A Survey on Different Deployment schemes of sensor nodes in WSNs

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Abstract: *In years we all have noticed the arrival of (WSNs) i.e. wireless sensor networks as a latest information-collecting model, in which huge number of sensors distribute over the network area and pull out data of interests by evaluating real-world phenomena from the physical location. One of the leading issues in the field of wireless sensor networks (WSN) is Localization. To route data from source to destination is the challenging tasks in wireless sensor network. From the sensor network area Sensors assemble data and surpass the assembled data to the base station. Lots of deployment methods are here by which one can improve both localization accuracy and localization success rates. The WSN operation is categorized as dynamic, static and energy aware node assignment. Different deployment algorithms of static, dynamic and energy aware protocols are studied in this paper.*

Keywords: *WSN, Localization of WSN Nodes, Node Deployment.*

I. Introduction

WIRELESS sensor network (WSN) is a particular class of mobile network [2] composed of hundreds or even thousands of self-sufficient and dense devices, which are called sensor nodes. The nodes can perform sensing, processing, and wireless communication tasks. In a typical WSN application, the source nodes collect data from an event and disseminate them toward the sink node using multi hop communication. One of the important problems of any sensor node design is the deployment of the sensor nodes in the area to be monitored. Sensor nodes usually have limited power storage along with processing and communication capabilities. Monitoring of the field may be based on uniform event recognition or differentiated event recognition, where the probability of appearance of the event in the areas concerned varies both geographically and temporally. Finally, it is important to maintain connectivity among the nodes so that the data collected by any individual sensor node can flow through other nodes to the sink node. Deployment of the sensor nodes taking all such objectives together is a very challenging problem.

II. Localization of WSN Nodes

Depending on the target applications [3], earlier studies in WSNs generally focus on either outdoor large-scale environments, where planned sensor deployment is difficult, or indoor small-scale monitoring zones, where sensor deployment mechanism is feasible and beneficial. For large-scale WSNs, several works have been proposed to address the energy conservation issue. For the monitoring environments where planned sensor deployment is possible, various static deployment strategies have been introduced to enhance the surveillance coverage. However, such static deployment involves manual sensor placement/installation, and is incapable of dynamically repairing sensing voids (uncovered areas) in the presence of unexpected sensor failures. Consequently, a number of research efforts have explored the movement-assisted sensor deployment techniques by utilizing mobile sensors to enhance the sensing coverage after an initial random placement of sensors. Those deployment techniques all consider homogeneous sensors (having equal sensing/detection radius). With the motion facilities equipped at the sensing devices, sensors can move around to deploy themselves.

Coverage [10] is one of the key research areas in wireless sensor network which refers to monitoring of a set of targets by sensor nodes. Two types of coverage exist in literature Area Coverage and Point Coverage. In area coverage, a given area is monitored by a set of sensors over a geographical area. In case of point coverage, a set of points is monitored by sensors in a geographical region. Normally the sensing range of a sensor is modeled as a disk in the 2D space or as a sphere in the 3D space, with the sensor located in the center. A sensor is able to keep track of all targets that are within its sensing range. The deployment of minimum number of sensors play a vital role in maximizing the coverage area thereby increasing the efficiency of the WSN. In this paper, we present the node deployment scheme of triangular deployment, grid deployment, hexagonal deployment, pentagon deployment and octagon type of node deployment with coverage maximization.
This paper is organized as follows: in section 2 we present the research already reported in literature, in section 3 we address various types of deployments of sensors in 2D and also find the coverage prediction for each of them along with the number of sensor nodes required for each type of deployment. The results are explained in section 4 and we conclude in section 5.

Schemes of Node Deployment [6]: The process of deployment of sensor nodes in WSN is processed out in three main schemes. They are,

I. Static Node Deployment
II. Dynamic Node Deployment
III. Energy aware node placement

In static node deployment, the sensor nodes are fixed in the particular area, because of which the perfonnance reduces. But in case of dynamic node deployment the sensor nodes are mobile and hence the performance is increased. In energy aware node deployment each sensor node is provided with the energy and is utilized for the collecting and transferring the data. It also explains the rate of energy consumption by the nodes for the transmission of data.

