Performance Comparison of Sensor Deployment Techniques Used in WSN

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Abstract - *Wireless Sensor Networks consisting of nodes with limited power and are deployed to gather useful information from the field. In WSN, it is critical to collect the information in an efficient manner. When nodes are randomly deployed, all the nodes may not be used efficiently which will reduce the network lifetime. In this paper, we implement artificial bee colony algorithm for proper deployment of sensor nodes and calculate network lifetime in terms of upper bound for this configuration. Simulation results prove that compare to random and heuristic deployment, artificial bee colony performs better for providing enhanced network lifetime.*

***Key Words*:** Wireless sensor network, Deployment, Scheduling, Upper Bound, Network Lifetime.

1.INTRODUCTION

1.1 Wireless Sensor Network:

Wireless sensor network is nothing but collection of huge numbers of sensor nodes. Each sensor node consists of sensors, actuators, memory unit and transceivers. Coverage and network lifetime are the basic two crucial problems associated with wireless sensor network and on which we are focusing in this paper. Coverage needs to guarantee that all the targets in area of interest should be monitored with required degree of reliability. In general, coverage answers the questions about quality of service (surveillance) that can be provided by a particular sensor network. In target coverage, there are several points of interest in a given region and sensors need to cover all the points. Sensors collect the data by monitoring the targets in their sensing ranges. With the current available technology, sensors are battery powered. Due to the limitation of battery, how to prolong the network lifetime is a critical issue in wireless sensor networks. For coverage problems, lifetime is the time duration that all the targets or the area is continuously covered. There are two main modes of sensor radio in the network, active and sleep. Sleep means a sensor radio is turned off without any activities while active means the radio is turned on and the active sensors can sense the environment surrounding them. One sensor can only be in one mode at a time. The power consumption of sleep mode is 0.03W much less than that of active mode which varies between 0.38W-0.7W. In this paper, we are implementing artificial bee colony algorithm for deployment of sensor nodes in wireless sensor network and comparing its result with random and heuristic deployment techniques.

1.2 Sensor Node Deployment: Deployment of node is nothing but placement of sensor node in monitoring area. Deployment maybe random deployment or deterministic deployment.

Random deployment: Random deployment is suitable for applications where the details of the regions are not known, or regions are inaccessible. An example of random deployment of sensor nodes would be in battlefield surveillance. In such a deployment, the most common way of extending the network lifetime is by scheduling the sensor nodes such that only a subset of sensor nodes that is enough to satisfy coverage requirement need to be active at a time.

Deterministic deployment: In deterministic deployment, the details of the region will be known a priori and a provision of deploying nodes at specific locations is possible. As nodes are deployed at particular locations, this method provides better target coverage.

1.3 Coverage in WSN: Each target in area to be monitored should be monitored continuously by at least one sensor node that is target should be in the sensing range of sensor node. Such network provides required degree of coverage and performs the task in proper way for which it is used.

1.4 Network Lifetime: Network lifetime for particular WSN configuration is the time gap between the instant at which network start functioning and the instant at which network does not provides proper coverage. As nodes are deployed there exists two ways by which network lifetime can be maximized. One is at deployment phase and the other is at scheduling phase. In [3] authors proves that for given a region with targets being monitored by sensor nodes, the upper bound of network lifetime can be mathematically computed. This information can be used for computing locations which would be appropriate for coverage to be satisfied as well as network lifetime to be maximize. Once the deployment locations are computed, then sensor nodes can be scheduled to achieve the optimum lifetime. Sensor deployment and scheduling in this way contributes equally to extend the network lifetime. In [8], authors use the ABC algorithm for the deployment of sensors nodes in the network to obtain good coverage in a 2-dimensional space.

2. Network Lifetime Upper Bound in WSN:

It is a parameter calculated mathematically and used for comparison of different deployment algorithms going to implement.

Assume m number of sensor nodes as S1, S2, . . . , Sm which are randomly deployed to cover the region with dimension as X by Y. These m number of sensor nodes monitors then targets as T1, T2, . . . , Tn.

