SD AND SS TO SOLVE *K*-COVERAGE USING ABC ALGORITHM[1]

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ABSTRACT

In the wireless sensor networks the Networks life time plays a key role for the efficient working. The main theme of this paper is "How to deploy the sensor in different places and how to schedule them to get the maximum life time". Thus, the main concept of this paper is to identify optimal deployment locations of the given sensor nodes with a pre-specified sensing range, and to schedule them such that the network lifetime is maximum with the required coverage level. Generally we know that area coverage problems can be solved with many algorithms whereas to know the particular target working cannot be there. In this paper a proposal is there to solve the target coverage problems can be theoretically solved.

Index Terms- *Wireless sensor networks, target coverage, deployment of Sensors, K Coverage*

INTRODUCTION

As we know today the Wireless sensor networks plays a major role in every domains. There is a tremendous improvement in using the WSN in different applications like Controlling the Air Traffic, Missile controlling, Monitoring the Environment, Forest Monitoring etc., Initially the while using the WSN the main challenge facing is Network Life Time and energy which is used for working will be in limited access to grow its life time because the nodes we are using are the battery powered which cannot be easily recharged or replaced.

In the WSN needs to have guarantee of delivery of messages from nodes to base station where the monitoring was done should maintain the degree of reliability. Mainly concerning on the coverage problems, categorized as area coverage and target coverage problems. The Area Coverage problems are mainly concerning the Monitoring of the entire region of interest. The Target Coverage problems are mainly concern on the particular target which should be monitored. As mainly concerning on the Target Coverage problems and these are again categorized as Simple Coverage, K – Coverage and Q coverage.

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The other problem is deployment of Sensor nodes and this can be broadly categorized asRandom Deployment. And deterministic Deployment. The Random Deployment is mainly suited for the applications where the sensor regions are not known or the regions are inaccessible. The Deterministic Deployment is that the region details will be known and by which the network life time can be maximized in two ways i.e., at the Deployment Phase and the other is at the scheduling phase. By Sensor deployment and Sensor Scheduling contributes for the enhancementof Network life time Hence the Problem is Summarized as “The Sensors which are taken is deterministically deployed, where to deploy and how to deploy the sensor and to schedule them to solve the target coverage problem and to maximize the Network Life time”

There are many ways for computing the deployments issues in WSN and for the Scheduling of nodes. In this Paper we use ABC (Artificial Bee Colony) Algorithm for solving the sensor deployments locations and the Heuristic and PSO (Particle swarm Optimization) algorithms to compute the deployment

By all working observed that ABC algorithm will performs better than the heuristic algorithm in maximize the network lifetime. It is observed that ABC algorithm have more robustness than any other algorithm. Then after computing the sensor locations then by using the Heuristic algorithm is used to scheduling the sensors to gain the theoretical upper bound of network lifetime

RELATED WORK

Most of the researches focus on the Area coverage problems in the sensor deployments problem. Environment also creates the some disturbance in the sensor deployment. From the perspective coverage provides the quality of address of the deployment of sensors which provides the quality measurement which indicate the redeployment is necessary or not. By the Use of Voronoi- based methodology the sensor deployment problem is solved and propose the deployment patterns to attain the full coverage and different connectivity (3-4-5-6- etc.,) for WSN Amodifies Virtual force based method which results poor coverage but drawbacks of Connectivitypreserved virtual force (CPVF) scheme is overcomes. Many sensor node scheduling algorithms are there to solve the area coverage problems. A deployment strategy, with sensors having adjustable sensing ranges to cover an area, is also proposed.

In this paper we use ABC algorithm to solve the target coverage problems and it is applied to the dynamic deployment problems in WSN with mobile sensors on binary sensing model. It is also applicable for the regions where the number of targets to be monitored are more compared with the number of sensors to be deployed. Here the main aim is save energy by minimizing the sensing range requirements of the sensors.

