International Journal of Application or Innovation in Engineering & Management (IJAIEM)
Web Site: www.ijaiem.org Email: editor@ijaiem.org
Volume 6, Issue 5, May 2017 **ISSN 2319 - 4847**

Energy Efficient Node Deployment Scheme in Wireless Sensor Network

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ABSTRACT

Wireless Sensor Networks are receiving significant attention due to their potential applications ranging from surveillance to tracking domains. Sensor Nodes closer to the sink node forward more packets than the SNs at the periphery of network is called funneling effect. The number of Sensor nodes, Relay nodes and their locations has significant influence on optimization of network lifetime. Optimal deployment of sensor nodes is a major point of concern as performance and lifetime of any Wireless Sensor Network. Proposed system considers node deployment in a 3D environment, in this system we can deploy minimum number of sensor nodes to cover maximum area that results in optimization of network lifetime. Hexagonal grid is used to deploy sensor nodes at 3D locations. It explore every sensor node sends its data to the relay node having maximum energy and then it is send to the nearest sink node of the WSN. This system gives advantages over the existing system that consider node deployment in 2D environment.

Keywords: 3D Node Deployment, Energy Hole Problem, Sink node, Regular Hexagonal Cells, Wireless Sensor Network.

1 INTRODUCTION

Wireless Sensor Networks (WSNs) collect data from the physical world and communicate it with the virtual information world, such as computers. Wireless Sensor Networks (WSNs) are a valuable resource for a lot of innovative monitoring applications, acting in home automation, weather monitoring, traffic management, tracking, industrial control, surveillance, among many others fields. Sensor nodes are battery powered devices it has limited power so we need to use it efficiently.

Proper sensor deployment improves monitoring and controlling of physical environment. SNs closer to the sink node forward more packets than the SNs at the periphery of network is called funneling effect. Funneling effect causes Energy Hole problem. We avoid redundant nodes for the conservation of energy. Node deployment strategy plays an important role in optimizing network lifetime. Node placement problem arise due to the undetermined locations of sensor nodes hence we have to avoid node placement problem [1]. In Location-wise predetermined deployment strategy, not only the number of SNs to be deployed in a network area is determined a priori but the precise locations are also predetermined. Distribution of number of heterogeneous SNs has significant role in controlling network lifetime. In this system SNs are distributed in a two dimensional plane covered by a set of Regular Hexagonal Cells (RHCs). The network coverage area is divided into N number of layers and each layer is divided into M number of RHCs with radius. The sink node is assumed to be located at one corner of the network area and responsible for collecting imagery data from SNs. All VNs exchange messages among neighboring RNs using assigned node ID and sends data to the nearest RN having highest residual energy [2].

Data is transmitted from source to destination. First it identifies the route for data transmission using multipath or multiobjective parameter. It disseminate data to the network for data transmission and then it finds shortest path using target localization algorithm. It increases accuracy of sensing network deployment due to predetermined location of sensors with hexagon cell based 3D node deployment. Main aim is to develop a general model for both homogeneous and heterogeneous WSN for defining appropriate sensing performance measure. The overview of data flow from source to target is shown in following figure.

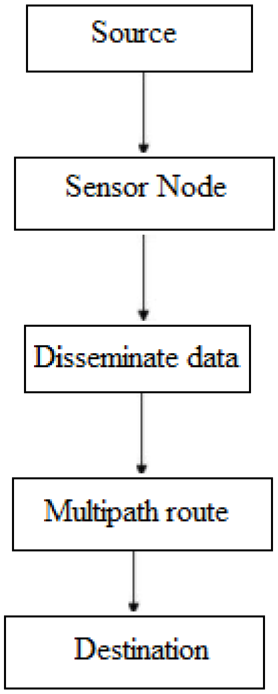

Figure 1: Data Flow Diagram

Purpose of node deployment for wireless sensor network is to deploy sensor nodes at static locations in order to overcome the energy hole problem and optimize network lifetime. Relay nodes are used to communicate between sensor node and sink node or base station. Relay nodes transfer data from sensor nodes to the sink node. Relay nodes are deployed in such a way that maximum area should be covered. Nodes are distributed based on precise locations that are mapped on to Regular Hexagonal Cells. Section II describes in detail about the various node deployment strategies available. Section III describes proposed system, Section IV describes mathematical model, Section V describes the algorithm used and Section VI describes Performance and Result Analysis.