Each sensor node has an initial energy Eo and a sensing radius Sr. A sensor node Si, 1 ≤ i ≤ m, is said to cover a target Tj, 1 ≤ j ≤ n, if the distance between Si and Tj is less than Sr . The coverage matrix is defined as,

$$Mij = \begin{cases} 1 & \text{if Si monitors Tj........(1)} \\ 0 & \text{otherwise} \end{cases}$$

where i = 1, 2, . . . ,m.
j = 1, 2, . . . , n.

Now consider initial battery power as bi and energy consumption rate of each node as ei and thus bi' = bi / ei represents the lifetime of battery in terms of time. By using above data, the upper bound is calculated as,

$$U = \min j \left(\frac{\sum_i Mij * bi'}{qj} \right) \quad \text{.............(2)}$$

For k-coverage,
$q\,j = k, j = 1, 2, \ldots, n.$

The upper bound is the maximum achievable network lifetime for a particular configuration.

3. PROPOSED METHOD :

Proposed method consist of implementation of Artificial bee colony (ABC) algorithms and comparison of results of ABC algorithm with random deployment and heuristic deployment algorithm.

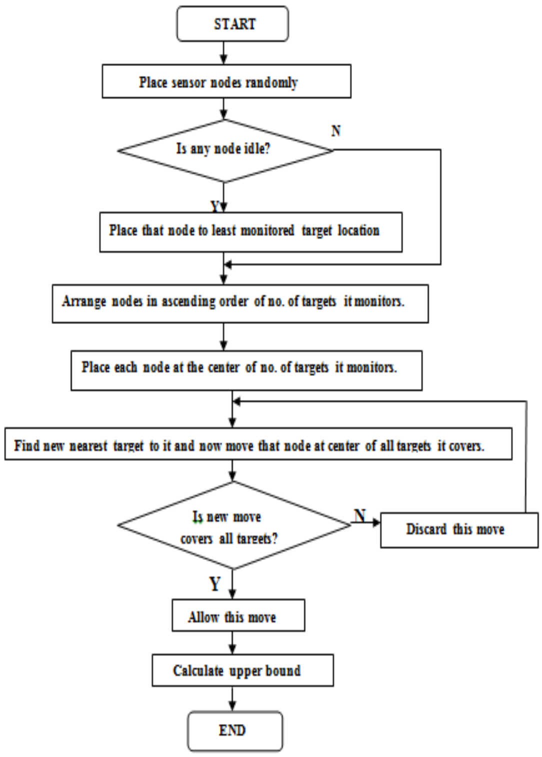
3.1 Random Deployment:

Large number of sensor nodes are placed randomly in the area to be monitored which is not accessible easily. Random deployment affects the network life in WSN because this deployment method does not provide required degree of coverage.

3.2 Heuristic Deployment:

One of the approaches of dynamic deployment of sensor nodes in WSN used to enhance network lifetime of WSN. This method gives efficient results compared with random deployment. In this technique, a sensor is moved in such a way that it should cover large number of targets. So that large number of cover sets can be formed. For that, initially place all nodes randomly and move any idle node to least monitored node. Now move all nodes at the center of targets it covers. Further, nearest target is to be identified and node is again placed at the middle of these entire targets. If node can covers this new target also then node is allowed to move else discard this move and finally calculate the upper bound.

Flowchart: The performance of Heuristic deployment is understood by following way



3.3 Artificial Bee Colony Based Deployment:

This optimization algorithm is based on intelligent behavior of Honey Bee Swarm. Here sensors are placed, where large numbers of targets are placed so that each target is covered by large number of sensors. In this algorithm, initially all the targets are covered such that each node at least covers one target and network lifetime is calculated using equation (2).

