An Efficient Approach of Deployment and Target Coverage in Wireless Sensor Networks

Surbhi Sachdeva, Naresh Kumar

Abstract: Sensing a given particular zone is one of the main goals of wireless sensor networks. This consists of deploying the sensor nodes in order to detect any event occurring in a particular zone of interest and gives this information to the sink. It should also be energy efficient so as to maximize the network lifetime. The lifetime maximization in sensors network with target coverage can be considered as: To divide the sensors in set covers in such a way that each set cover can cover all the targets at a particular instant of time. We have to find maximal number of set covers which becomes active successively. This arrangement can maximize the lifetime of the network. In this paper, I have proposed an efficient SDSG algorithm that produces maximum number of disjoint sets of the sensors, such that each sensor set is a set-cover. I have also compared proposed algorithm with Simple Greedy and Greedy MSSC algorithm.

Keywords: SDSG, Greedy MSSC, Networks

I. INTRODUCTION

Wireless Sensor Networks is an arrangement of some specified components that can sense, compute and communicate to each other, in such a manner that can extract and observe the information from the outside environment, and the environment can be a biological system, physical environment or an IT framework.WSN is a group of low-cost, low-power, multifunctional and small size wireless sensor nodes that work together to sense the environment, perform simple data processing and communicate wirelessly over a short distance. Wireless Sensor Networks have a large range of the applications. In current time wireless sensor networks are being use everywhere. Due to the applications and convince of these WSNs we are getting into habit of these networks and in the current days these networks are being part of our life. A wireless sensor networks contains a huge number of wireless sensors. These wireless sensor nodes are deployed into a physical environment. A wireless sensor node has the capability of capturing the outside environment that is covering it. To find an efficient, effective and reliable performance, the deployment and sensor node selection must be done by keeping characteristics of physical environment in mind. Due to the size limitation each sensor node has limited power. So in most of the wireless sensor networks design of most protocols focus on as less as possible energy consumption. The deployment of wireless sensor nodes in one of the most crucial issue is development of the protocols of the Wireless Sensor Network.

The deployment strategy determines the position of the wireless sensor nodes in the deployed network. It is not necessary that the deployment should be predefined.

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Deployment can be random or according to any algorithm. If the deployment is random then it requires the special self-organizing communication protocols. The sensing range of the sensors is low, so it makes the dense deployment in the nature. Hence the communication use multi-hop communication protocol, that makes it more challenging for routing, communication and overhead problems.

II. TARGET COVERAGE IN WSN

Coverage is a crucial issue in the Wireless Sensor Networks. It determines how well an area or the targets are being covered by a sensor network, i.e. it gives a measure to define the quality of performance of the sensor network. Different measure captures the different aspects of performance. In wireless Sensor Networks there are two types of coverage 1) Target Coverage and 2) Area Coverage. In Area Coverage we have to deploy sensors in such a manner that covers to the entire given area all the time of the sensor network life. And in Target Coverage, we have some targets (locations of the targets are known already) and we have to deploy the sensors in such a manner that covers all the targets all the time of the sensor network life.

Target coverage in wireless sensor network is the task of covering all the targets spread in an area with the given sensors all the time. We know the locations of the sensors. In Target Coverage Problem, the fixed numbers of targets are continuously observed by a number of sensor nodes. Possibly, each target is monitored by at least one sensor node. There are a specific number of targets which are to be covered by a set of sensor nodes. After getting deployed, the sensor nodes start the task of monitoring the said targets. Since sensor nodes are provided with only some limited resources and can't withstand extreme environmental conditions, they are deployed in large number much more than actual requirements. A sensor covers all the targets which lie within its sensing range.

III. PROPOSED WORK

The lifetime of the network will equal to the sum of lifetime of all the set covers. Thus to increase the life time of the sensor networks then we will have to find the maximum number of the set covers from the given number of sensors. As it is known that all the sensors are of homogenous type so their all characteristics are equal, their lifetime is also same. The life time of the set cover is equals to the minimum lifetime of any sensor in the set. So here it clears that the lifetime of a set cover is equals to the lifetime of the lifetime of any sensor in that cover.

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Now our objective is to find maximum set covers. We can divide the set of sensors into maximum set covers only if each of the set cover contains minimum sensors, i.e. if each set cover is minimal then we can find the maximum number of set covers, and as the number of set cover increase the lifetime of the network also increase.

