Journal on Science Engineering & Technology
Vo1ume 2, No. 04, December 2015

Sensor Deployment and Scheduling for Target Probabilistic Coverage Problem with Expectation Maximization in Wireless Sensor Networks

S. Saranya and Dr.M. Deva Priya

Abstract--- Network lifetime is a fundamental factor with the purpose of find out the effectiveness of a Wireless Sensor Network (WSN). Energy usage must be restricted to attain improved lifetime. Since sensor nodes used in the WSN are not be simply recharged or replaced. To solve this problem, coverage is introduced which is categorized into two ways area coverage problem and target coverage problem. From this target coverage problem is most focused.The research work under probabilistic sensing model and becomes very crucial to each and every one environmental condition. The research work introduced a new method under Probabilistic Coverage Problem (PCP) with the purpose of consideration of probabilistic models. The major objective of this PCP is considered in two ways. The primary objective of this work is sensor deployment under optimal location with enhanced network lifetime. The second one is to schedule sensor nodes with highest lifetime. To optimal location identification, proposed work introduce an Expectation Maximization (EM) schema with the intention of find probability within distance is equal to is one or else zero. In the distance, there is a definite probability p, with the intention of an object determination be detected through the sensor. The quantity is a measure of improbability in sensor detection. The paper present of the which solves the coverage problem in WSN briefly discussed.

Index Terms--- Wireless Sensor Networks (WSNs), Target Coverage, Sensor Deployment, Probabilistic Coverage Problem and Expectation Maximization (EM) Methods

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I. INTRODUCTION

Wireless Sensor Networks (WSNs) are disseminated networks of such sensors, devoted to strongly monitor real-world occurrence. Such sensors might be surrounded in the location through mobility; are able to be deployed in unattainable, hazardous, or hostile environments [1]. The sensors require in the direction of configure themselves in a message network; in regulate to gather information with the purpose of has to be pieced jointly to collect a broader picture of the surroundings than what each sensor independently senses. Coverage in a WSN desires to assurance with the purpose of the region is monitored through the essential degree of consistency. Locations of sensor nodes comprise the essential contribution used for the algorithms with the purpose of observe coverage of the network [2]. In general coverage in WSN is categorized into two ways area and target coverage problem. Area coverage major focus on examine to monitoring the complete region of interest within certain specific points.

The work the target coverage problem only considered and it is categorized into three types such as simple coverage, k-coverage and Q-coverage. Among simple coverage, every target must be monitored through at least one sensor node. In k-coverage, every target has towards be monitored through at least k sensor nodes, where k is a predefined threshold constant. In Q-coverage, the target vector $T = \{T_1, T_2, \dots, T_n\}$ must be monitored through $Q = \{q_1, q_2, \dots, q_n\}$ such that target T_j is monitored through at least q_j number of sensor nodes $1 \le j \le n$. To perform this task sensor nodes must be deployed earlier , for that purpose sensor node deployments algorithms is preferred Sensor node deployment algorithm is categorized into two types such as random deployment and deterministic deployment. Random deployment is appropriate designed for applications without knowing regions of each node. In such a deployment, the majority ordinary way of expand the network lifetime is through development the sensor nodes with the intention of merely a separation of sensor nodes must satisfy all the nodes at active at a time [3]. In deterministic deployment, the information of the region determination is well-known a priori and network lifetime is able to be maximized. It follows two major phases namely, deployment phase and scheduling phase. Specified a region through targets being monitored through sensor nodes, the upper bound of network lifetime be able to be exactly computed [4], [5]. This information is able to be second-hand for calculate locations which would be suitable designed for coverage to be contented as well as network lifetime to be utmost. Formerly the deployment positions are determined, sensor nodes be able to be scheduled to attain the best lifetime. During this process, target coverage problem occur which may leads to the following issues:

(i) Position added sensors increases communication cost,
(ii) More number of redundant sensor nodes present which increases collision, intrusion and misuse energy, and eventually,
(iii) Reduces the network lifetime of WSN.