This network lifetime is used as the fitness function for evaluating the solutions. Each sensor node is associated with a cluster, where a cluster corresponds to the set of targets monitored by the sensor node. Let Di = (Xi ,Yi)be the initial position of i^{th} cluster. F (Di)refers to the nectar amount at food source located at Di. After watching the waggle dance of employed bees, an onlooker goes to the region Di where large numbers of targets are present with probability pidefined as,

$$Pi = \frac{F(Di)}{\sum_{i=1}^{m} F(Di)} \text{........}(3)$$

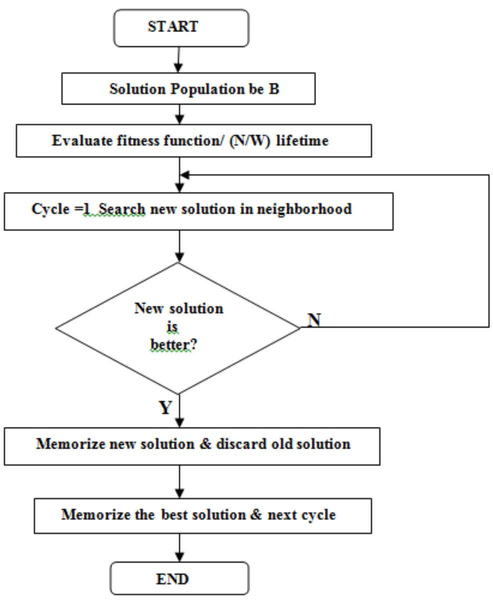
where*m* is the total number of food sources. The onlookerfinds a neighborhood food source in the vicinity of Di as,

$$Di\ (t + 1) = Di\ (t) + \delta ij \times f \text{..........}\ (4)$$

where$\delta ij$is the neighborhood patch size for j^{th} dimension of i^{th}food source, and f is a random uniform variate $\in[-1, 1]$.

It should be noted that the solutions are not allowed to move beyond the edge of the search region. The new solutions are evaluated using the fitness function (2). If any new solution is better than the existing one, the old solution is replaced with new solution. Scout bees search for a random feasible solution. The solution with the least sensing range is finally selected as best solution.

Flowchart: The performance of ABC based deployment is understood by following way



4. SIMULATION RESULTS

Simulation for analyzing performance of random, heuristic and ABC deployment is carried first on 300m x 300m region area and then varied to 400m X 400m. For both region areas, comparative results of ABC with random and heuristic deployment are obtained by changing following parameters. Simulation is carried out using Matlab1012a.

Table -1: Specification Table

Sr. No.	Specification	Value
1	Region area	300m X 300m and 400m X 400m
2	Number of Targets	30, 40 and 50
3	Number of sensor node	50,100, 150
4	Sensing Range	30m to 50m
5	Sensor node battery power	1000 units

Case I: Performance analysis for change in number of sensor nodes.

