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Node Deployment Technique Using Wireless Sensor Networks

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Abstract— A wireless sensor network involves of sensor nodes which are capable to perform sensing, computation and transmission. These sensor nodes have limited battery power. Therefore to increase the lifetime of wireless sensor network, it is required to develop such techniques to consume less energy. Less consumption of overall energy of the network results is increase in the system capacity. In this kind of networks, some of the key parameters that need to be satisfied are connectivity, number of sensor nodes and energy consumed by nodes. We proposed a multi-objective optimization algorithm based on energy and connectivity to prolong WSN lifetime. The efficiency of algorithm can be shown as finding the optimal solutions among the least energy consumption while maintaining the connectivity of the network

Index Terms: WSN, Energy Efficient Routing, Relay

I. INTRODUCTION

Wireless sensor network is a network consisting of several number of heterogeneous nodes called as sensors nodes which are spatially distributed all over the location and these networks are used to monitor physical or environmental conditions such as temp, pressure, sound, vibration at these locations. Wireless communication enables[1] the co-operation of nodes to fulfill bigger tasks that single nodes cannot. Nodes in WSN are thickly deployed and are greater in numbers as compared to mobile ad hoc networks. These nodes communicate with each other and pass data along from one to each other from source to sink. Essentially Sensor nodes bridge the gap between physical world and the virtual world. Each node consists of processing capability, may contain many processing units like multiple types of memory, have a RF transceiver, have a power source like battery, and accommodate various sensors and actuators.

A sensor network generally consists of several[3] tiny sensor nodes and a few powerful switch nodes also called base stations or called as sink. Sensor nodes are usually densely set up in a large area and communicate with each other in short distances through wireless communication. Although particular sensor nodes have limited number of resources, they are able to achieve worthy task of big volume when they work as a team member. Information gathered by and transmitted on a sensor network of wireless networks describes conditions of physical environments of the area where the sensor network is set up.

II.Routing in wireless sensor network

The nodes in the wireless sensor network are deployed at inaccessible location, so different routing protocol have been proposed over a period of time for the routing the packets in wireless sensor network. The routing protocol for the sensor nodes depends upon the type of application. The routing protocol in wireless sensor network is broadly classified as cluster based routing, single path routing, Multipath routing. The routing protocols in the wireless sensor network have to meet a strict power saving constraint. The main goal for the routing protocol is to deliver the packet from source to destination based on the topology or position addressing. If the addressing is host based then it is called as topological addressing and if a unique identification is chosen for the addressing of node then it is called as position based.

The sensor node is capable of delivering[4] the requested user query back to the base station. The routing protocol for wireless sensor network can further be classified as single path algorithm in which only one instance of packet are sent at any time. There are many other protocols for wireless sensor network such as partial flooding and multipath routing. The single path routing protocol algorithm uses resources less than the resources used in multipath or partial flooding routing. The delivery of data is the main aim for single path, multipath and partial flooding routing protocol. The channel access problem is the main problem that is faced by the routing protocol. The routing protocol guarantees to access the channel efficiently by the user to increase the throughput of network. The routing algorithm used the concept of memorization of past traffic to increase the reliability of network.

Energy Efficient Routing: As the energy consumption for performing computation has been significantly increased in present days but battery lifetime has not improved considerably. The signal strength adjustment consumes large amount of energy. The energy efficient routing protocol is necessary to reduce the energy consumption[5] problem both in channel activation and data transfer.

Planner Graph Routing: If the neighbors are not closer to the target and the packets are dropped by the used path. Data recovery scheme is used to recover the data. It resends the data and provides end to end delivery of packets. The use of planner graph routing increase the efficiency of network.

2.1 Routing Challenges and Design Issues

Depending upon the application there are several challenges in the wireless sensor networks that affects the performance of the routing protocol. Some of the challenges and design issues are as follows:

Node Deployment: In WSN motes are deployed according to the demand of the application. Thus affects the productivity of the routing protocol. The nodes are deployed in uniform way or randomized way. In uniform way, the nodes are placed manually at fixed spot and routing paths are predetermined. In randomized way, the nodes are scattered randomly. This causes several issues such as optimal clustering, coverage etc. The position of the sink node or cluster head is an important factor in terms of energy efficiency.