In recent work several numbers of studies [6]–[9] have been introduced to solve the probabilistic sensing models confine the activities of sensors further practically than the deterministic disk model. Example considers simulation study of Passive Infrared (PIR) sensors [9], it results demonstrates that the sensing range is improved via continuous measuring the probability values. In [7] introduced a new polynomial function within the sensing range. In addition, the authors of [8] make an assumed that sensing choice is proficient to be representation as layers through increasing diameters. A probabilistic sensing model is further practical for the reason that the experience being sensed, sensor plan, and environmental conditions are each and every one stochastic in environment ,so the work focus on probabilistic coverage algorithm than the target coverage algorithm. Network lifetime is an essential aspect with the purpose of decides the effectiveness of a Wireless Sensor Network (WSN). Energy procedure must be restricted to accomplish improved lifetime. Propose the Probabilistic Coverage Algorithm (PCA), an expansion of the target coverage algorithm in the direction of calculate the highest maintained detection probability designed for a target region. The proposed EM_PCA algorithm be able to be second-hand to estimate the successful coverage with the purpose of be able to be provided to the application make use of the sensor network. Relying on the sensing range, a single node determination is capable to sense a measurement of the sensing field. From the EM_PCA model, describe the concept of probabilistic coverage. Propose new Expectation Maximization based probabilistic coverage methods. EM is comparatively common and be able to be second-hand through different sensing models. Expectation Maximization (EM) schema with the intention of find probability within distance is equal to is one or else zero. In the distance, there is a definite probability p, with the intention of an object determination be detected through the sensor. In exacting, EM necessitates the calculation of a distinct parameter beginning the adopted sensing model, at the same time as the whole thing else leftovers the same. The proposed EM_PCA is carryout in two stages (i) the probabilistic EM sensing model, and (ii) the sensor deployment using ABC. The primary representation is selected for the reason that it is conventional in terms of estimating sensing capability, and it has been second-hand before in ABC, which assists to carry out a fair comparison. The subsequent model is selected to demonstrate with the purpose of EM be able to straightforwardly function as a probabilistic coverage problem. This assumption is merely suitable designed for positive type of sensors such as acoustic, seismic etc through the distance beginning the source to destination for all sensors nodes in WSN. The work present an Expectation Maximization (EM) schema in PCP of WSN to solve two challenges maximum network lifetime and network connectivity respectively.

II. BACKGROUND STUDY

Mini & pujari [10] defined a new phase-transition behavior of maximum lifetime target coverage problem in WSN domain to solve target coverage problem; this algorithm has the unique ability of distinguishing hard problem instances. Wang et al [11] introduced two methods in the direction of approximation the lower bound of sensor density to assurance a bounded localization error over the sensing field. It first converts the coverage problem for localization to a usual disk coverage problem, where the sensing area is a disk centered at the sensor. A distributed sector coverage algorithm is second-hand for solving the coverage problem with more computation time. Pujari et al [12] introduced a new greedy heuristic which prioritizes sensors on residual battery life. It shows empirically that the proposed greedy heuristic algorithm outperforms when compared to all other heuristics in terms of quality of solution.

Maximum Lifetime Coverage Problem (MLCP) [13] is measured as most important difficulty which has been studied expansively in the literature. It is a long-standing open problem whether MLCP has a polynomial-time constant-approximation. MLCP is bargained to Minimum Weight Sensor Coverage Problem (MWSCP) which is mainly used to find the minimum total weight of sensors to cover a given area or a given set of targets with a given set of weighted sensors. Zorbas et al [14] introduced a novel coverage algorithm, which is used for together disjoint cover sets and non-disjoint cover sets. While searching for the greatest sensor to comprise in a cover set, this algorithm used a cost function, its association through poorly monitored targets, however in addition the sensor's remaining battery life. Cardei & Cardei [15] discussed the target coverage problem in WSNs. The major reasons used for extending the network life time are Communication and sensing consumes energy. The prearranged sensors in coverage sets activated consecutively which are used for energy saving. The main aim of this algorithm is finding a maximum number of set covers such that each sensor node to be activated is connected to the Base Station (BS). A sensor can participated in multiple sensor sets, but the total energy spent in all sets is constrained by the initial energy reserves.

Lee et al[16] introduced a new Ant Colony Optimization (ACO) algorithm to solving the Energy Efficient Coverage (EEC) problem. The ACO algorithm used three types of pheromones one of them for local and other two of them for global to discover the result proficiently, whereas usual ACO algorithms make use of simply one type of pheromone. Local pheromone, which is mostly used for organizing ant and its coverage set through fewer sensors. Global pheromones, one of them is used to improve the number of required active sensors per Point of Interest (PoI), and the other is used to form a sensor set that has as many sensors as an ant has selected the number of active sensors by using the former pheromone with increased network lifetime. Liao et al [17] considered a Glowworm Swarm Optimization (GSO) schema for sensor deployment to optimize the coverage after an initial random deployment of the sensors. Each sensor node is calculated as individual glowworms produce a luciferin and the strength of the luciferin is relying on the distance among the sensor node and its neighboring sensors with limited movement of the sensor nodes.

Mostafaei &Meybodi[18] introduced an new scheduling method based on learning automaton, which helps the node to select its proper state, at any given time with extended lifetime of the network in comparison to similar existing methods. He et al [19] introduced leverage prediction toward solve target coverage problem, through make use of temporal-spatial correlations between sensory information. An efficient centralized Truncated Greedy Algorithm

(TGA) is used to solve this NP hard problem. The implementation issues such as network connectivity and communication cost are extensively discussed with data correlations on the network lifetime. Shazly et al [20] deals with a resource sharing problem in WSNs. The formalized problem, called K-Balanced Area Coverage Slices (k-BACS), calls for identifying an ensemble of k trees that share the sink node only in a given WSN. From this literature still some problems are not solved, so efficient heuristic algorithm is needed, which is focused the research work.