Number of Targets = 25

Sensing range of sensor node = 50m

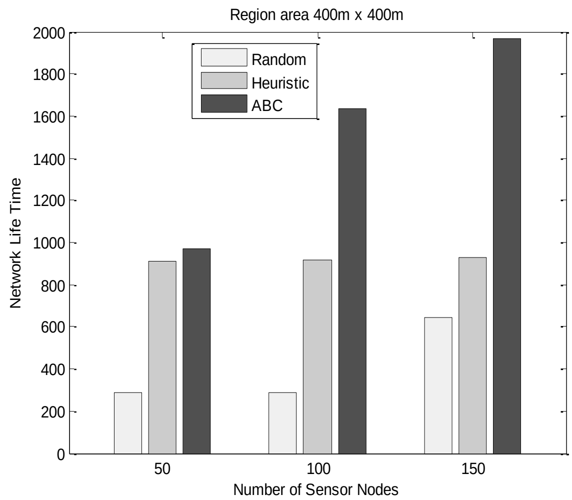


Chart -1: Effect of change in sensor nodes

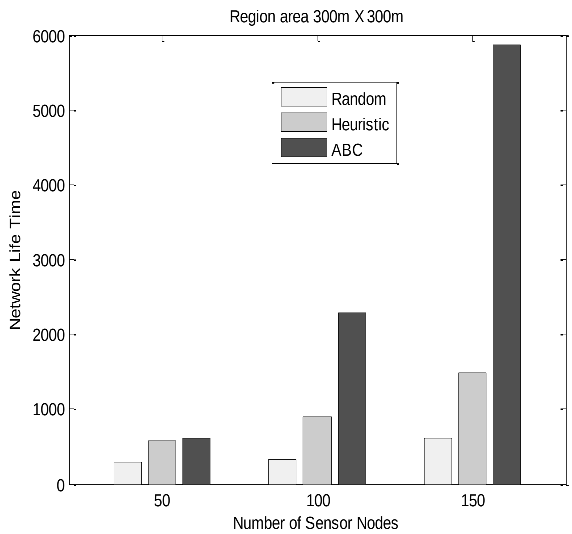


Chart -2: Effect of change in sensor nodes

Case II : Performance analysis for change in coverage (sensing) range of sensor nodes as 30m, 40m and 50m.
Number of sensor nodes = 100
Number of Targets = 25

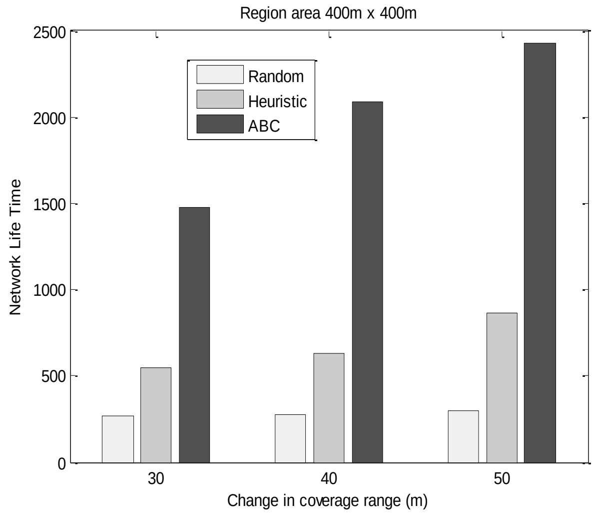


Chart -3: Effect of change in sensing range

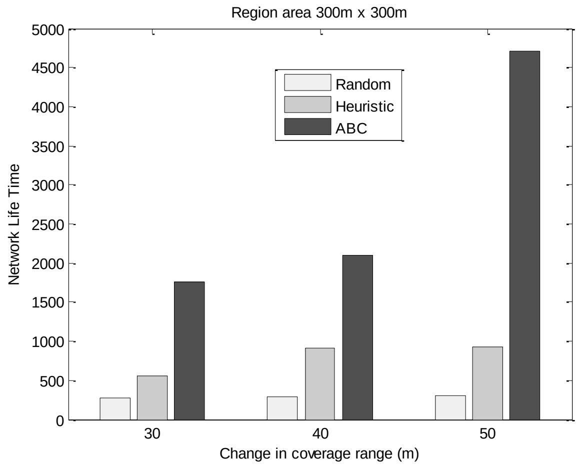


Chart -4: Effect of change in sensing range

Case III: Performance analysis for change in target nodes.
Number of sensor nodes = 100
Sensor node coverage range = 50m