A. Primary objective of the node deployment

Application developers mainly appreciate the sensors to get deployed in a manner that aligns to the overall design objectives. Hence, most of the proposed node deployment strategies in the literature have concentrated on maximizing the coverage area, optimizing the energy consumption, achieving the strong network connection, extending the lifetime of the network and/or increasing data fidelity.

B. Static Node Deployment

The static node deployment goes with the best location considering the optimization energy and the location of nodes does not change in the lifetime of WSN. Here, after the sensors' placing, there is no further movement in the network. Static sensors do not have the ability to get changed with their location.
1) Static node deployment based on deployment strategies.
In WSN, the sensor nodes are generally deployed in a selected area either randomly or deterministically (Controlled). The deployment of the nodes not only impact on the coverage of area but also affects the network topology properties. The controlled type of node deployment is required when the sensors are more costly or when the procedure of the sensors is ideally affected by their deployed area. This deployment methodology achieves the required performance goals depending on the sensor node distribution and level of the redundancy. By considering the fault tolerance as one of the parameters for performance measurement, it is concluded that the R-random deployment has a better placement strategy. The main reason for this is the deployment of more nodes near to the base station as they tend to transmit a lot of traffic and thus exhaust their energy (battery) rather quickly. Hence the maximized sensors population towards the base station safeguards the availability of spares for replacing the faulty relay nodes (RN) and hence results in the network connectivity.
2) Static node deployment based on optimization objective.
In WSN, the sensors have to be deployed in a way that desires with the complete design goals. Hence, most of the deployment methodologies in literature have concentrated on maximizing the coverage, gaining strong network connectivity, increasing the network lifetime and/or achieving the data fidelity. The secondary objectives viz, tolerance of node failure and load balancing has also been considered. An attempt is made to maximize the design goals making use of the minimum amount of resources, e.g., number of sensor nodes. Achieving the design goals through random sensor node distribution is a highest challenge.
Meanwhile detenninistic deployment theoretically achieves all primary and secondary goals; but the required network resources keep the problem very hard.

C. Static Node deployment Algorithms

The algorithms for static node deployment are Artificial Bee Colony algorithm (ABC) algorithm and Bio-geography Based Optimization algorithm (BBO). These algorithms can also be applied for dynamic node deployment.

The following section explains the ABC and BBO algorithm applied for static deployment.
1) Artificial Bee Colony Algorithm: The ABC algorithm is one among the new approach for the study of both static and dynamic node deployment problem in WSN. This algorithm was introduced by considering the foraging actions of honeybee swans. The coverage rate of ABC algorithm is compared with other dynamic deployments algorithms and has come up with good result (99.34% for 10,000 iterations) . The network coverage rate or the total area of coverage of sensors resembles to the fitness value (nectar) of the solution.

2) Bio-geography Based Optimization algorithm (BBO): In the beginning of node deployment, an effective or good coverage rate of the nodes cannot be reached, because of the randomness of the nodes. This BBO algorithm works in combination of both static and dynamic sensor nodes. The BBO algorithm is encouraged by the migration species between islands (or habitats) in search of more compatible islands.

D. Dynamic Node Deployment Algorithms

Finding the positions of the sensor nodes is an important notion of deployment, which in tum depends on the area coverage. In dynamic node deployment type, the sensor nodes are initially positioned in the randomly selected areas.
The deployment decision is taken in the beginning of network setup and it does not depend on dynamic changes during the functionality of network. The different dynamic node deployment algorithms are explained in the following sub-sections.