2. LITERATURE REVIEW

A brief survey of different node deployment strategies is described. In [3] proposes effective solution for routing information in wireless multimedia sensor network using multipath and multi-objective routing scheme. The ubiquitous nature of the future Internet demands multi-objective routing for serving the dynamic applications and new technologies. Multimedia data and scalar data should be treated differently while routing through WMSN. This separation of data requires multiple paths for multiple objectives. Objectives can be the speed of communication, the energy efficiency of the network, the lifetime of the network and reliability of communication. This paper discusses the advantages of multipath routing and proposed an effective solution for finding multiple paths depending upon the demand of quality of service from the network. In [4] described the sensor deployment problem as a source coding problem with distortion reflecting sensing accuracy. When the communication range is limited, a WSN is divided into several disconnected sub-graphs under the condition that every sensor node location should coincide with centroid of its own optimal sensing region. In this a backbone network is designed for communication between sensor nodes and cluster node. In [5] authors tackle the problem of optimal surface deployment problem on 3D surfaces, aiming to achieve the highest overall sensing quality. It introduces a new model to formulate the problem of sensor deployment on 3D surface. We assume stationary and homogeneous sensors deployed on surfaces. The accuracy of their collected data depends on the distance between the sensor and the target point to be sensed. It presents the optimal solution for 3D surface sensor deployment with minimized overall unreliability.

In [6] authors conducts a survey of the various methodologies for routing and the vital issues in the design of routing protocols for WMSN, and it also discusses about the effect of mobility on various routing methodologies of WMSN. WMSN ubiquitously performs data acquisition, processing and routing for scalar and multimedia data in a mobile environment. The routing protocols should be adaptive in nature and should have a dynamic approach to service effectively for future network. In [7] authors proposed a mathematical model to compute the desired sensor density in the monitored area for determining the optimal deployment of nodes. By using this

dynamic deployment scheme, energy balance can be achieved. The density distribution optimization problem is solved by determining number of nodes in each sub-region as a result, longer lifetime is achieved. In [8] authors focused on deploying sensors on 3d terrains to maximize of Quality of Coverage and Quality of Network Connectivity. The locations of sensors are determined with a multiobjecive genetic algorithm by determining minimum path loss values.
In [9] authors introduces a approach for deployment strategy for energy balancing using customized Gaussian distribution in a layered network architecture by discrediting the standard deviation. Standard deviation has been identified as the parameter responsible for energy balancing. The target of the strategy is achieving energy balancing and enhancing network lifetime. In [10] authors proposed a curve based sensor deployment for coverage barriers in WSN. For enhancing barrier coverage performance, we introduced a concept of distance-continuous curve, and provided an algorithm to obtain the optimal sensor deployment when the deployment curve is distance continuous, and an algorithm which can attain close- to-optimal sensor deployment when the deployment curve is not distance continuous.

In [11] two deployments strategies-Hexagonal Deployment Strategy (HDS) and Diamond Deployment Strategy (DDS) are proposed in this system. A Radar Sensor Network (RSN) is effectively deployed to detect multi-target within a given surveillance area with required detection performance and energy consumption. In [12] authors proposed an efficient genetic algorithm using a novel normalization method. To cover a wide range of a target area with a minimum number of sensors and can be accomplished by efficient deployment of the sensors. Sensor coverage models measure the sensing capability and quality by capturing the geometric relation between a point and sensors. In [13] a new approach to find out least covered regions in a sensor network where further sensor deployment is desirable is described. This approach used some graph-theory based algorithm. The main aspiration of the proposed approach is to find the probability of detecting any event over the network. It can be shown that the probability of detecting any event entirely depends on the length of the monitored Voronoi edge as well as number of deployed sensors.

3. PROPOSED SYSTEM

A.Motivation:

Maximizing Network Lifetime:-
Optimal sensor deployment of nodes may maximize network lifetime and energy balance can be achieved. Results show that the hexagonal cell placement performs better in prolonging the lifetime of WSNs.
Location wise Sensor Deployment:-
Locations has great importance on limiting the energy hole problem and optimization of network lifetime. Location wise sensor deployment helps to solve problem of energy hole.
Balanced Energy Consumption:-
Balanced energy consumption can be achieved by using residual energy of sensor nodes and maintain load balancing.
Distributed Sensor Deployment:-
Location wise sensor deployment implies by distributing wireless sensor in distributed manner. It helps in homogeneous and heterogeneous type of sensors.

B.System Architecture:

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In Existing system Sensor nodes are distributed in a 2D plane covered by Regular Hexagonal Cells. In deployment strategy nodes are deployed in three phases using hop to hop communication. In first phase, VNs are deployed on the boundary of each layer for ensuring complete coverage of the network. In second phase RNs are placed at the centre of each RHC of each layer and the remaining RNs are deployed uniform randomly within each RHC in third phase.