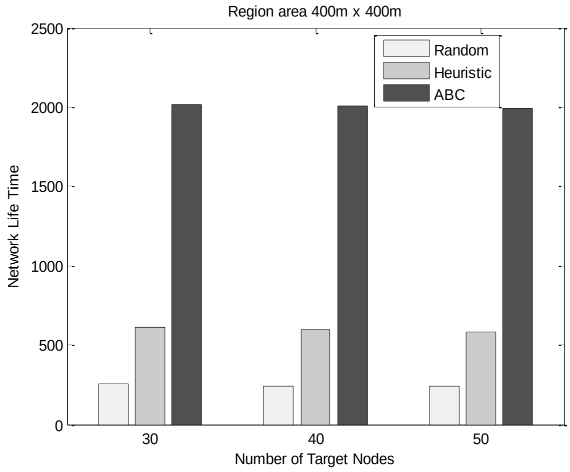


Chart -5: Effect of change in target nodes

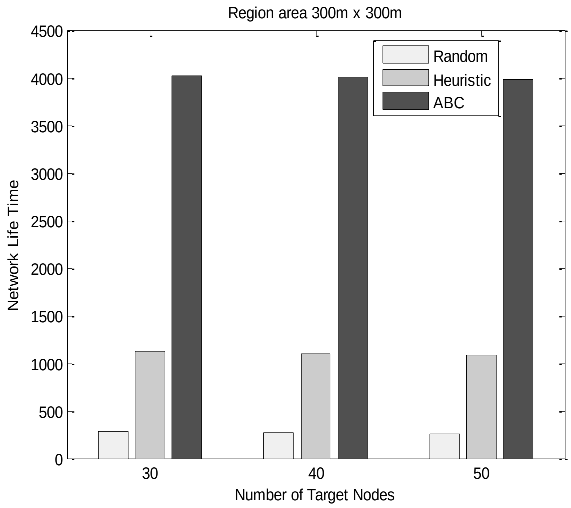


Chart -1: Effect of change in target nodes

Table -2: Effect on network lifetime.

Sr. No.	Area (Sq. meter)	Range (meter)	No.of Sensors	No.of Targets	Network Lifetime		
					Random	Heuristic	ABC
1	100	20	50	25	298	1226	5054
2	150	20	50	25	299	887	2635
3	200	20	50	25	280	554	868
4	250	20	50	25	274.6	588	658
5	250	20	75	25	279.6	896	2454
6	250	20	100	25	304	1122	3320

6. RESULT DISCUSSION

Performance of ABC is definitely better compare to random and heuristic deployment which is shown in all figures. It is the improvement in one of the quality factor of wireless sensor network by using such techniques for deployment of sensor nodes in WSN.

Also simulation results shows that by changing different parameters of WSN, performance of ABC deployment algorithm is more and more efficient compare to basic random and heuristic deployment algorithm.

When region area is increases while keeping other parameters of WSN remains constant, then network lifetime reduces as shown in all three cases. As region area increases, sensor nodes dispersed more when deployed. So number of sensor nodes covering a target goes on reduces. Due to that cover sets providing required coverage also go on reduces, which affects the network lifetime.

When numbers of sensor nodes are increases in constant region area, definitely network lifetime enhances shown in case I. As in this situation, there is chance of more number of sensor nodes will cover a target. Because of that large number of cover sets will form. When more number of cover sets are there in WSN, then during scheduling it will improve the network lifetime.

The same results will obtained when sensing range of sensor nodes is increases. Because as sensing range of sensor node increases, more number of near most targets may come in the range sensor node. So case II shows that improvement in network lifetime with increase in sensing range of sensor node.

When numbers of target nodes are increases while keeping other parameters constant, network lifetime reduces as shown results in case III. Because same number of sensor nodes should sense the information continuously and transmit that to the base station from all the targets as go on increases.

Table 1 again shows the effect on network lifetime. Sr. no. 4 and sr. no 6, if compare then it is clear that in same area if numbers of sensors are doubled then network lifetime is approximately five times more for ABC deployment algorithm. By analyzing such comparison, it is easy to select the network parameters depending on the requirement of application.

7. CONCLUSION

In this paper, we analyze the performance of random, Heuristic and Artificial Bee Colony deployment algorithms. Network survives for more time if ABC algorithm is used for deployment of sensor nodes in wireless sensor network. Even if different parameters of WSN are changed compare to other deployment, ABC deployment algorithm outperforms in all situations.

Future work is performance study of scheduling algorithms with dynamic deployment for improvement of network lifetime with required level of target coverage.

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