III. Proposed Target Probabilistic Coverage Problem with Expectation Maximization

In recent work several number of studies [21]–[22] have been introduced and developed with the purpose of solving probabilistic coverage problem to confine the behavior of sensors more realistically than the deterministic disk model. In these works, nodes in a Wireless Sensor Network (WSN) performing two major tasks concurrently, sensor deployment to environment and communicating through each other on the way to transmit valuable information. Sensing is an assignment of principal significance designed for appropriate functioning of Wireless Sensor Network (WSN). The sensing exposure of a sensor node is frequently preassumed identical in each and every one direction subsequent the binary discovery representation. An event with the purpose of occurs inside the sensing radius of a node is constantly assumed detected through probability 1 at the same time as some event outside this circle of manipulate is assumed not detected. This binary discovery representation has been expansively second-hand in recent research works in the direction of calculate the total coverage in the target area. On the other hand, discover the difficulty of determining the coverage, provided through non-deterministic deployment of sensors, by means of an additional practical probabilistic coverage representation. Propose the Probabilistic Coverage Algorithm (PCA), an expansion of the target coverage algorithm in the direction of calculate the highest maintained detection probability designed for a target region. The proposed EM_PCA algorithm be able to be second-hand to estimate the successful coverage with the purpose of be able to be provided to the application make use of the sensor network. Relying on the sensing range, a single node determination is capable to sense a measurement of the sensing field. From the EM_PCA model, describe the concept of probabilistic coverage. Propose new Expectation Maximization based probabilistic coverage methods. EM is comparatively common and be able to be second-hand through different sensing models. In exacting, EM necessitates the calculation of a distinct parameter beginning the adopted sensing model, at the same time as the whole thing else leftovers the same. The proposed EM_PCA is carryout in two stages (i) the probabilistic EM sensing model, and (ii) the sensor deployment using ABC. The primary representation is selected for the reason that it is conventional in terms of estimating sensing capability, and it has been second-hand before in ABC, which assists to carry out a fair comparison.

The subsequent model is selected to demonstrate with the purpose of EM be able to straightforwardly function as a probabilistic coverage problem. This assumption is merely suitable designed for positive type of sensors such as acoustic, seismic etc through the distance beginning the source to destination for all sensors nodes in WSN.