A SN in network chooses a RN as a forwardee which is nearest to SN and has the highest residual energy for sending its data. Relay nodes acts as intermediate node for transmitting data from sensor node to sink node. If there is more than one forwardee node with the same highest residual energy, one of them is chosen randomly. Next, the forwardee RN employs the same procedure to choose the next forwardee RN in the network for sending its data. This process repeats till the data arrives at the sink node. SNs sends data to the nearest sink node, which is having large battery power and after that data is send to the outside network. For target tracking sensor deployment in WSN Target localization algorithm are used. A sensor node can transfer data outside if and only if there exist a path from the sensor to the Access Point (AP). Proposed sensor deployment leads to accuracy model as shown in following architecture.

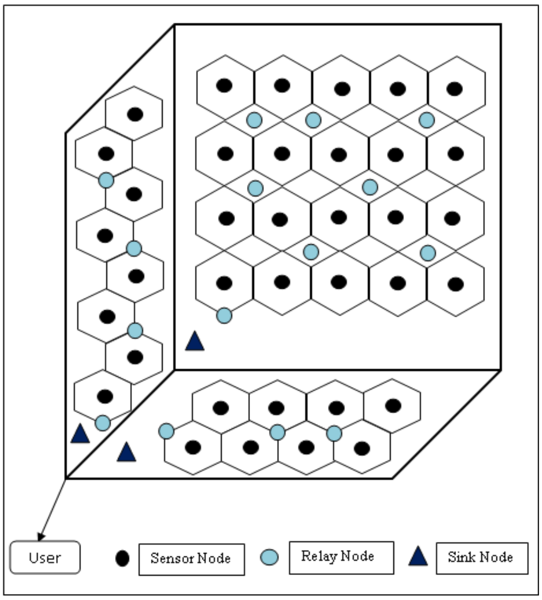

Figure 2: 3D Node Deployment Architecture

In proposed system optimal sensor deployment with hexagonal cell based sensor nodes are deployed in both homogeneous and heterogeneous Wireless Sensor Network. The motivating factors towards designing of new deployment scheme are cost of the existing sensor nodes, complex and time consuming shipping process. We deploy sensor nodes in 3D environment in order to cover maximum area with minimum number of sensor nodes. It considers multi objective parameter such as distance, We define the AP as the sensor node that can transmission capacity, communication range and energy. Our main goal is to mitigate energy conservation, load balancing and maximize success ratio of random node deployment.

TABLE I. Comparison with Similar System

Goals	Existing System	Proposed System
Throughput	70%	90%
Network	Hexagonal Grid	Polygonal Hex grid
Controller	Sink Sensor	Radio Sensor
Security	Hop to Hop	Sensor Node Authentication
Protocol	Mobile Application Part	Radio Resource Control
Algorithm	Routing Algorithm	Target Localization algorithm

4. MATHEMATICAL MODEL

We define the AP as the sensor node that can communicate with the outside information world. Let *S* (*P*) is the set of sensor nodes that can communicate with the AP when the sensor deployment is *P*. Note that in general not all nodes can communicate with the AP and $card(S(P)) \leq n$, where *card* (*A*) is the number of elements in set *A*. We define a new sensor deployment, which is a subset of the all sensor locations, When *S* (*P*) includes all sensor nodes, we have $card(S(P)) = n$.

$$Set= \{N, n, k, c= \{c1, c2,, \ldots . c_n\} ,S,SEN, t, loc \} \quad (1)$$

Where,
N=Network
n=Number of nodes

k= the number of clusters
c= Cluster
S=Sensor nodes
SEN=Size of the Sensor Network
loc= Location of Sensor Nodes.

Let *t* be the set of sensor deployments that provide full connectivity, two sensor nodes can communicate with each other within one hop if and only if the distance between the two is smaller than $R_{c,}$ where R_c is referred to as the communication range. A sensor node can transfer data outside if and only if there exist a path from the sensor to the AP. The path consists of a sequence of sensor nodes where each hop distance is smaller than the communication range $R_{c.}$ Sensor nodes that are connected to the AP construct the backbone network.

Specifically, we can choose the AP as the root and run Breadth First Search (BFS) or Depth First Search (DFS) to obtain the spanning tree. Obviously, sensors in the spanning tree construct the backbone network. If all sensors are included in the backbone network, we call the network fully connected. Otherwise, the network is divided into several disconnected sub-graphs. For target tracking sensor deployment in WSN Euclidean distance between points p and q is the length of the line segment between two sensor points.