1) Virtual Force based algorithm (VFA): It is one of the popular approaches for node deployment. In this type of the algorithm the obstacles, sensor nodes and the coverage areas are recognized as main perceptions for attractive or repulsive force among the nodes. VF A comes across three assumptions. First, a single node should have the ability to acquire relative position of other nodes within its communication range. Second, all the remaining nodes will move according to the calculated results of the algorithm effectively. And third, all the nodes are similar with Omni-directional sensors, which means that for each node, the sensing range is equal for all nodes and the sensing areas they sensed are circles with node at its midpoint, and hence results in the communication range. AVF A algorithm [5], is designed in which each node Si is related to three kinds of

forces: a) repulsive force Fir, exerted by obstacles, b) attractive force c) attractive or repulsive force, by another node Sj, depending on its distance and orientation from Si. The net force on a sensor Si is the vector sum of all the above three forces.

2) Van Deer Waal's Force based algorithm: The Van Deer Waal's force is the summation both of repulsive and attractive forces between the particles other than those due to covalent bonds or to the electrostatic interaction of ions with one another or with neutral particles [8]. The Van Deer Waal's force (Magnitude of attractive force) can be modeled as below [4], A B F(d) = da - db (2) here d is the remoteness between the neighboring sensor nodes and a>b where ,fI' is attractive force and ,p' is repulsive force [4].

E. Virtual Force directed Co-evolutionary Particle Swarm Optimization (VF-CPSO) algorithm.

This VF-CPSO algorithm is the combination of Virtual Force Algorithm (VFA) and Co-evolutionary Particle Swann Optimization (VF-CPSO) algorithm. CPSO algorithm makes use of number of swarms and minimizes the different modules of solution vectors for dynamic deployment supportively.

F. PSO and PPSO algorithms.

The working of the PSO algorithm includes the swarm (considered as a population) of candidate solutions (also called as components). The components are moved in an area in search of area according to simple mathematical equations. The movement of particle is controlled by the best-known location in the search-space and also the entire swarm's best-known location. As better locations are being exposed, these will then be used to control the movements of the swarm. This procedure is frequently repeated and by doing so it is expected, but not guaranteed, that a satisfactory solution will ultimately be discovered.

G. Energy aware node placement in WSN.

Nowadays the major difficulty for the node deployment is energy consumption and exploitation of WSN technology.

The factors such as MAC design with energy efficient, topology management and error control strategies could affect the lifetime of WSN. An energy-efficient scheme objects at optimizing consumption rate of energy from the sensor node level in a WSN. In the beginning the distance between receiver and transmitter is calculated with the available data t Transmission so as to minimize the communication energy consumption of the sensor node, and then, the minimum communication energy needed to transfer the data is calculated. The nodes are then set to the sleep mode between two consecutive measurements for energy saving in normal operating conditions.

1) Bio-geography Based Optimization algorithm (BBO)

SEAD protocol is mainly applicable for sink nodes in WSN and is called as a distributed self-organizing protocol. The sink node is also called as relay node and is an external network but is directly connected to WSN. These nodes are considered as moving nodes. They control the sensor nodes. SEAD protocol saves the energy both in constructing and maintaining the Dissemination-tress (D-tree). Hence this protocol is mainly used for saving the communication energy. It balances the endwise delay and energy consumption. SEAD is developed for least cost entry to the tree for the sink using unicast. Simulations results concluded that SEAD accordingly conserves the battery energy of the sensor node powerfully while delivering data without intermission to mobile sinks. The distance between the nodes and data transmission rate is considered by the SEAD protocol.

2) CODE (Coordination based data Dissemination) Protocol

CODE is developed on the basis of network structure and synchronization protocol GAF to deliver an energy efficient data broadcasting path to dynamic sinks for synchronizing sensor networks. It is mainly adopted for dynamic sink nodes. The density of nodes does not affect the communication overhead of CODE. It is also compared with other protocols like TTDD and SODD for communication overhead and is projected that it is less in CODE because only the coordinators will come into the picture of sending and receiving of data. But in other protocols such as, TTDD and SODD, all N-nodes will interact in the data transmission process. CODE has three major phases; data dissemination, data announcement and query transfer.