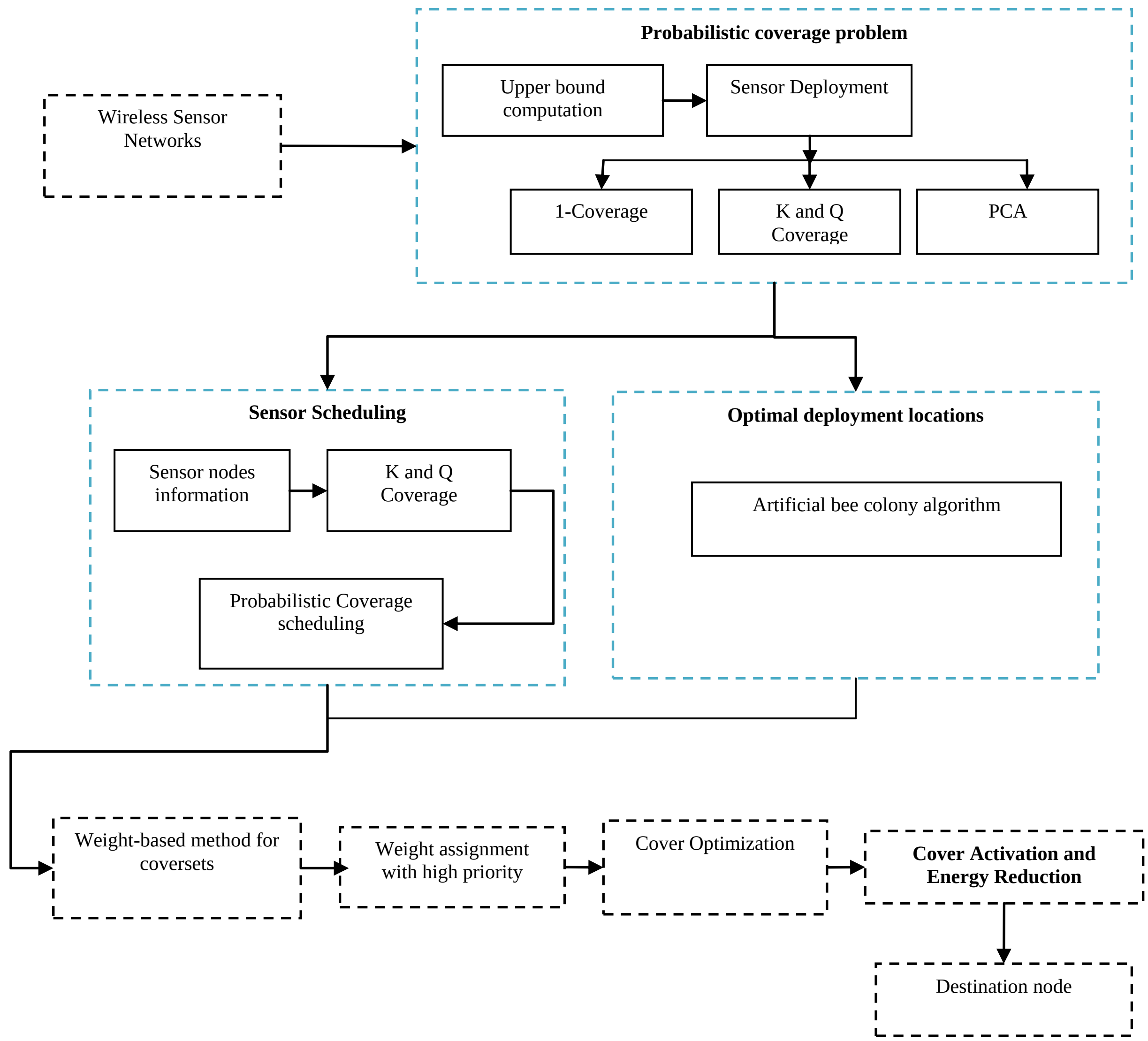


Figure 1: Architecture Diagram for Proposed Probabilistic Coverage Problem with EM

Specified group of n targets $T = \{T_1, T_2, \ldots, T_n\}$ positioned in $u \times v$ area and m sensor nodes $S = \{S_1, S_2, \ldots, S_m\}$, position the nodes such with the purpose of each and every one targets are enclosed as per the coverage condition.

Upper Bound of Network Lifetime: Presume m sensor nodes $S = \{S_1, S_2, \ldots, S_m\}$, indiscriminately organize to cover the region R among n targets { $T = \{T_1, T_2, \ldots, T_n\}$. Every sensor node has an preliminary energy E_0 and a sensing radius, s_r . A sensor node S_i, $1 \le i \le m$, is supposed in the direction of cover a target T_j, $1 \le j \le n$, if the distance among S_i and T_j is less than s_r . The coverage matrix is definite as,

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

where $i = 1, 2, \ldots, m$ and $j = 1, 2, \ldots, n$. Define $b_i' = b_i / e_i$ denote the lifetime of battery, where b_i is defined as original battery power and e_i is the energy utilization rate of S_i . The upper bound is the greatest attainable network lifetime designed for an exacting design and as stated in [4] and [5], the upper bound is considered as,

$$U = \min_j \left[\frac{{}_i M_{ij} * b_i'}{q_j} \right. \quad (2)$$

Designed for k-coverage, $q_j = k, j = 1, 2, \ldots, n$

Sensor Deployment

1. Sensor Deployment to attain 1-Coverage: Specified group of n targets $T = \{T_1, T_2, \ldots, T_n\}$ positioned in $u \times v$ area and m sensor nodes $S = \{S_1, S_2, \ldots, S_m\}$, position the nodes such with the purpose of each and every one targets are enclosed as per the coverage condition with highest network lifetime . The goal is to make the most of U with the purpose of each target is examined through at least single sensor node.
2. Sensor Deployment to attain k-Coverage : Specified group of n targets $T = \{T_1, T_2, \ldots, T_n\}$ positioned in $u \times v$ area and m sensor nodes $S = \{S_1, S_2, \ldots, S_m\}$, position the nodes such with the purpose of each and every one targets are enclosed through at least k-sensor nodes and to maximize U.
3. Sensor Deployment to attain Q-Coverage : Specified group of n targets $T = \{T_1, T_2, \ldots, T_n\}$ positioned in $u \times v$ area and m sensor nodes $S = \{S_1, S_2, \ldots, S_m\}$, position the nodes such with the purpose of each and every one targets $T_j, 1 \leq j \leq n$ are enclosed through at least q_j -sensor nodes and to maximize U.
4. Sensor Deployment to attain Probabilistic Coverage: Specified group of n targets $T = \{T_1, T_2, \ldots, T_n\}$ positioned in $u \times v$ area and m sensor nodes $S = \{S_1, S_2, \ldots, S_m\}$, position the nodes such with the purpose of each and every one targets $T_j, 1 \leq j \leq n$ are enclosed through at least q_j -sensor nodes and to maximize U with effective coverage range, R_{effec} .

Probabilistic Coverage Algorithm: Implement a computational Expectation Maximization (EM) and suggest Probabilistic Coverage Algorithm (PCA) to ensure whether the presently nodes are deployed or not with following assumptions used the research work.