The coverage function of the model is given by f (d(s, x))and d(s, x) R_s, where d(s, x) is the Euclidean distance between a sensor s and a point x, and the constant R_s is called sensing range. Indeed, this function defines a disk centered at the sensor with the radius of the sensing range. All points within such a disk have a coverage measure of 1, and are said to be covered by this sensor. All points outside such a disk have a coverage measure of 0, and are said not covered by this sensor. The distance between points p and q may have a direction (e.g. from p to q), so it may be represented by another vector, given by,

Euclidean Norms:-

In the Euclidean plane if $\mathbf{p} = (p_1, p_2)$ and $\mathbf{q} = (q_1, q_2)$ then the distance is given by

$$d(p,q)=\sqrt{(q1-p1)^2+(q2-p2)^2} \quad (2)$$

Where, p and q are Euclidean vectors.

5. ALGORITHM

This algorithm is used to deploy sensor nodes in a Regular Hexagonal Cells. It considers coverage requirements and calculates cost between two points. Based on minimum cost it transmits data from one sensor node to another.

Steps for Target Localization Algorithm
1. Set loops=0;
2. Set MaxLoops=MAX_LOOPS;
3. While (loops<maxLoops)
4. For P(x,y) in Hex Grid, x ∈ [a, width], y ∈ [1,height]
5. For si € {s1, s2, s3….sk}
6. Calculate Cxy (Si,P) from the sensor model Using (d (si,P), cth, dth);
7. End
8. If coverage requirement are met
   Break while loop
9. End
10. End
11. For si ∈ {s1,s2,···,sk}
12. Calculate- Fij using d (si,sj), dth, wA, wR;
13. Calculate- FiA using d(si, PA1,···,P AnP), dth;
14. Calculate–FiR using d (si,OA1,···,O AnO),dth;
15. Fi= Fij+FiR+FiA;
16. End
17. For si∈{s1,s2,···,sk}
   Fi(si) virtually moves si to its next position;
18. End
19. Set loops=loops+1;
20. End.

4. PERFORMANCE & RESULT ANALYSIS

This section illustrates the simulation results and performance analysis parameters. Our work proposes the system model for deployment of sensor nodes in Homogeneous and Heterogeneous Wireless Sensor Network. In this environment we provide number of sensor nodes, size of network placing hexagonal grid and other simulation parameters were chosen carefully to ensure that the real environment is to be reflected through simulation. We provide target location as a destination location for transmitting data from source node to destination node. It considers 3D space and *N* number of sensor nodes deployed in that space. The number of nodes, N is changed to several values for examining the effects of the algorithm. Simulation parameters consists of number of sensor nodes, transmission range and network area covered.

TABLE II. Simulation Parameter

Parameter	Value
Simulation Time	500ms
Terrain Area	600*500
Time Arrival	32ms
Protocol	RRC Based
No. of nodes	25,45,100

Proposed system aims to improve throughput maximization by reducing packet loss during wireless communication. Optimal sensor deployment helps to maximize network lifetime. Different performance analysis parameters as given below:

1. Packet Delivery Ratio:- It is defined as the ratio of packets received by destinations to the packets transmitted by source. We need to maximize packet delivery ratio in order to increase network lifetime. Packets are transmitted based on number of sensor nodes that transmits sensed data and time (in ms) required to send data from one location to another location. Delivery ratio is increased when we have highest residual energy for sensor nodes and maximum number of sensor nodes in particular area.

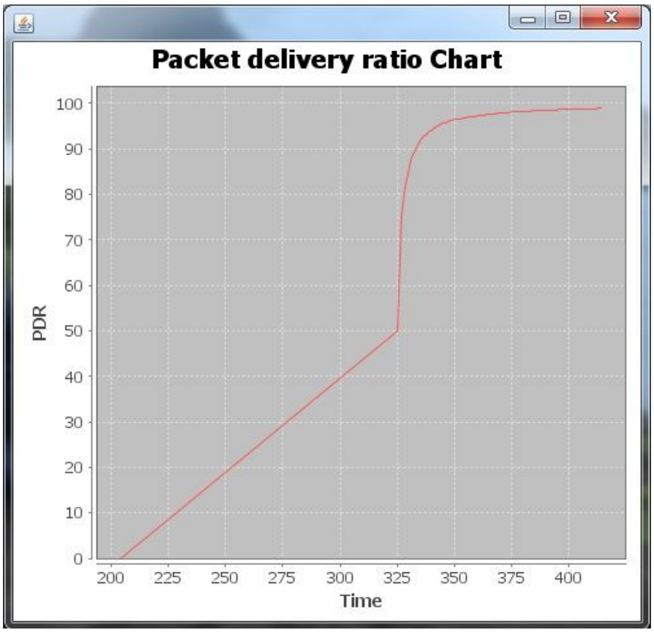

Figure 3: Packet Delivery Ratio

2. Packet Loss Ratio: It is defined as when one or more packets of data travelling across network is fail to reach their destination. Packet loss is minimized by maintaining transmission capacity, routing table and communication between source node and destination node.