3) TTDD (Two-Tier Data Dissemination) protocol

This approach provides the efficient and scalable data delivery to numerous and dynamic (mobile) sink nodes. This protocol also uses network structure, so that the sensors situated at network points prerequisite to acquire the advancing information. The data transmission is based on the virtual grid infrastructure and query flooding method to gain scalability and efficiency. The effect of sink node's speed increases the TTDD performance. As the sink node moves faster, the rate of energy depletion and connection defeat ratio also increases.

4) DD (Directed Diffusion) protocol

In Directed diffusion, all the sensor nodes are application aware. This results in diffusion to attain energy saving with the selection of empirically better path and by processing the data in the network. This protocol also works on the data centric naming approach to activate the data or packet aggregation. The DD protocol follows several paths till it reaches the best path for flooding the data over the entire network. Directed Diffusion consists of several elements such as, data messages, interests, reinforcements and gradients. Data is collected information; an interest IS a message, which specifies the user needs.

5) ADMR (Adaptive Demand Driven Multicast routing) protocol

This protocol is also called as on-demand protocol as it does not maintain the path information frequently. Fellow nodes in ADMR protocol does not direct explicit leave messages. Here the group fellowship and multicast routes are recognized and rationalized by the source node on demand. The processing tree includes sources, receivers and processing nodes which are not receivers for the related group. The main task of this processing tree is to direct the packets along the defined path from group G to sender S and each sensor node of the tree directs each data packet at most once. There is no coincidental of the occurrence of duplicate packets as this tree maintains the routing tables.

III. Literature Survey

In paper [1] author proposed a sensor deployment scheme for k, covered and k, connected network. There is no bound on the relationship between the communication distance and the sensing distance of the sensors, so this can be viewed as a generalized solution. They have also considered multilevel connectivity and multilevel coverage. In that work they assume a binary sensing model and take the sensing and communication ranges of the sensors to be circular in shape. As future work their work can be extended to probabilistic sensing model and also for sensing and communication regions of irregular shape. Energy saving protocols to increase the lifetime of sensor networks can also be implemented on the deployment scheme proposed in their paper and the utility of this scheme for lifetime enhancement can also be investigated.

This paper [2] has addressed the density control scheme for sleep scheduling of a densely deployed sensor network to maximize the coverage and minimize energy consumption for maximizing the network lifetime. This paper is the first of its kind to incorporate differentiated coverage with sleep-scheduling methods in a multi objective optimization framework. The idea of differentiated coverage is very interesting from a practical point of view as it reduces wastage of energy by reducing the level of sensing in the regions of less interest. Every time a node failure occurs, the multi objective algorithm is called to rearrange the network to have maximum coverage and minimum energy consumption. This sleep-scheduling density control method helps in maintaining required coverage but produces very high network lifetime than traditional deployment schemes. Simulation results clearly indicate that MOEA/DFD out performs MOEA/D, NSGAII, and CPLEX in all those measures. In context to this application, evolutionary algorithms have fared better than mathematical optimizers like CPLEX.

In this paper [3], author proposed an enhanced sensor deployment protocol, entitled EVFA-B, with the objective of providing sufficient surveillance coverage for smart indoor environments. In the development of EVFA-B, distance threshold settings and weight constants (associated with attractive/repulsive forces) have been judiciously designed to effectively increase the sensing coverage ratio. Performance results showed that EVFA-B outperformed other virtual forces algorithms due to its better parameter choices and the incorporation of virtual boundary forces. Furthermore, an automated monitoring network (MoNet) powered by our EVFA-B deployment mechanism was implemented as a proof-of-concept prototype to corroborate the protocol feasibility.