- Sensor nodes are indiscriminately deployed in the field.
- Location information is available in the direction of every sensor node.
- Communication range of sensors nodes in WSN is at least twice the effectual coverage region, R_{effec} .
- Sensors are able to detect boundary of the area if the border is inside a sensor'sR_{effec} .
- Broadcast power of target P_t and obtain threshold γ designed for a sensor are identified and γ is the similar designed for each and every one the sensors. n Mean significance of path loss part n and shadowing deviation σ is assumed for each and every one the sensors.

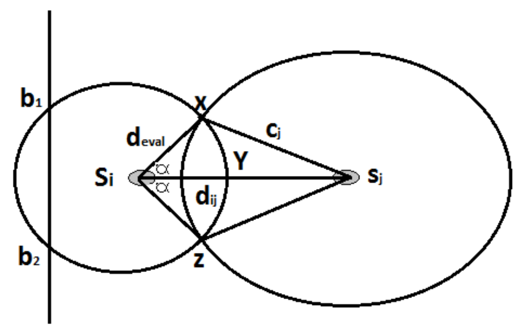


Figure 2: Neighbor Contribution of Coverage

In the initialization stage of the PCA, a node S_i in WSN return the location information of all sensor nodes from source to destination with one hop communication neighbors. It determines the hop count distance to all nodes and nearest nodes in WSN by keep all distance in descending order. Each sensor node S_i contains two sensing circles through radius d_{reqd} and d_{eval} . d_{reqd} is the required or specified distance regarding sensor providing ρ_{reqd} while d_{eval} is the subsequently distance addition which is greater than d_{reqd} given that a lesser detection probability than ρ_{reqd} . Node S_i primary detects whether it is within surrounding area of the region border. Make an assumption that each node in the WSN be able to detect border if it is inside distance R_{effec} beginning the border line of the area. If the area boundaries cross the circle of sensor node S_i on

d_{eval}, the node considered as inside the circle or else consider as outside the circle and marked as rejected node. The segments on perimeter with the intention of lie outer surface the area boundary are assigned detection probability of 1. In the subsequently step, a neighbor part towards detection probability is determined Neighbors with the purpose of inside a distance of $d_{eval} + R_{effec}$ beginning S_i are simply designed for probability determination; other nodes mightn't give some coverage in the direction of S_i' perimeter on d_{eval}. A node S_j with the intention of neighbor of S_i has a number of concentric circles on behalf of regions of varied detection probabilities. The probability of discovery of a target through a sensor reduces exponentially through raise in distance among the target and the sensor. By means of the EM, the path loss PL on a distance d is known through Equation 3.

$$\overline{PL(d)} = \overline{PL(d_0)} + 10.n.\log\left(\frac{d}{d_0}\right) + X_\sigma \tag{3}$$

Where, d_0 = Reference distance, n = Path loss component through distance, X_σ = Zero-mean Gaussian distributed random variable through σ –variance [32], $\overline{PL(d_0)}$ = Mean path loss at reference distance d_0. Correspondingly $PL(d_0)$ be able to be calculated experimentally designed for known event and sensor characteristics. Every sensor have a receive prespecified threshold value γ with the purpose of illustrate the smallest amount signal strength be able to be appropriately decoded at the sensor is specified through Equation 4, necessitate Q-function to calculate probability concerning the Gaussian process as

$$Q(z) = \frac{1}{\sqrt{2\pi}} \int_z^\infty exp\left(-\frac{x^2}{2}\right)dx \tag{4}$$

$$Q(z) = 1 - Q(-z) \tag{5}$$

$$\Pr[\Pr(d) > \gamma] = Q\left[\frac{\gamma - \Pr(d)}{\sigma}\right] \tag{6}$$

For a known nodes , determine the cumulative detection probability Pr within the region via the EM is given as follows. Specified group of n targets $T = \{T_1, T_2, \dots, T_n\}$ positioned in $u \times v$ area and m sensor nodes $S = \{S_1, S_2, \dots, S_m\}$, position the nodes such with the purpose of each and every one targets are enclosed as per the coverage condition and unknown distance results Z desire to approximation parameters θ with maximum likelihood and maximum a posteriori:

$$\hat{\theta}_{ML} = arg \max_\theta \log p(x|\theta) \tag{7}$$

$$\hat{\theta}_{MAP} = arg \max_\theta \log p(x, \theta) \tag{8}$$

$$= arg \max_\theta [\log p(x, \theta) + \log p(\theta)] \tag{9}$$

Might straightforwardly maximize $l(\theta) = \sum_z P \ log\, p(x, z|\theta)$ by means of a gradient method. Regard as the subsequent discrimination,