Energy Consumption: Sensor nodes are small in size so they have limited power supply to perform sensing[9], processing and transmitting the information via a wireless communication. The lifetime of the sensor node is totally dependent on the battery. Once the battery is depleted the sensor node will be dead it causes change in topology rerouting of data. The multi-hop communication consumes less energy than direct communication. But it increases the overhead on the topology management and MAC. Direct communication is better when nodes are close to the sink node.

Fault Tolerance: A fault can occur in a node due to depletion of power supply, physical damage etc. If a sensor nodes stops working it should not effects the overall working of the WSNs. Routing protocol must be capable of handling the failure of sensor nodes by accommodating new link formation , routes to the base stations and by adjusting the transmit and receiving power on the link to reduce the energy consumption.

Network Dynamics: For most of the application the sensor node are stationary but according to the need of the application the base station and sensor node are mobile. Routing becomes a challenge due to the mobility of nodes. According to the need of application the sensing phenomenon can be static or dynamic. Dynamic sensing is done target detection application while forest alert application requires static sensing.

Data Delivery Models: The Data Delivery models depend upon the application of the network. There are four types of data delivery models: continuous, event driven, query driven and hybrid. In continuous the data is send periodically to the sink. In event driven the data is transmit when the event happens. In query driven the data is transmit when sink generates a query to the node. Hybrid use combination of all three models depending upon the need of application.

Scalability: A large number of sensor nodes in range of thousands are deployed in sensing area. Scalability means that the routing algorithms should work efficiently with large number of sensor nodes. Routing protocol must be efficient to react to the event occurring in the environment. Most of the sensor node remains in the sleep state until event does not occurs.

Data Aggregation: Sensors nodes generates huge amount of similar packets, data aggregation is used to reduce the transmission of similar packets. Data aggregation is combination of information from different sensor nodes by applying functions like suppression, average, maximum. The routing protocol incorporates this data aggregation technique to reduce data redundancy and achieve energy efficiency.

Node capabilities: According to the demand of application different functionalities can be given to the sensor nodes. Depending on the application a sensor node can be perform functions like sensing, relaying, aggregation

III.Need and significance of proposed research work

The main motive of research is to increase the lifetime of WSN using multi-objective node deployment. The two main multi-objectives are: (i)Energy consumption(ii) Connectivity. There are various optimization protocols: Pareto optimal and non-dominant sorting genetic algorithm (NSGA-II) that are used to improve the lifetime of WSN network.

3.1 Objectives of proposed work

To enhance the lifetime of wireless sensor networks using optimal multi-objective node deployment. The network lifetime is very critical parameter related to sensor network and has been tackled at various levels such as design, operation and deployment. A multi-objective routing protocol is designed to maximize the lifetime while considering other conflicting objectives like, minimization of energy consumption, maximization of connectivity.

To make cluster heads using DE (Differential Evolution) algorithm. The DE algorithm is a simple, fast, efficient and population-based direct search algorithm for solving global optimization problems. The DE algorithm has been widely used in many areas. The DE algorithm uses the basic framework of the genetic algorithm for designing a unique differential mutation operator. The main operations of the DE algorithm have the mutation operation, crossover operation and selection operation. It takes on some advantages of the simple structure, ease of use, robustness, and fast convergence.

A wireless sensor network consists of sensor nodes which are capable to perform sensing, computation and transmission. These sensor nodes have limited battery power. Therefore to increase the lifetime of wireless sensor network, it is required to develop such techniques to consume less energy. Less consumption of overall energy of the network results is increase in the system capacity.

Many researches are made on node deployment in wireless sensor networks. In this kind of network, some of the key objectives that need to be satisfied are connectivity and energy consumed by nodes. NSGA-II based multi-objective algorithm for optimizing all of these objectives simultaneously. The efficiency of this algorithm can be finding the optimal balance point among the least energy consumption, and the minimum number of active nodes to maintaining the connectivity of the network.

