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Network Lifetime Enhancement by Node Deployment in WSN

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Abstract— The key challenge in wireless sensor network is network lifetime so it is necessary to increase the network lifetime. The work deals with the enhancement of the network lifetime for target coverage problem in wireless sensor network while deploying the sensor nodes. Initially sensor nodes and targets are placed randomly, where the targets are the not sensor nodes its external parameter. Network lifetime for this scenario is computed, where the sensing range and initial energy of the battery are assumed. Network lifetime is based on sensor nodes that monitor the targets and lifetime of battery. The randomly placed sensor nodes are redeployed using optimization algorithm called Artificial Bee Colony (ABC). The network lifetime for redeployed sensor nodes are computed and compared with randomly deployed sensor nodes.

Index Terms— Artificial Bee Colony (ABC), Coverage, Deployment, Network lifetime, Wireless sensor network (WSN)

1 INTRODUCTION

Group of sensor nodes together forms the wireless sensor network. Wireless sensor network plays important role in military, environmental, health applications. It is used to monitor the physical and environmental parameters such as temperature, pressure, humidity. The sensor nodes communicate among themselves using their sensing range. Sensor nodes have tiny battery, recharging or replacing the battery is difficult. Some of the issues in designing the wireless sensor networks are deployment, fault tolerance, infrastructure. Network lifetime plays the vital role in wireless sensor network.

Sensor nodes are deployed in the network field [1]. Proper node deployment can reduce the complexity of the coverage, connectivity problems in wireless sensor networks. The deployment, sensor nodes are placed in the field randomly like for example dropping from the airplane. In deterministic deployment, sensor nodes are placed with the help of some details like placing in grid.

The coverage problems in the wireless sensor network are of two type's target and area coverage [4]. Target coverage is that focus on the specific area or a point. Simple coverage, k-coverage and q-coverage are various types of target coverage. When the target is monitored by at least one sensor node then it is called simple coverage. k-coverage is each target should be monitored by k number of sensor nodes, q-coverage means target vector should be monitored by q number of sensor nodes. When the sensor node monitors the entire area then it is called area coverage.

1.1 Related Works

The components of sensor nodes are sensing unit, processing unit, communication unit and power unit [4]. The sensing unit has the sensor and ADC. The sensors sense the data and send the data to the ADC which converts the analog data that sensed to the digital form. The processing unit has the processor and storage. The processor may be a microcontroller which is used to program the operation that has to be performed and the storage which the memory part to store that data. The communication unit has the transmitter and the receiver. The power unit which used to give power supply to the communication and sensing unit.

Coverage problem of the wireless sensor network and analyzed the efficiency of the regular deployment pattern for coverage [5]. The efficiency is compared by varying the number of nodes increases the efficiency will also increase.

The network lifetime computations for different deployment strategies in network are made to maximize the network lifetime [2]. It is concluded that if the network area increases, the maximum achievable network lifetime will decrease and when the number of data sink increases for the same dimension that network lifetime increases. It also discusses about the cost model of the network.

ABC optimization algorithm is discussed about the ABC algorithm which is motivated by the intelligent behavior of honey bee [7]. Entire Bee colony process can be divided into three phrases: employed bee phase, onlooker phase and scouts. The employed bee takes a load of nectar of food source and returns the hive and unloads the nectar of food store. After unloading the food, the employed bee performs a special form on dance called waggle dance which contain the information about the distance from hive and its quality rating. Since the information about the current rich sources is available to an onlooker on dance floor, onlooker bee probably could watch numerous dances and choose to employ itself at most quantitative source. There is greater probability of onlooker's choice. Scouts bee searches for a random feasible solution. In ABC system, artificial bees fly around the multidimensional space in search of food source. He split the entire bee process on the basis of its functioning. With its experience if the search it will find the good quality food. ABC algorithm was implemented in dynamic deployment of nodes in the network to get better gain by increasing the coverage area. It concludes that when the numbers of iteration increases, the gain will also increases simultaneously.

1.2 Motivation

Wireless sensor network is a developing area and has a wide area of applications. The major design constraint in wireless sensor network is their lifetime because the wireless sensor network operates on the battery with limited energy. Wireless sensor networks are used in area where human monitoring is difficult. Hence the sensor nodes has small size battery, recharging and replacing of the battery are difficult.

1.3 Paper Organization

In section I introduction of the wireless sensor network has made and discussed about the coverage problems and deployment methods in the wireless sensor network. In section II network scenario which gives some knowledge about the network field. The section III discusses about the random deployment scenario. In Section IV presents the proposed algorithm for redeploying the sensor nodes in order to cover all the targets. In section V made the result analysis of the random deployment and ABC based algorithm deployment. In section VI is the conclusion of the work made.