$$l(\theta) = \log p(x|\theta) = log \sum_z p(x, z|\theta) \tag{10}$$

$$= log \sum_z q(x, z|\theta) \frac{p(x, z|\theta)}{q(x, z|\theta)} \tag{11}$$

$$\geq \sum_z q(x, z|\theta) \frac{p(x, z|\theta)}{q(x, z|\theta)} \equiv F(q, \theta) \tag{12}$$

where $q(x, z|\theta)$ is an random concentration over Z. As an alternative of maximizing $l(\theta)$ straightforwardly, EM make the most of the lower-bound $F(q, \theta)$ by means of coordinate ascent,

$$\text{E-step : } q^{t+1} = arg \max_q F(q, \theta^t) \tag{13}$$

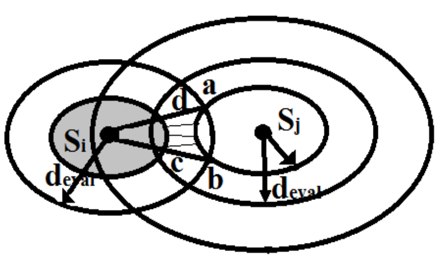
$$\text{M-step : } \theta^{t+1} = arg \max_\theta F(q^{t+1}, \theta^t) \tag{14}$$

Starting through a number of initial assessment of the parameters θ^0 among the E and M-steps until θ^t congregate to a local maxima. On the other hand, it is potential to show with the intention of $q^{t+1} = arg \max_q p(x, z|\theta^t)$ with transmit power, P_t and be given threshold for sensor, γ are well-known, a *probability table*, PT be able to be precomputed with the intention of give the detection probability on a diverse range of distances beginning the sensor. If ρ_{reqd} is specified as the Desired Detection Probability (DDP) designed for a region in the direction of compute the coverage with d_{reqd}. If the above step achieves the sensor node S_i determines the cumulative detection probability at d_{eval} through a variety of circles of neighbor S_j circle c_j. The segment on perimeter with the purpose of is covered through the circle c_j is determined via cosines rule ,

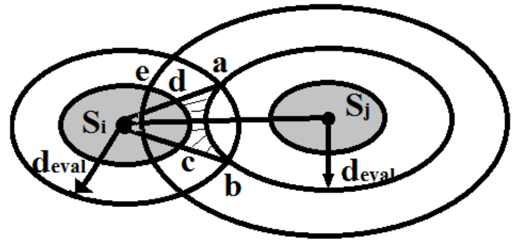
$$\cos\alpha = (d_{eval}^2 + d_{ij}^2 - c_j^2)/(2.d_{eval}.d_{ij}) \quad (15)$$

Where α is the angle subtended through the section xy on perimeter of S_i. This calculation is repeated until all the nodes in the neighbor S_j is completed at circle at d_{eval} The cumulative detection probability is then send to segment $[0, 2\pi]$ perimeter of S_i at d_{eval}. This process is continuously repeated for nodes in the neighbor S_j by perimeter enclosed through probability $\rho \geq DDP$. Procedure of proposed PCA [23-24] is shown in Algorithm 1 ,it starts with listing of all sensor nodes and perform sorting for those nodes distance . The coverage problem is checked and ensured at line 8 with detection probability from EM within the circle at d_{eval}. Step 8-10 sensor nodes , S_i and S_j are positioned at d_{eval} is intersecting through S_j via radius d_{reqd} between the points a and b is covered through ρ_{reqd} .

Every sensor determines this perimeter coverage separately and is able to statement whether the region encircled through its circle among radius d_{eval} is adequately covered or not. If each and every one the sensors report adequately enclosed perimeters at $C_i(d_{eval})$, the entire region is adequately enclosed.



(a)



(b)

Figure 3: Coverage Calculations

ABC Based Sensor Deployment: Artificial Bee Colony (ABC) Algorithm [25-26] is an optimization algorithm and it is performed based on the intellectual activities of honey bee swarm. It consists of three major bees such as employed, onlookers and scouts. The employed bee obtains a weight of nectar beginning the source and proceeds toward the hive and discharges the nectar to a food store. Subsequent to unloading the food, the bee executes a particular structure of dance called waggle dance [26] and its quality rating. Onlooker bee almost certainly might observe numerous dances and decide to make use of itself at the nearly everyone qualitative source. Employed foragers contribute to their information through a probability, which is comparative to the value of the food source. Hence, the employment is comparative to quality of a food source is not attained and it is carried out through scouts. To achieve optimal scheduling for determining the cover sets consists of four major steps: 1) Weight assignment , 2) Cover formation, 3) Cover optimization and 4) Cover activation and Energy reduction is described in detail [27].

