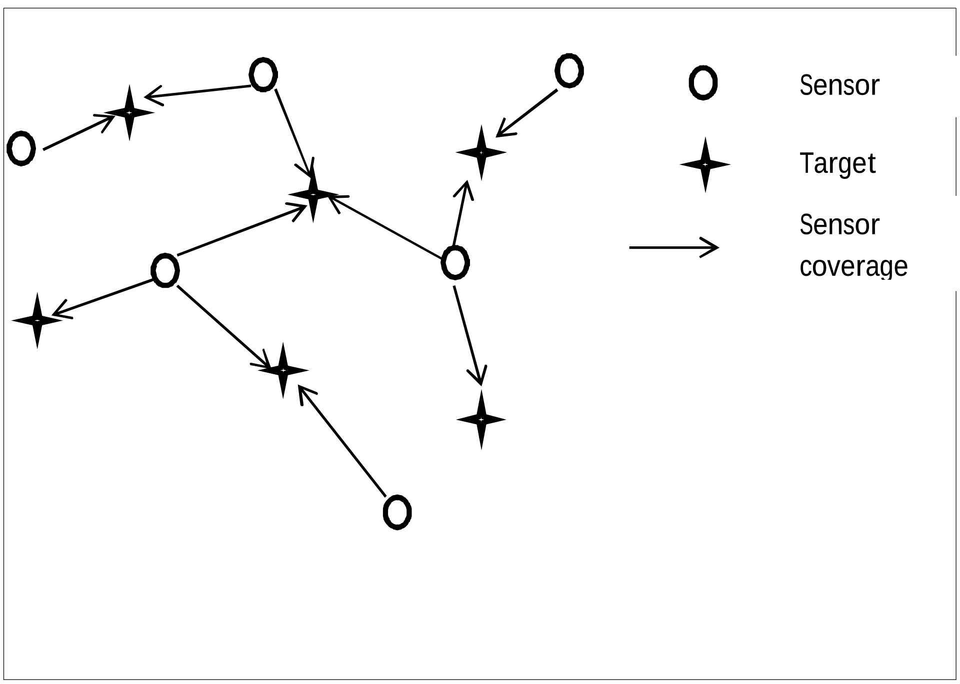

Fig. 2 Coverage plane

Sensor nodes [2] [14] typically rely upon the battery for energy to process data however, its replacement is not possible in most of the deployment. So managing of energy is an important issue to increase the life of each node. Transmission of data generate high amount of traffic, which requires longer transmission time and higher energy consumption. Lifetime of nodes entirely depends on the energy consumption behaviour. Many different methods [12] have been projected by researchers for longevity of the nodes. Some of the methods are to keep the nodes which are not required in sleep mode and keeping only the required nodes in active mode. A certain time limit is assigned for each node to be in sleep mode and when it reaches the threshold limit, it goes to the listen mode to examine if it must be activated. Another method is to adjust the transmission range so that less energy is use for transferring the data to the neighbouring node. If different sensor nodes are sending the same information then the shortest path is used for sending the data for conserving the energy. There is a cost [1] [4] for deployment of each node: fixed and variable. Fixed cost refers to the cost of the node which depends on the number of nodes and variable cost is the cost of deploying the sensors. Variable cost may vary according to different deployment points, distance between the current position of nodes to the destination, roughness of terrains, slope, energy consumption etc.

III. PLACEMENT TECHNIQUES FOR DIFFERENT OBJECTIVES

P. Pace and V. Loscri [2] compared two placement techniques, evenly/uniform placement and energy spaced placement of nodes for wireless nodes. Its main objective is energy consumption reduction. In evenly/uniform placement, the relay nodes are placed in the evenly spaced position on a straight path from the source to the destination nodes. All the nodes have the same residual energy for this technique. In energy spaced placement, residual energy is taken into account where the positions of the nodes are placed incrementally from the position of all previous nodes. The energy consumption is high in case of evenly placed and its lifetime is much shorter than the energy spaced but its video quality is good. Whereas for energy spaced placement, the energy consumption and its lifetime is high.

W. Y. Poe and J. B. Schmitt [3] uses three deployment plan: Uniform random, square grid and a pattern based Tri-Hexagon Tiling (THT) node deployment. The challenges taken by them are coverage, energy consumption and delay reduction. In uniform random deployment, all the sensors have a same probability of being deployed at any place in a deployment area. In square grid, nodes are deployed in a square grid uniformly. In a square cell, half of the area is covered exactly by 3 node coverage sensors since it is a symmetric cell. In THT node deployment, nodes are placed in a semi-regular tiling which uses triangle and hexagon cell. Here a small area is covered by all the 6 nodes in hexagon cell which is the best area for placing the sink because all the nodes will share the same load and hence energy consumption will be less. Energy consumption and delay rate is the lowest in THT deployment plan. In random deployment all the areas are not covered because of its random placement whereas all the areas are covered quite well in square grid and THT node deployment.