2. NETWORK SCENARIO

The network consists of m sensor nodes and n targets with the region R. Each sensor nodes has the sensing range S_r with the initial battery power b_i, where the energy consumed by the sensor node is assumed.

2.1 Coverage Matrix

If the target is within the sensing range S_r, then the sensor node senses the target [2]. A sensor node S_i, $1<i<m$ is said to cover target T_j, if the distance between the sensor node S_i and the target T_j is less than S_r, this helps in determining the coverage matrix M_{ij} which show that whether the target is being monitor by the sensor node or not.

$$M_{ij}=\begin{cases}1 & \text{If } S_i \text{ monitors } T_j \\ 0 & \text{Otherwise}\end{cases} \quad (1)$$

2.2 Network Lifetime

Network lifetime is defined as the time until the first node or group of nodes runs out of energy. Alternatively the network lifetime [2] is defined as the time duration from the launch of the sensor networks to the instant when some of the targets are not covered by certain number of sensor nodes. The upper bound is the maximum achievable network lifetime [3].

$$U=\min_j \frac{\sum_i M_{ij} * b_i^{'}}{q_i} \quad (2)$$

Where i =1,2,…m and j=1, 2 ,…n.

$b_i^{'} = b_i / e_i$ is the lifetime of the battery,

b_i is the initial power of the battery and e_i is the energy consumption rate of S_i.

For k-coverage, q_i=k, j=1, 2,… n.

3. RANDOM DEPLOYMENT

Required number of sensor nodes and targets are taken. The sensor nodes have the equal sensing range. Deploy the sensor nodes and target randomly in the network field. The upper bound of the network lifetime is computed based on the coverage matrix. The distance between the sensor nodes and target is calculated. If the distance is less than sensing range of the sensor node, then the target is being monitored by the sensor node.

Some of the targets are left unmonitored and some sensor nodes are not being used which makes the coverage problem in the network. In order to avoid the coverage problem any of the optimization technique has to be used.

4. ABC ALGORITHM

Artificial Bee Colony (ABC) algorithm is used for redeploying the sensor nodes. This algorithm is based on the intelligent behavior of honey bee swarm. The colony of bees consists of three groups: employed bee, onlookers and scouts. The employed bees search the food source, carry information back to the hive and share it with the onlookers. An onlooker helps in determining the best food path using the information given by the employed bees. The information consists of quality, quantity and locations of the food source. Scouts are the unemployed bees which will go for random search of foods [6]. Here the targets are represented as bees and the sensor nodes as food source.

Initialization of parameters such as number of sensor nodes, targets, maximum cycle and limits for scouts is made.

Initial solution B represented as B_a= {(x_1,y_1), (x_2,y_2), …..(x_m,y_m)}where a=1, 2..n_b, n_b is the number of targets and m is the number of sensor Compute the fitness function $F(D_i)$ for population solution which is the network lifetime of the WSN [8]. Each target has to be monitored by at least one sensor node.

$$F(D_i) = \min_j \frac{\sum_i M_{ij} * b_i^{'}}{q_i} \quad (3)$$

Each sensor node is associated with the cluster, where the cluster corresponds to the set of targets monitored by the sensor node. D_i is the initial location of the i^{th} cluster.

After getting the information from the employed bee, onlookers will explores the region for food source at B_i with the probability value P_i defined as

$$P_i = \frac{F(D_i)}{\sum_{l=i}^{m} F(D_l)} \quad (4)$$

The onlookers find the neighbor solution in the vicinity of B_i by using

$$D_i(t+1)=D_i(t)+^{\delta}_{ij} * f \quad (5)$$

f =random number in range [-1, 1]

$D_i(t)$ = initial solution of i^{th} cluster

$^{\delta}_{ij}$ = difference between the initial position to new position

A. Pseudo Code For ABC Algorithm

1. Initialize the solution population B.
2. Calculate the fitness value
3. Cycle=1
4. Search for neighbor solution
5. If new solution is better than the old solution then
6. Register the new solution and discard the old solution
7. End if
8. Register the best solution so far
9. cycle=cycle+1
10. cycle=maximum cycle

5. RESULT ANALYSIS

Sensor nodes and targets are randomly deployed in the region of 1000*1000. Mat lab tool is used to perform the simulation. The assumed the sensing range of the sensor node is 75m and the initial battery power of 100 joules and energy consumed by the sensor node when the sensor node monitors the target is 1 unit. The target is kept constant which are 10 and numbers of sensor nodes are varied.

5.1 Random Deployment

The network scenario of 150, 300 and 500 number of sensor nodes are used for deployment with 10 targets. The dotted line represent the sensor node monitors the target (i. e the target is within the sensing range of the sensor node). The network lifetime is calculated for randomly deployed sensor nodes and targets.