Algorithm 1. Probabilistic Coverage Algorithm (PCA)

Notations :

ρ_{reqd} = Desired detection probability, d_{reqd} = Radius of circle around S_i that provides ρ_{reqd}, ρ_{eval} = Detection probability at next circle with $\rho < \rho_{reqd}$, d_{eval} = Radius of circle around S_i providing ρ_{eval}, $\rho_{cum\ ij}$ = Cumulative detection probability of S_i and S_j, G_α = Angle subtended by the arc on perimeter of sensor, S_i circle with radius d_{eval} that is covered by a neighbor, G_ρ= Cumulative probability of detection on perimeter of S_i circle with radius d_{eval}, $C_i(x)$ = Circle of S_i with radius x

Input :

ρ_{reqd} Neighbor locations

Probability table (PT) of probabilities P and distances D (precomputed)

Process :

1. ascertain ρ_{eval} and d_{eval} from PT
2. check boundary intersection with circle at d_{eval}
3. if $C_i(d_{eval})$ lies outside the region boundary then
4. mark segments on perimeter of $C_i(d_{eval})$ that are outside the boundary as sufficiently covered
5. end if
6. sort the neighbor list in ascending order of distance
7. for each neighbor j do
8. if $d_{ij} < d_{eval} + R_{effec}$ then
9. for each circle of S_j in $D\,(C_j\,(D_j))$ that intersects with $C_i(d_{eval})$ do
10. if $D_j < d_{eval}$ then
11. mark intersection point on perimeter of $C_i(d_{eval})$ as sufficiently covered by ρ_{reqd}
12. else
13. mark intersection point on perimeter of $C_i(d_{eval})$ as covered by $\rho_{cum\ ij}$
14. end if
15. end for
16. update global G_ρ & G_α
17. sort G_ρ & G_α in ascending order on G_α
18. if G_α is all covered from 0 to 2π with $G_\rho = \rho_{reqd}$ then
19. declare all perimeter at $C_i(d_{eval})$ is sufficiently covered
20. end algorithm
21. end if
22. end if
23. end for
24. declare perimeter at $C_i(d_{eval})$ is not sufficiently covered.

IV. Simulation Results

The section perform the simulation results for WSN under PCA, for simulation work consider a 500 m $\times$ 500 m region designed for experiments with targets is 25. The total number of sensor nodes (m) chosen for simulation work is varied from 100 to 250. Sensing range of each sensor node in WSN is predetermined as 75 m. Network lifetime designed for easy coverage problem by means of random deployment, heuristic and ABC algorithm is also experimented. Network lifetime designed for k coverage problem by means of random deployment, ABC and EM illustration in every configuration is also experimented. Primarily, every sensor node have 100 units of battery power, with energy utilization rate is 1 unit. A simulations result of the proposed EM_PCA and existing methods is simulated carried out using network simulator NS2.

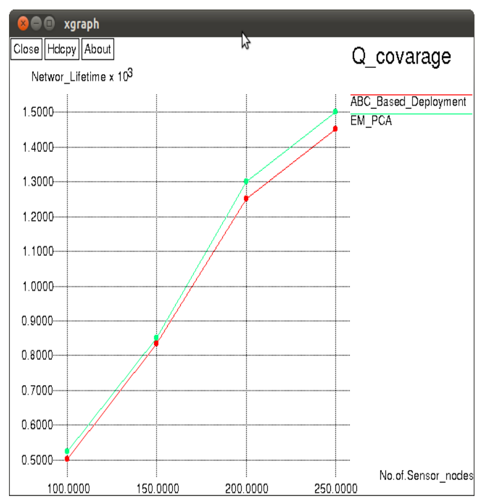


Figure 4: Network Lifetime for Simple Coverage Problem using ABC Algorithm and Proposed EM_PCA with Q-coverage

Figure 4 show the network lifetime comparison results of various deployment methods such as proposed EM_PCA and ABC algorithm. When compare to proposed EM_PCA method, existing ABC deployment might not attain highest network lifetime. Figure. 2 show that the results of proposed EM_PCA and ABC algorithm schemas under varied sensor nodes such as 50,100, 150, 200 and 250, results are tabulated in table 1.

Table 1: Network Lifetime for Simple Coverage Problem using ABC Algorithm and Proposed EM_PCA with Q-coverage

No. of nodes	Network lifetime	
	ABC algorithm	Proposed EM_PCA
100	500	523
150	845	852
200	1250	1300
250	1432	1500

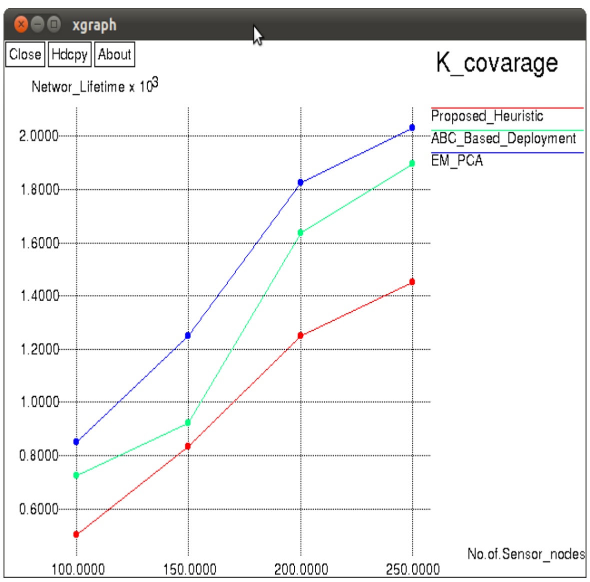


Figure 5: Network Lifetime for Simple Coverage Problem using ABC Algorithm and Proposed EM_PCA with k-Coverage