3.2 Planning of work

i. To maximize the lifetime of wireless sensor network we proposed mainly two approaches named **"Non-Dominated Sorting Genetic Algorithm-II and Differential Evolution Algorithm".**

ii. NSGA-II is one of the most efficient multi-objective optimization algorithm. It finds the optimal locations of node deployment into the network. The optimal differential evolution algorithm to find the direction of node deployment to the optimized selection of cluster heads.

NSGA-II algorithm is one of the most popular algorithms. By introducing the fast non dominated sorting approach, binary crowding tournament selection, and the Pareto-optimal front can be searched effectively. NSGA-II has a diversity-preserving mechanism which assures convergence toward the Pareto optimal front without losing solution diversity.

Initially, a random population Dt (t = 0) is created and is sorted into different non dominance levels. For each solution a fitness value is equal to its non dominance level. For creating an offspring population Et of size N, some operators such as binary tournament, mutation, selection and recombination are used. Then the following steps will be repeated until the number of generation reaches the maximum number of generations.

Algorithm 1: Fast non-dominated sorting algorithm
Input: population P

Output: The non-dominated fronts (Fr1, Fr2, . . .)

For each $p \in P$

For each $q \in P$

If ($p < q$) then

$Sp = Sp \cup \{q\}$

Else if ($q < p$) then

$np = np + 1$

if $np = 0$ then

$F1 = F1 \cup \{p\}$

$i = 1$

while $Fi <> \emptyset$

$H = \emptyset$

For each $p \in$ Fri

For each $q \in Sp$

$nq = nq - 1$

if $nq = 0$ the$H = H \cup \{q\}$

$i = i + 1$

Fr$i = H$

Step 1: Combine parent and offspring populations to create $Pt = Dt \cup Et$. Perform a fast non dominated sorting in Pt according to the algorithm shown in Algorithm 1 and identify different fronts Fri, i = 1, 2,..

Step 2: Set a new population Dt+1 = Ø. Set counter i = 1. While $|Dt+1|+|\text{Fr}i| < N$, do $Dt+1 = Dt+1 \cup \text{Fr}i$ and $i = i+1$.

Step 3: Select $(N-|Dt+1|)$ most widely spread solutions from Fri using the binary crowding tournament selection operator and insert them into Dt+1.

Step 4: Create an offspring population Et+1 from Dt+1 by using the binary crowding tournament selection, crossover, and mutation operators. Set $t = t + 1$.

The process of non dominated sorting and filling the population Dt+1 steps can be performed together. In Step 3, the crowding-sorting of the solutions in front Fri, which is the last front that could not be completely accommodated, is performed by using a crowded-distance metric. The crowding comparison operator compares two solutions and returns the winner of the tournament. The winner is selected based on two attributes: the non dominance ranking ri and the local crowding distance di in the population. This crowding distance attribute of a solution i is a measure of the search space around i, which is not occupied by any other solution in the population. Based on ri and di, the binary crowding tournament selection operator works as follows. A solution i wins a tournament over another solution j if any of the following conditions is true.

(1) If ri < rj (this assures that the selected solution lies on a better non dominated front).

(2) If ri < rj and di < dj (this is applied when both solutions lie on the same front and the above condition cannot be applied; in this case, the solution residing in a less crowded area with a larger *di* wins).

IV.Simulation Parameters

The used simulation parameters are shown in Table 4.1

Table 4.1: Simulation Parameters.

Name of the parameter	Parameter values
Network area (variable)	100 m · 100 m
Number of sensor nodes (variable)	50
Initial energy(Einit)	0.5 J
Eelec	50 nJ/bit
Efs	10 pJ/bits/m2
Eamp	0.0013 pJ/bit/m4
Distance do	sqrt(efs/emp)
Eda	50 nJ/bit/signal
Packet size (variable)	4000 bits

4.2 Simulation Scenario

Initially there is a network in which nodes are deployed randomly. This is shown in figure 4.1.

