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 presents 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

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 \( T = \{T_1, T_2, \ldots, T_n\} \) must be monitored through \( Q = \{q_1, q_2, \ldots, q_n\} \) such that target \( T_j \) is monitored through at least \( q_j \) number of sensor nodes \( 1 \leq j \leq n \). 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 assure 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

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(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 PROBABILITY 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.
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 \( S_i \), \( 1 \leq i \leq m \), is supposed in the direction of cover a target \( T_j \), \( 1 \leq j \leq n \), if the distance among \( S_i \) and \( T_j \) is less than \( s_r \). The coverage matrix is definite as,

\[
M_{ij} = \begin{cases} 
1 & \text{if } S_i \text{ monitors } T_j \\
0 & \text{otherwise} 
\end{cases}
\]

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,

\[
U = \min_j \left( \sum_{i} M_{ij} \cdot b_i' / q_j \right)
\]

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 \( T_j, 1 \leq j \leq n \) 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 \( T_j, 1 \leq j \leq n \) are enclosed through at least \( q_j \)-sensor nodes and to maximize \( U \) with effective coverage range, \( R_{\text{eflec}} \).

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, \( R_{\text{eflec}} \).
- Sensors are able to detect boundary of the area if the border is inside a sensor’s \( R_{\text{eflec}} \).
- Broadcast power of target \( P_t \) and obtain threshold \( \gamma \) designed for a sensor are identified and \( \gamma \) is the similar designed for each and every one the sensors.
- Mean significance of path loss part \( n \) and shadowing deviation \( \sigma \) is assumed for each and every one the sensors.

![Figure 2: Neighbor Contribution of Coverage](image)

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 \( d_{\text{reqd}} \) and \( d_{\text{eval}} \). \( d_{\text{reqd}} \) is the required or specified distance regarding sensor providing \( \rho_{\text{reqd}} \) while \( d_{\text{eval}} \) is the subsequently distance addition which is greater than \( d_{\text{reqd}} \) given that a lesser detection probability than \( \rho_{\text{reqd}} \). 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 \( R_{\text{eflec}} \) beginning the border line of the area. If the area boundaries cross the circle of sensor node \( S_i \) on
\[ d_{\text{eval}} \], 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 \( d_{\text{eval}} + R_{\text{eff}} \) beginning \( S_1 \) are simply designed for probability determination; other nodes mightn’t give some coverage in the direction of \( S_1 \)’ perimeter on \( d_{\text{eval}} \). A node \( S_j \) with the intention of neighbor of \( S_1 \) 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.

\[
PL(d) = PL(d_0) + 10 \cdot n \cdot \log \left( \frac{d}{d_0} \right) + X_s
\]  

Where, \( d_0 \) = Reference distance, \( n \) = Path loss component through distance, \( X_s \) = Zero-mean Gaussian distributed random variable through \( \sigma \) –variance [32], \( PL(d_0) \) = 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 \( \gamma \) 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

\[
Q(z) = \frac{1}{\sqrt{2\pi}} \int_{-\infty}^{z} e^{-\frac{x^2}{2}} \, dx
\]

\[ Q(z) = 1 - Q(-z) \]  

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

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 \( T = \{T_1, T_2, \ldots, T_n\} \) 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 and unknown distance results \( Z \) desire to approximation parameters \( \theta \) with maximum likelihood and maximum a posteriori:

\[
\hat{\theta}_{\text{ML}} = \arg \max_{\theta} \log p(x|\theta) \]  

\[
\hat{\theta}_{\text{MAP}} = \arg \max_{\theta} \log p(x, \theta) \]  

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

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

\[
l(\theta) = \log p(x|\theta) = \log \sum_z p(x, z|\theta) \]  

\[
= \log \sum_z q(x, z|\theta) \frac{p(x, z|\theta)}{q(x, z|\theta)} \]  

\[
\succeq q(x, z|\theta) \frac{p(x, z|\theta)}{q(x, z|\theta)} \equiv F(q, \theta) \]  

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,

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

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

Starting through a number of initial assessment of the parameters \( \theta^0 \) among the E and M-steps until \( \theta^t \) 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, \( \gamma \) 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 $\rho_{reqd}$ 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,

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

Where $\alpha$ 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 $\rho_{reqd}$.

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.
of detection on perimeter of $S_i$ circle with radius $d_{eval}$. $C_i(x) = \text{Circle of } S_i \text{ with radius } x$

Input:

- $\rho_{reqd}$ Neighbor locations

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

Process:

1. ascertain $\rho_{eval}$ 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 $\rho_{reqd}$
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 $G_p & G_a$
17. sort $G_p & G_a$ in ascending order on $G_a$
18. if $G_a$ is all covered from 0 to $2\pi$ with $G_p = \rho_{reqd}$ 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 $500 \times 500$ 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

<table>
<thead>
<tr>
<th>No. of nodes</th>
<th>Network lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>ABC algorithm</td>
</tr>
<tr>
<td>100</td>
<td>500</td>
</tr>
<tr>
<td>150</td>
<td>845</td>
</tr>
<tr>
<td>200</td>
<td>1250</td>
</tr>
<tr>
<td>250</td>
<td>1432</td>
</tr>
</tbody>
</table>

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

<table>
<thead>
<tr>
<th>No. of nodes</th>
<th>Network lifetime</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heuristic</td>
</tr>
<tr>
<td>100</td>
<td>550</td>
</tr>
<tr>
<td>150</td>
<td>815</td>
</tr>
<tr>
<td>200</td>
<td>1256</td>
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<tr>
<td>250</td>
<td>1452</td>
</tr>
</tbody>
</table>

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.
Similarly the current work plan to extend the network lifetime. This EM_PCA method helps out to circumvent the battery drain of each and every 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 $\sigma$ 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 $(\rho_{reqd}, k)$, where $k$ is the degree of coverage.

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 $\sigma$ 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 $(\rho_{reqd}, k)$, where $k$ is the degree of coverage.

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

<table>
<thead>
<tr>
<th>No. of nodes</th>
<th>Throughput x 10^{-3}</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Heuristic</td>
</tr>
<tr>
<td>100</td>
<td>726</td>
</tr>
<tr>
<td>150</td>
<td>672</td>
</tr>
<tr>
<td>200</td>
<td>651</td>
</tr>
<tr>
<td>250</td>
<td>610</td>
</tr>
</tbody>
</table>

### REFERENCES


for target coverage problem in wireless sensor networks”. In INFOCOM, 2012 Proceedings IEEE (pp. 1584-1592). IEEE.