On analyzing the simulation result [4] it is concluded that in the perspective of energy model, mica mote with ASK modulation is more efficient than BPSK and O-QPSK modulation with mica mote and mica z in transmit and receive mode. While mica z consumes less energy in idle mode with BPSK modulation. As in WSN, nodes are operate in four mode i.e. transmit, receive, idle and sleep mode. So comparatively in these four mode mica z energy model consumes less energy than mica mote energy model with ASK modulation. In the perspective of QoS, ASK modulation provide better QoS among three modulation at 868 MHz frequency. As ASK provide high throughput, low delay, and low jitter than BPSK and O-QPSK modulation. At last one more point concluded from above analysis that is BPSK modulation has less fraction of error in received signal but their QoS is worst among ASK and O-QPSK modulation.

WSNs are comprised [5] of resource-constrained nodes. One of the scarce resources of nodes is energy that needs to be preserved so that network lifetime is optimized. In this paper, they have analyzed the problem of network lifetime optimization by balancing energy consumption at different CHs in a clustered WSN. Analysis revealed that the number of clusters and the number of MNs associated with each cluster have significant roles in the optimization of network lifetime by avoiding the energy hole problem. Considering the results of this analysis, we have developed a routing-aware optimal clustering strategy. Our routing-aware optimal clustering strategy considered the deployment of both CH and MN at some predetermined locations. To deploy both CH and MN at some predetermined locations, we have identified Archimedes' spiral, based on which a deployment function is proposed for distributing MN and CH. Simulation results prove that our scheme achieves the design goal by prolonging network lifetime without compromising the network performance metrics such as end-to-end delay and throughput. The results also show the dominance of our scheme over other competing schemes [5-6] with respect to both set of parameters including parameters for achieving design goal and standard network performance metrics. As a future extension of our work, the clustering strategy may be made more realistic by considering a three-dimensional environment.

WSNs are [6] mainly designed for specific applications. Each application varies in characteristics and requirements. For the diversity of applications, the WSN had to endure for deployment of nodes with the growth of algorithms and protocols. This paper has surveyed and compared different schemes of node deployment. The analysis shows that ABC algorithm which is implemented for both static and dynamic node deployment provides a better performance for parameters such as number of nodes, coverage rate, standard deviation, energy consumption and computation time. This survey has shown the results of coverage rate as 98.83minlrun (164s) for 10000 iterations and standard deviation as 0.0891. It also compares the results of other algorithms of static and dynamic node deployment.
The SEAD protocol, which is an energy aware node deployment protocol is compared with other protocols such as DD, ADMR and TTDD and is found that SEAD consumes mlmmum energy. Future work in this area entails the survey of other deployment algorithms such as BBO, CPSO.

This work [7] presents a node deployment approach that takes the shape of a given farmland and calculates an optimal number of nodes. A deployment scheme is proposed with the minimum number of sensor nodes to form a sensor network. The proposed system was evaluated based on different performance metrics. A routing protocol PEGASIS was also selected because it has a better network lifetime than LEACH. Based on the evaluation results, it can be concluded that the proposed node deployment strategy (i.e., scheme) is a better option for precision agriculture in Wireless Sensor Networks (WSNs). The scheme can be used for any shape of the monitored farm area. In addition to precision agriculture, our approach can also be used for other applications of a similar nature such as large scale environmental monitoring. In our future work, we are planning to extend the scheme to address heterogeneous sensor nodes and three-dimensional area. Other deployment strategies like hexagon, square, etc. will also be assessed.

In this paper [8] the nodes of event driven sensor network are placed at optimum inter node distances such that very less residual energy remains on each sensor node after the lifetime of network and further if any node has some finite energy then the sensor node starts working on single hop mode and hence further the lifetime of some sub-regions are extended for some finite period. For the performed experiment the variance in energy consumption and residual energy in the sensor nodes in multi hop and single hop mode is negligibly small and can be neglected.