Theoretical treatment of target coverage in wireless sensor networks address the problem of achieving an optimal network lifetime in surveying the sensor networks. The heuristic algorithm is used to schedule the sensor nodes to maximize the network lifetime and is easy to achieve the theoretical upper bound. In the literature Survey while computing the sensor deployment and sensor scheduling for the coverage problems many methodologies have been proposed separately

The work is started with the deploying the sensor nodes such that the upper bound of the network lifetime is maximized for the specific coverage of the requirement and the by the Heuristic is used to schedule the sensor nodes so that the network life time should be reached maximum

PROBLEM DEFINITION

Let us consider given a set of n targets T = {T_1, T_2……. T_N} located in u × v region and m sensor nodes S = {S_1, S_2,… ,S_m}, place the sensor nodes such that all nodes are covered as per the coverage requirement. The main theme is

1) The sensor nodes are deployed such that to achieve the maximum network life time
2) The sensor nodes are scheduled such that to achieve the upper bound of the optimal network lifetime

Computing the Upper bound of the Network lifetime, consider m sensor nodes {S_1, S_2,… , Sm}, deployed randomly to cover region R with n targets T = {T_1, T_2……. T_N}. let the each sensor node has an initial energy E_0 and the radius of sensing s_r. Also consider that sensor nodes S_i , $1 \leq i \leq m$, is said to cover a target T_j, $1 \leq j \leq n$, then the distance between the $S_i$and T_j is less than s_r. Then the Coverage Matrix is defined as follows

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

Where i= 1,2,3,…….,m and j= 1,2,3,… n

We define the $b_i{}' = \frac{b_i}{e_i}$ to denote the lifetime of the battery where the b_i is the initial battery power and e_i is the energy consumption rate of Si. The upper bound is maximum to achieve the network lifetime for a particular configuration and is calculated by using the below formula

$$U = min_j \left\lfloor \frac{\sum_i M_{ij} * b_i{}'}{q_j} \right\rfloor$$

For K – Coverage q_j= 1,2,3… ,n

Sensor Deployment to achieve K- Coverage: Given a set of n targets T = {T_1, T_2, . . . ,T_n } located in u × v region and m sensor nodes S = {S_1, S_2, , S_m }, place the nodes such that each target is monitored by at least k-sensor nodes and to maximize U .

Sensor Scheduling for the K-Coverage: Given a set of sensor nodes S = {S1, S2, . . . , Sm } with battery power B = {b1, b2, . . . , bm }, energy consumption rate ei for Si and a target set T = {T1, T2, . . . , Tn }, generate a schedule {C1, . . . , Cy }, for {t1, . . . , ty }, such that for all ticks, $1 \leq k \leq m$

1) each target is covered by at least k sensor nodes, $1 \leq k \leq m$
2) Network Life time is

$\sum_{p=1}^{y} t_p$ Is maximized

PROPOSED METHOD

As the sensor nodes are deployed deterministically, the prior to actual deployment will be decided at the base station and the optimal deployment locations and also the scheduling of sensors. The sensor nodes are dynamically deployed at different places, by using the theoretical upper bound of the network lifetime we calculate the optimal deployment locations using ABC algorithm. The heuristic algorithm is used to schedule the sensor nodes such that the network lifetime is maximum.

<u>Algorithm 1</u>

1: Input: S, T
2: Output: Optimal location of S and sensor schedule
3: Deploy S randomly
4: Compute upper bound of network lifetime using (2)
5: Recompute sensor node positions using ABC algorithm such that the upper bound of network lifetime is maximum
6: Design sensor schedule using the proposed heuristic for sensor scheduling such that thenetwork lifetime upper bound is achieved

<u>Sensor Deployment</u>

We found the upper bound network lifetime can be computed then we have to find the sensor deployment locations such that the network lifetime is maximum. Heuristic algorithm is used to compute the sensor nodes deployment locations and to computation the locations od the sensor nodes will be done by using the ABC and PSO algorithm.

1. <u>Heuristic algorithm for sensor deployment:</u>

Consider that the sensors are placed randomly, if any node is idle, the node is moved to the least monitoring targets location. The all sensor nodes play their part in monitoring the targets. Initially the sensor node is placed at the middle to cover all the networks and then it finds the new target which has to be find, it monitors continuously and collect the information. If the targeted node is out of the coverage then discard to move, then the upper bound is calculated. The main drawback of this approach is "Initially it depends on the initial position of the sensor nodes" but it performs a better results for the dense deployments, consistency cannot be always trustable