S. Al-Omari and W. Shi [4] considered a problem of choosing how many nodes to use and where to deploy them for proper coverage and connectivity with minimum cost. The authors proposed three strategies one of which is at-front. This strategy does not plan for further deployment visits and only studies the unfriendly environment and the WSN lifetime to calculate the number of nodes required. At first it has ample amount of nodes for meeting the user-defined availability but later on it shows a weak scalability as the WSN lifetime and node failure rate increases. The next is on demand strategy which does not conduct any planning for node placement but have a deployment visits when number of node become lesser than the threshold number of nodes. Then the third is pro-active strategy which considers the node failure and the cost ratios. In all the strategies the authors assumes that the nodes that have previously been deployed and the nodes that have deployed recently has the same probability of failure rate. The pro-active deployment strategy shows better cost result compared to at-front and on-demand strategies when the failure rate increases. The at-front strategy shows the worst strategy for cost minimization and scalability for the node failure. Moreover pro-active can adapt to any number of nodes and number of trips and achieve a total low cost.

X. Wang and S. Wang [5] mainly focus on the coverage and energy consumption of nodes. The authors use different virtual force directed co-evolutionary particle swarm optimization (VFCPSO) method to satisfy the requirements. Four different VFCPSO used were centralized VFCPSO (C-VFCPSO), distributed VFCPSO (D- VFCPSO), heterogeneous hierarchical VFCPSO (Hetero-H-VFCPSO) and homogeneous hierarchical VFCPSO (Homo-H- VFCPSO). In centralized VFCPSO, virtual repulsive force between sensor nodes and PSO methods are used for deployment of nodes. In PSO, each node renews its result with only the global best result and its local result. This technique increases the coverage and lifetime of nodes but leads to high computation time. In D-VFCPSO, PSO is used and it constantly updates it position optimally but it can lead to high energy consumption and decrease quality of service because of the data exchanges between the nodes which occurs very frequently. In both Hetero-H-VFCPSO and Homo-H- VFCPSO, deployment plane are divided into different clusters where each clusters contains a cluster head with many sensor nodes. Hetero-H-VFCPSO contains C-VFCPSO in its cluster whereas Homo-H- VFCPSO has D-VFCPSO. Homo-H-VFCPSO is built in many different hierarchical structures which has good scalability and is able to search globally. All the techniques decrease the energy consumption. Homo-H-VFCPSO performs the best among the four techniques for coverage. The computation time of D-VFCPSO is the least and the cumulative time of C-VFCPSO is the least among all. But when average of all time computed is taken the Homo-H- VFCPSO performs comparatively better among all.

IV. COMPARISON OF DIFFERENT PLACEMENT TECHNIQUES

Table 1 COMPARISON BETWEEN DIFFERENT PLACEMENT TECHNIQUES

Author Paper	Objectives	Techniques	Energy Consumption	Video Quality	Coverage	Computation Time	Cost
P. Pace and V. Loscri [2]	Reduction of Energy Consumption	Evenly/Uniformly	High	Good	---	---	---
		Energy Spaced	Low	Average	---	---	---
W. Y. Poe and J. B. Schmitt [3]	Coverage, Reducing Energy Consumption, Reducing Computation Time	Uniform Random	High	---	Not all areas are covered	Medium	---
		Square Grid	Medium	---	Good	High	---
		THT	Low	---	Good	Low	---
S. Al-Omari and W. Shi [4]	Coverage, Optimizing Cost	At-front	---	---	Good	---	High
		On-demand	---	---	Good	---	Average
		Pro-active	---	---	Good	---	Low
X. Wang and S. Wang [5]	Coverage, Reducing Energy Consumption	C-VFCPSO	Low	---	Good	High	----
		D-VFCPSO	Low	---	Poor	Medium	---
		Hetero-H-VFCPSO	Low	---	Good	Medium	---
		Homo-H-VFCPSO	Low	---	Best among 4 VFCPSO	Low	---

V. CONCLUSION

This paper summarizes and analyzes the Placement of nodes based on different strategies. All the deployment depends on the objective of placement, type of sensor and the type of environment. The different techniques used and proposed by the researchers can optimize various parameters like coverage, energy consumption and cost etc. Each one of the techniques discussed has some advantage and disadvantage as shown in Table 1. There are still many challenges that need to work on placement of nodes.

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