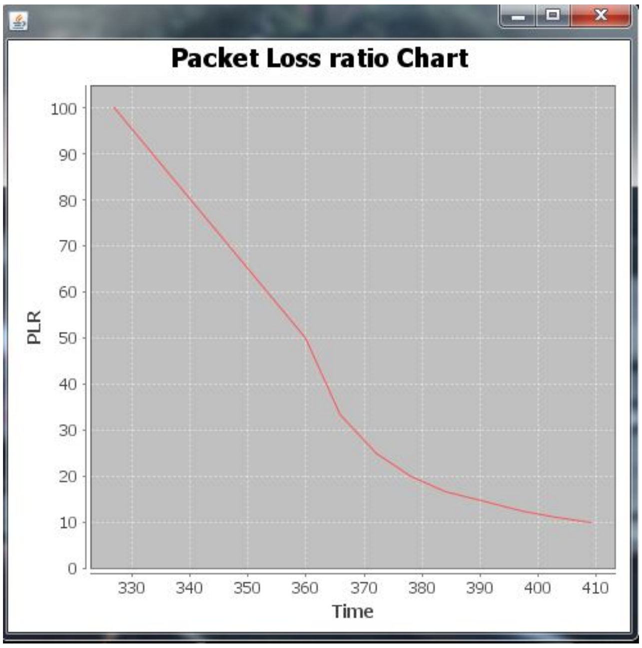

Figure 4: Packet Loss Ratio

3. Network Throughput: Network Throughput is the amount of data received in terms of bits at the sink per unit time. It is the data successfully moved from one place to another. We need to maximize network throughput in order to increase performance of the network based on the location of sensor nodes in network.

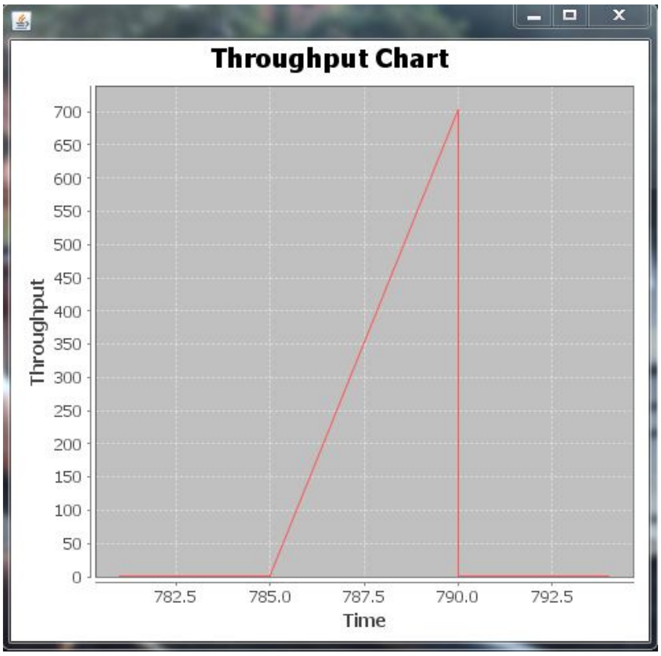

Figure 5: Network Throughput

5. CONCLUSION

We introduce the node deployment scheme for homogeneous and heterogeneous wireless sensor network. We have analyzed the issue of energy hole problem and node placement problem in existing systems. Node deployment strategy has significant influence on limiting energy hole problem and optimizing network lifetime. We consider a 3 dimensional environment to deploy sensor nodes by considering multi objective considerations. Coverage is one of the most important performance metrics for sensor network reflects how well a sensor field is monitored. Minimum number of sensor nodes are used to cover maximum area. Using target localization algorithm to deploy sensor we select nodes which is having minimum cost for data transmission. It formulates the problems of sensing and connectivity. Our future work includes increase the battery power of sensor nodes by providing solar energy support to nodes which helps nodes active for long time.

ACKNOWLEDGMENT

This work would not have been possible without kind support and help of many individuals. I would like to extend my sincere thanks to all. I am highly indebted to Prof. Rachana Satao; Department of Computer Engineering of Smt. Kashibai Navale College of Engineering affiliated to Savitribai Phule Pune University, Pune for her guidance and constant supervision and all staff members for providing important information at every phase of my work.

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