Algorithm2 A Heuristic for Sensor Deployment

1: Place sensor nodes randomly
2:for i = 1 to m do
3:if Si does not monitor any target then
4:Move Si to the least monitored target
5:Recompute sensor-target coverage matrix
6:end if
7:end for
8:S = Sensor nodes sorted in ascending order of number of targets it covers
9:for i = 1 to m do
10:repeat
11:Place Si at the center of all targets it covers
12:Move Si to the center of all targets it covers and its next nearest target
13:if Si can cover a new target then
14:Recompute sensor-target matrix
15:else
16:Discard move
17:end if until Si can cover another target
19:end for
20:Compute upper bound of network lifetime using (2) equation

2. ABC Based Sensor Deployment:

It is an optimization algorithm based on the intelligent behavior of the Honey bee. The honey bees are categorized as employed bees, onlookers and scouts.The employed bee takes the load the nectar from the flowers and unloads the nectar in the hive where they store the food. After the unloading of the nectar bee performs a special dance called "WAGGLE" dance which contains information about the direction in which the food will be found, its distance from the hive and its quality rating. Since information about all the current rich sources is available to an onlooker on the dance floor, an onlooker bee probably could watch numerous dances and choose to employ itself at the most qualitative source. There is a greater probability of onlookers Algorithm 3 describes ABC algorithm. Let the solution population be B . The region is assumed to have only stationary targets. Each solution $Ba = \{(x_1, y_1), (x_2, y_2), \ldots, (x_m, y_m)\}$ where $a = 1, 2, \ldots, n_b$, where n_b and m represents total number of bees and total number of nodes respectively, corresponds to a bee. The initial solution is generated in such a way that all the targets are covered, and each sensor node covers at least one target. The network lifetime is computed for each solution using (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 $D_i = (X_i, Y_i)$ be the initial position of i t h cluster. $F(D_i)$ refers to the nectar amount at food source located at D_i. After watching the waggle dance of employed bees, an onlooker goes to the region of D_i with probability p_i is defined as

..........(3)

where m is the total number of food sources. The onlooker finds a neighborhood food source in the vicinity of D_i as,

$$D_i(t+1) = D_i(t) + \delta_{ij} \times f \quad \text{.....................(4)}$$

whereδi j is the neighborhood patch size for j t h dimension of i t h 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 areevaluated 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 chosen as the best solution.

<u>Algorithm 3 – ABC Algorithm</u>

Initialize the solution population B
Evaluate fitness
cycle = 1
repeat
Search for new solutions in the neighborhood
if new solution is better than old solution then
Memorize new solution and discard old solution
end if
Replace the discarded solution with a new randomly generated solution
Memorize the best solution
cycle = cycle + 1
until cycle = maximum cycles

3. PSO Based sensor Deployment

The Particle swarm Optimization consists of swarm of particle moving in a search space for a possible solutions for the problem. Each particle contains the memory that stores its own best position so far and best position through which communication is obtained with its neighbor particle. It swarm of w candidates which explore in n_d dimensional hyperspace in search of global solution. A particle p occupies position x p_d and velocity v p_d in the d t h dimension of the hyperspace, $1 \leq p \leq w$ and $1 \leq d \leq n_d$.

Here, ϕ_1 and ϕ_2 are constants, and $r_1(t_r)$ and $r_2(t_r)$ are random numbers uniformly distributed in [0,1].

$$v_{pd}(tr+1) = w.v_{pd}(tr) + \varphi_1.r_1(tr).pbest_{pd} - x_{pd} + \varphi_2.r_2(tr).(gbest_d - x_{pd})$$

$$x_{pd}(tr+1) = x_{pd}(tr) + v_{pd}(tr+1).$$

Algorithm 4 - PSO Algorithm

1: Initialize particles
2: repeat
3: for each particle do
4: Calculate the fitness value
5: if fitness value is better than the best fitness value (p_{best}) in history then
6: Set current value as the new p_{best}
7: end if
8: end for
9: Choose the particle with the best fitness value of all the particles as the g_{best}
10:for each particle do
11:Calculate particle velocity according to velocity update equation (5)
12:Update particle position according to position update equation (6)
13:end for
14:until maximum iterations or minimum error criteria is attained

Heuristic Algorithm for Sensor Scheduling:

It is used to schedule the sensor nodes to achieve the theoretical upper bound of the network life time, so we proposed a weight based method for determing the cover sets which includes the following steps

1. Weight assignment
2. Cover formation
3. Cover optimization
4. Cover activation and Energy reduction

Algorithm 5 - Heuristic for Sensor Node Scheduling

Input M, B
Initialize k/Q, max run, priority calculated using battery power
for r = 1 to max run do
for iteration = 1 to
if cover possibility exists then
Determine cover based on priority
Optimize cover
Activate optimized cover and reduce battery power
else
    break
    end if
    end for
    Calculate network lifetime (n_{life})
    if $n_{life} < U$ then
    Consider weight due to covered targets to compute priority to check for better lifetime
    else
    break
    end if

Nodes with different coverage degree may coexist in a network. Though the initial battery power of all the nodes in the network might be the same, subsequently it may vary in accordance with the cover activation.