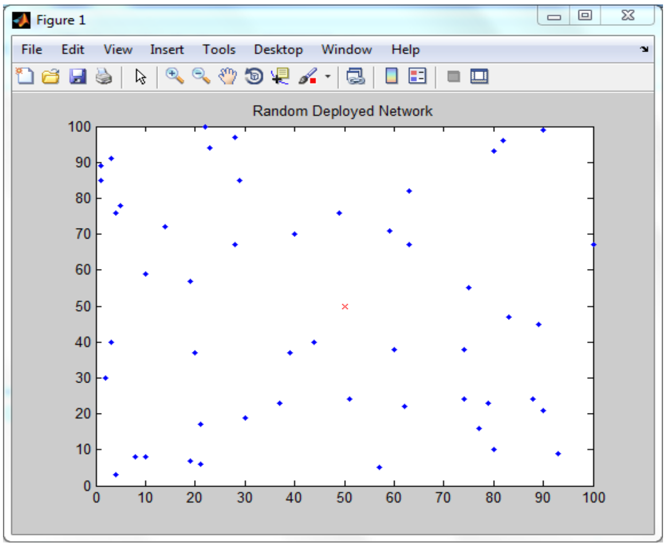

Figure 4.1: Random network deployment using 50 nodes.

Initially there is a network in which nodes are deployed optimally. This is shown in figure 4.2.

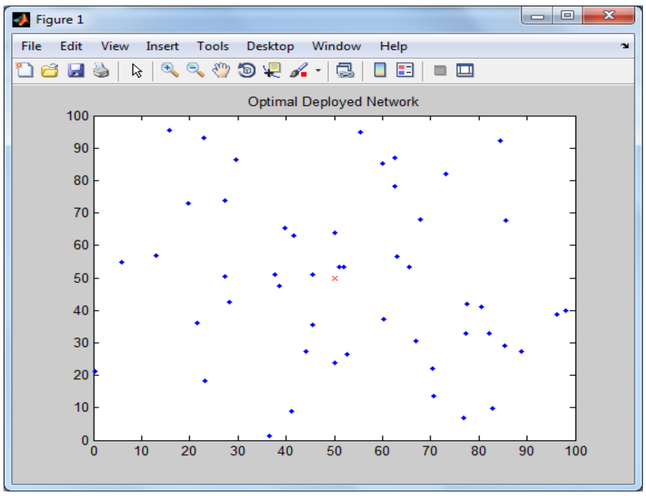

Figure 4.2: Optimal network deployment using 50 nodes.

4.3 Performance Evaluation

The figure 4.3 shows the graph of half node dead in optimal deployment DE algorithm happens after 1000 rounds in spite of random deployment DE algorithm which is having its half dead after 800 rounds. Hence optimal deployment algorithm is energy efficient than random deployment algorithm. The figure 4.3 as shown below:

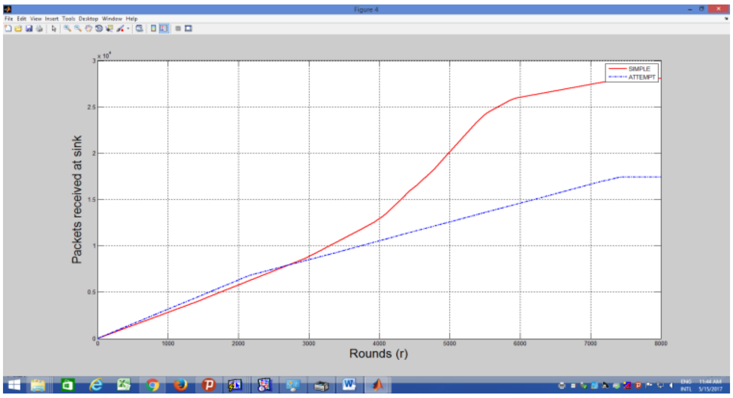

Figure 4.3: Comparison of optimal and random deployment in terms of half node dead.