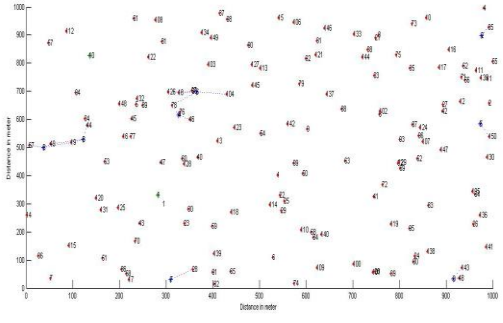


Fig .1 Random deployment scenarios for 150 sensor nodes

Fig (1) is the random deployment of 150 sensor nodes which monitors the 10 targets within the network field. Here 1st and 10th target in the network are not monitored by the sensor node. The target has to be monitored by at least two number of sensor nodes when k=2 in k-coverage. If the deployment is random there occurs a coverage problem, which is all target may not be monitored by 2 number of sensor nodes.

5.2 ABC Based Deployment

The randomly deployed sensor nodes are redeployed using the ABC algorithm. The network lifetime is computed for the redeployed location of sensor nodes.

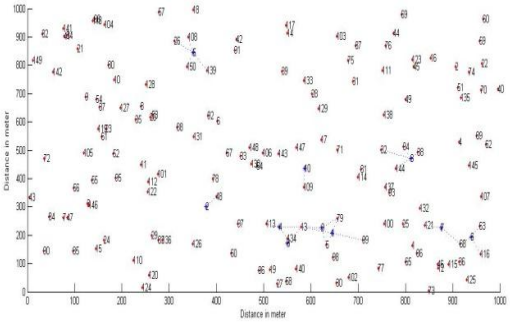
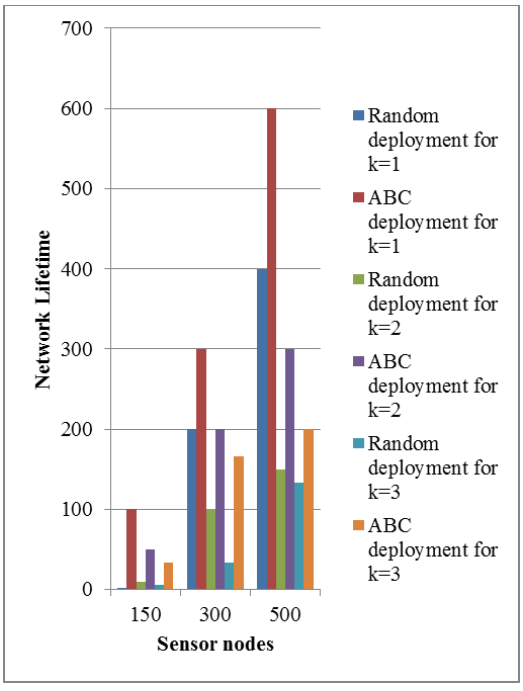


Fig. 2 ABC algorithm scenario for 150 sensor nodes

Fig (2) is the deployment of 150 sensor nodes to monitor the 10 target within the network field after using the ABC optimization algorithm. Here all the targets in the network field monitored by the sensor nodes.

For the k-coverage of 2 which means the target has to be monitored by minimum of 2 sensor nodes. Let the initialization parameters taken limits as 10 and the maximum cycle as 1000.

5.3 Comparison Of Network Lifetime



and

fixed number of targets 10. The numbers of sensor nodes are varied 150, 300 and 500. Coverage problem: simple coverage and k-coverage (k-1, 2, and 3) are considered.

In random deployment for the coverage problem some of the targets are life unmonitored. When the sensor node is 150 the network lifetime seems to be less compared to 300 and 500 number of sensor nodes. When the number of sensor nodes is the network there is a chance of increasing in coverage area.

In ABC based deployment, all the targets in the network covered by the sensor node. For k=1, 2 and 3 the network lifetime gets increased after ABC algorithm.

A simple coverage (i. e k=1) the network lifetime is maximum when compared to k-coverage (k=2 and 3).

6. CONCLUSION

In this paper, the sensor nodes are deployed randomly and they are redeployed to overcome the target coverage problem, where all targets in the network are covered. Here the simple coverage and k-coverage are used. And the network lifetime for the scenario is computed for the random deployment and the deployment location after the ABC algorithm. By the simulation results it is conclude that in random deployment when the numbers of sensor nodes increases the network lifetime will also increases simultaneously. After the redeploying the randomly deployed sensor nodes for the target coverage the network lifetime seems to be increased for varying sensor nodes. By comparing the different network scenario for coverage problem, the network lifetime seems to decrease with increase in the coverage.

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