The weights are recalculated for all the nodes at each time instant if,

1. Weight due to the remaining energy changes: It happens due to reduction in battery power for nodes which were in the previous cover.

2. Node turns off due to no battery power: If a sensor node that monitors a target turns off, it will reassign weights to all other sensor nodes monitoring it.

The weight due to the covered targets can be calculated by using the below formula

$$w_i = \sum_{i=1}^{n} \frac{M_{ij}}{\sum_{i=1}^{m} M_{ij}} \qquad \text{.........................(7)}$$

5. Cover Formation :

To cover all the targets in K Coverage a cover can be generated in different ways if the network has many nodes. The proposed approached uses a priority based method to select the nodes In general, a sensor node Si can be added to a cover set Cov _S if and only if for k-coverage problem: Cov _S U {Si } contributes to k-coverage requirement

Algorithm 6 – Cover Function

1: Input:Sorted S in descending order of assigned weight
2: Output: Cov _S
3: Initialize Cov _S = φ
4: for i= 1 to m do
5: if Si contributes to coverage then
6: Cov _S = Cov _S ∪ {Si}
7: end if
8: if coverage requirement met then
9: break;
10: end if
11:end for

Cover Optimization:

By optimizing the generated cover, minimized energy usage can be there by the proposed scheme attempts. During this a problem will be raised with the formation of the cover at its phase that it cannot cover all the nodes and targets. But this can be solved by step by step addition till the targets are covered. The nodes in the cover set are subject to optimization using least priority first approach. This method of elimination the high priority nodes being discarded and the least priority nodes will be in the cover and cannot be eliminated as it satisfies the k- coverage requirement. Elimination starts from the last but one node as per increasing priority. A node Si ∈ Cov _S, 1 ≤ i ≤ length (Cov _S), represented as Si Cov _S will not be added to the optimized cover set O pt. Cov _S if Cov _S − {Si .Cov _S} meets k/Q coverage requirement

Algorithm 7 Cover Optimization

1: Input: Cov _S
2: Output: O pt .Cov _S
3: Initialize O pt. Cov _S = φ
4: for i = length (Cov _S) down to 1 do
5: if Cov _S − {Si .Cov _S} meets k/Q coverage requirement then
6: Ignore Si .Cov _S
7: Cov _S = Cov _S − {Si .Cov _S}
8: else
9: O pt .Cov _S = O pt .Cov _S ∪ {Si .Cov _S}
10: end if
11: end for

Cover Activation and Energy Reduction:

The nodes in the optimsed cover are activated. The total energy consumes by the sensor nodes will not fall beyond the minimum usage of energy, E_{min}, if it is beyond its limit then the nodewill be automatically inactive state and will be able to monitor the targets further. Let us assume that number of sensor nodes deployed in the area is greater than the optimum required to monitorthe targets so the sensor cover switches from one node from other in a scheduling manner such that only the minimum nodes should be active.

Algorithm 8 – Cover Activation and Energy Reduction

```
Input: O pt .Cov _S
for i = 1 to length (O pt .Cov _ S) do
Si .state = true
decrement bi
if bi ≤ Emin then
for j = 1 to n do
Mij = 0
end for
end if
end for
```

CONCLUSION

In this paper we compute the deployment locations using the ABC Algorithm to achieve the maximum lifetime of the network. In order to avoid the battery drain all the nodes are schedule at a time and the minimum number of nodes are only work which satisfies the coverage requirement needed to turn on the battery and the other which are remain idle will be used further. As this is a theoretical approach to solve the Sensor scheduling and deploying in the K- coverage. The future work will be implementing them practically and also extending my work to deployment and scheduling for probabilistic coverage in WSN

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