Figure 5 show the network lifetime comparison results of various deployment methods such as proposed EM_PCA and ABC algorithm with k-coverage. When compare to proposed EM_PCA method, existing ABC deployment might not attain highest network lifetime. Figure. 3 show that the results of proposed EM_PCA and ABC algorithm schemas under varied sensor nodes such as 50,100, 150, 200 and 250 with k-coverage .It shows that the proposed EM_PCA achieves highest network lifetime under k-coverage when compare to existing Heuristic and ABC based sensor deployment ,results are tabulated in table 2.

Table 2: Network Lifetime for Simple Coverage Problem using ABC Algorithm and Proposed EM_PCA with k-Coverage

No. of nodes	Network lifetime		
	Heuristic	ABC algorithm	Proposed EM_PCA
100	550	712	826
150	815	896	1214
200	1256	1628	1815
250	1452	1928	2158

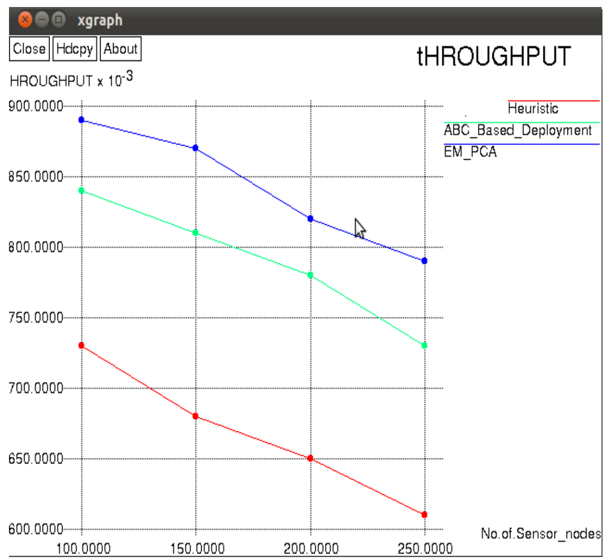


Figure 6: Throughput for Simple Coverage Problem using ABC Algorithm and Proposed EM_PCA with k-coverage

Figure 6 show the throughput comparison results of various deployment methods such as proposed EM_PCA and ABC algorithm with k-coverage. When compare to proposed EM_PCA method, existing ABC deployment might not attain highest network lifetime. Figure. 4 show that the throughput results of proposed EM_PCA and ABC algorithm schemas under varied sensor nodes such as 50,100, 150, 200 and 250 with k-coverage .It shows that the proposed EM_PCA achieves highest throughput under k-coverage when compare to existing Heuristic and ABC based sensor deployment ,results are tabulated in table 3.

Table 3: Throughput Comparison for Simple Coverage Problem using ABC Algorithm and Proposed EM_PCA with k-Coverage

No. of nodes	Throughput x 10^{-3}		
	Heuristic	ABC algorithm	Proposed EM_PCA
100	726	843	882
150	672	816	868
200	651	794	821
250	610	736	795

V. CONCLUSION AND FUTURE WORK

The proposed work considering the problem of probabilistic coverage in WSN, which are further sensible. It showed all the way through simulation with the purpose of an Expectation Maximization Probabilistic Coverage Algorithm (EM_PCA) might consequence in considerable savings of energy utilization and expands the network lifetime. The proposed EM_PCA consideration of variant sensing behavior of deployed sensor nodes and implement a PCA in distinguish to extensively make use of idealistic unit disk model. In addition EM_PCA method determines optimal sensor node deployment locations under Artificial Bee Colony (ABC) to extend network lifetime. In order to circumvent the battery drain of each and every one node at a time, sensor node scheduling with satisfying coverage requirements. The remaining nodes are able to be reserved designed for later use. This EM_PCA method helps out to extend the network lifetime of deploying on most favorable locations with the intention of achieves utmost hypothetical upper bound and then perform scheduling them. A simulation result demonstrates that the proposed EM_PCA methods achieves in higher detection probability. In future work plan to expand the current implementation work under some realistic assumption such as mean values of path loss part, n , and the shadowing deviation σ used for each and every one the sensors in the region. Similarly the current work plan to integrate the multiple coverage constraint as another future work. The Multiple Probabilistic Coverage Problem (MPCP) is able to be defined under (ρ_{reqd}, k), where k is the degree of coverage.

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