In a corona-based WSN [9], CHs closer to the sink are loaded more than those farther from it. To overcome this situation, we propose END-BE, which adjusts the initial energy of sensor nodes in the outermost corona. Based on the analysis, we can calculate how many sensor nodes should be deployed into each corona, so that each cluster can use up its energy at approximately the same time. We also propose END-MLT, which further lengthens the network lifetime by arranging appropriate sensor nodes (with "k D 1) in the outermost corona with the goal of balancing the energy consumption in coronas C1 to Ck1. Simulation results show that energy consumption is nearly balanced by implementing END-BE, and the network lifetime is greatly improved by adopting END-MLT. As to future work, we will investigate the energy-balanced node deployment scheme for other models, such as areas with irregular shapes and situations where the sink is located at different places. In addition, what is the best value of "k? The parameter can be further investigated as well.

We have [10] described the different types of sensor node deployment schemes for wireless sensor networks that help us to understand the coverage prediction in each case. Deployment remains one of the most researched topic on the maximization of coverage in wireless sensor networks. We describe the triangle, square, hexagon, pentagon, and octagon type of node placement and give a comparative review of the various node deployment schemes with the coverage prediction and the number of sensors to be used in each case. We find that octagon node deployment scheme has the highest coverage prediction and triangle and hexagon have the least. With the given node placement in the deployment schemes, we find that the triangle and the hexagon node deployment schemes return the same coverage prediction and the number of sensor nodes used. Also although the octagon deployment has the best coverage prediction but it also uses the maximum number of sensors while the hexagon and the triangle use the least number of sensors along with the lowest coverage prediction. Therefore most practical deployment scheme is the square deployment which uses an average number of sensors for average coverage prediction.

In this paper [11], authors consider partitioned MSNs and investigate the relationship between the node deployment schemes and the connectivity restoration cost. To simulate large-scale node failures in MSNs, we have presented three different node deployment schemes, namely SDkM, SDkM-F, and MD. SDkM populates a single connected component and then applies k-means clustering algorithm to designate partitions. Unlike SDkM, SDkM-F simulates repulsive force on nodes like magnets of opposite orientation. Application of the repulsive force enables forming topologies with nodes distributed uniformly.MD, on the other hand, deploys multiple connected components in an iterative manner. MD ensures that each connected component is deployed apart from each other with a minimum distance based on the defined damage scale. To restore connectivity, we have employed a centralized heuristic and evaluated the cost of recovery in terms of total travel distance and the number of relocated nodes. We have observed that the recovery cost pattern is closely related with the employed deployment algorithm. Therefore, novel recovery solutions must be evaluated according to the considered deployment scheme.

Aerial scattering [13] of SNs has emerged as a practical solution to large scale deployment problem. Such types of schemes are time efficient and can be used to achieve blanket coverage over the large region. But their stochastic nature desist them from achieving the optimal coverage. In this article a uniform distribution scheme for aerially dropped SNs has been proposed. It is an enhancement on the (Centrifugal Cannon based Sprinkler) CCS, which is a basic scheme for stochastic scatting of SNs in large scale regions. The main focus of this work is to increase the coverage achieved by the CCS with optimal number of SNs. This model uses the parachutes with different dimensions to float the SNs with different floating angles in order to reach their destined locations. The simulation results shows that the proposed scheme achieves better coverage than CCS.

IV. Conclusions

One of the main issues in WSNs is Localization. In NLOS which means the non-line of sight which is a type of environments a signal which is used to determine the distance between nodes, because of the obstacles between the anchor nodes and other nodes, cannot pass through a straight path. And localization error is increases because of this difficulty. Localization method based AOA measurement has excellent performance in localization in the NLOS conditions. To increase the coverage achieved by the CCS with optimal number of SNs this model uses the parachutes with different dimensions to float the SNs with different floating angles. An optimal policy for scheduling generates by Markov Decision Process model. The analysis results gives that ABC algorithm for parameters such as number of nodes, coverage rate, standard deviation, energy consumption and computation time which is implemented for both static and dynamic node deployment gives a better performance.

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