The figure 4.4 shows the graph of last node dead in optimal deployment DE algorithm happens after 1600 rounds in spite of random deployment DE algorithm which is having its last dead node after 1200 rounds. Hence optimal deployment algorithm is energy efficient than random deployment algorithm. The figure 4.4 as shown below:

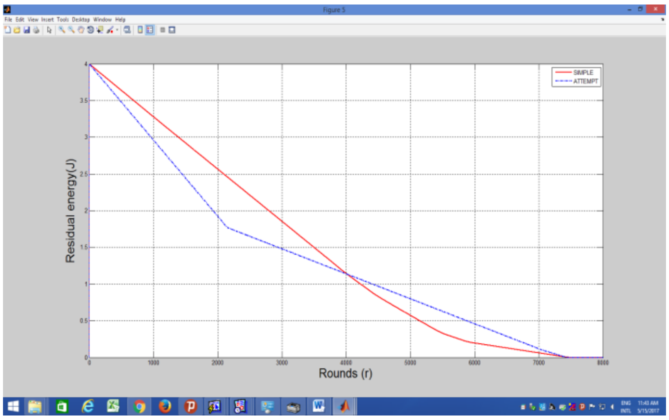

Figure 4.4: Comparison of optimal and random deployment in terms of last node dead.

Figure 4.5 gives the graph which compares the performance of random and optimal deploy DE in terms of number of dead nodes with total number of rounds. Green line represents the optimal deployment DE and blue line represents the random deployment DE. Graph shows that optimal deployment shows improved performance over random deployment after 800 rounds.

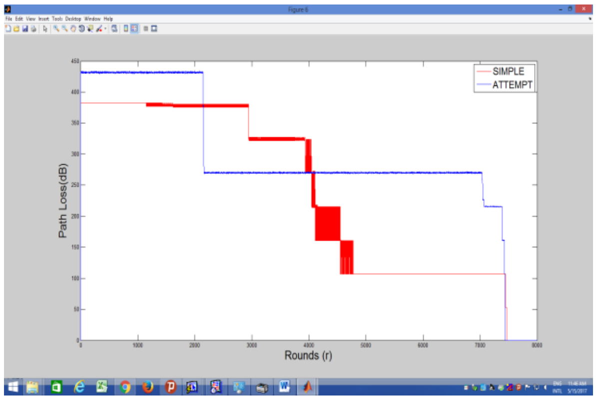

Figure 4.5: Comaprison of the performance of random and optimal deploy-DE in terms of number of dead nodes & number of rounds.

Figure 4.6 gives the graph which compares the performance of random and optimal deploy DE in terms of number of remaining energy with total number of rounds. Green line represents the optimal deployment DE and blue line represents the random deployment DE. Graph shows that random deployment have almost same residual energy up to initial 100 rounds as optimal deployment is having. The optimal deployment shows improved performance of the remaining energy over random deployment after 100 rounds.

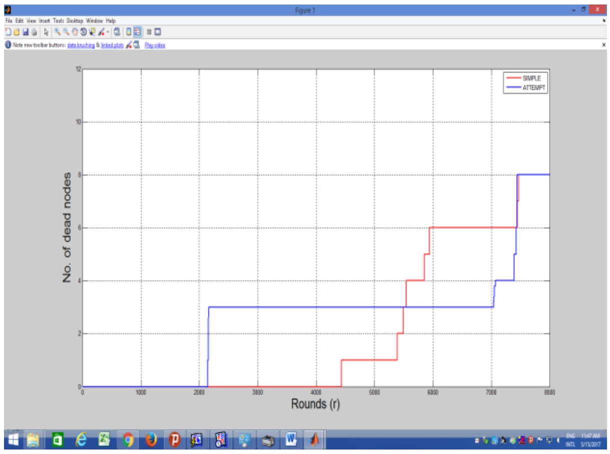

Figure 4.6: Comaprison of the performance of optimal and random deploy-DE in terms of number of dead remaining energy with total number of rounds.

V. Conclusion and Future Scope

In this paper , We executed different simulation results to show the performance of the proposed algorithm. The simulation results to show the random and optimal deployment of nodes in the network. The results obtained from the simulations showed that with the same number of active sensor nodes, optimal deployment DE can obtain better results than random deployment DE algorithm

In the future, NSGA-II algorithm is implemented for multi objective parameters in wireless sensor networks. Algorithm can be further implemented for other parameters such as coverage, reliability and quality of service (QoS).
Hybrid DE-PSO algorithm can be used further to get the optimal results in the wireless sensor network to improve the lifetime of the network.

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