Given:

- N sensor nodes: S1, S2, S3, …, Sn
- M targets : T1, T2, T3, ,…, Tn
- P sensing ranges : R1, R2, R3,…,RP

And the corresponding energy consumption E1, E2, E3, …, EP ;

IV. GREEDY ALGORITHMS

The name Greedy describes its nature. It selects best solution available at any particular instant of time and considers it as best Global solution or a part of Global solution it global solution contains a series of small solutions. Greedy approach is simple and straightforward. It is directly to the point in this strategy the method is to finds the solution just by analysing the current information in the hand without taking care of the future result. It is very easy to use and implement this approach.

A. Functions of Greedy Algorithm:

- Tells either chosen set of items provides a solution or not.
- Checks the feasibility of a set.
- The selection function that shows which of the candidates is the most promising.
- An objective function, which does not appear explicitly, gives the value of a solution.

As we have discussed that to maximize the lifetime of a WSNs, it required to find maximum number of set covers. Now we will discuss the Greedy Algorithms to find maximum number of set covers. Here we will discuss the set-cover generation algorithms using greedy strategy. These algorithms generate a set cover. To find maximum number of set covers repeat the algorithm again and again until it finds all the possible set covers.

B. Types of Greedy Algorithms for Set cover Generation

There are two methods for generating set-covers for a wireless sensor networks using Greedy Method.

- Simple Greedy Set-cover Generation
- Greedy MSSC (Maximum Sensor Set-Cover Generation)

These algorithms take targets and sensors as input and provide a set-cover. To find maximum number of set-cover call these algorithms again and again until it finds all the possible set covers.

V. SIMPLE GREEDY METHOD OF GENERATING SET-COVER

Babacar DIOP [1] has given Greedy approach for lifetime maximization problem with respect to target coverage in WSNs. The lifetime maximization problem in target coverage application can be addressed by determining "How to partition sensors into an optimal number of sets and schedule their operating intervals so that coverage requirement can be satisfied and the network lifetime can be maximized." This greedy approach produce disjoint set covers. The simulation result shows the performance of generating the sensor-covers v/s number of sensor used. This method produces the maximum disjoint set-covers those activate one after another.

A. Assumptions

- The number of targets is fixed and all targets are static.
- The locations of targets are predefined.
- Several low power sensors are deployed randomly.
- This method is using disjoint set approach.
- Sensors are being deployed randomly into the plane.
- All sensors are homogeneous

B. Algorithm Greedy-Sensors Set Covers Generation

```
Input: Set of targets Z=Z1, Z2, …, Zn
        Set of sensor S=S1, S2, …, Sm
Result: C=number of set covers
Begin;
        Generate s[m][n]= covering matrix by sensors;
        Uncovered=Z, C=[];
        While (Uncovered≠Null) or (S≠NULL) do
                X=[]
                for i=1 to m do
                        if  S[i]∩Uncovered≠NULL  then
; ∩ is covers
                                insert S[i] into list X;
                        [End If]
                [End for loop];
                C=C U X;
                P=set of targets being covered by the X;
                Uncovered=Uncovered-P;
                S=S-X;
        [End While]
        Return C
End
```

VI. GREEDY MSSC (MAXIMUM SENSOR SET-COVER GENERATION)

In [1] author proposed an improved version of the simple greedy approach we discussed earlier to generate more number of set covers for network's lifetime maximization. In the previous approach it takes every sensor into set-cover which is covering at least one new target, and repeat this process again and again until we find the sensor cover. In this case it does not give best result many times such as when new node is covering maximum nodes which are already covered, thus this approach increase the size of sensor cover.

A. Algorithm 2: Greedy MSSC Set Cover Generation

Input: Set of targets $Z=Z_1, Z_2, Z_3, \ldots, Z_n$

Set of sensors $S= S_1, S_2, \ldots, S_m$

Result: C=Number of set covers.

Begin;

```
        Generate s[m][n]=covering matrix by sensors;
        uncovered=Z, C=[];
        While (Uncovered≠NULL) or (S≠NULL) do
                count=0;
                max=0;
                for i=1 to m do
                        uc=s[i][n];    no. of uncovered
                targets covering by i^th sensor;
                        if uc> max then
                                Count=i;
                                max=uc;
                        [End if]
                [End for]
                X=Count; the sensor which is covering
        maximum uncovered targets;
                C=C U X;
                P=set of targets being covered by sensor
        X;
                Uncovered= Uncovered-P;
                S=S-X;
        [End while]
        Return C
End
```

VII. PROPOSED EFFICIENT SDSG METHOD

Here we present more improved version than Greedy MSSC, we discussed earlier. In the Greedy MSSC method it analyses all the sensors and find the sensor which is covering maximum uncovered targets, and add it to the set-cover. Then it repeat this process until either all targets get cover i.e. until it finds a set cover or all sensors comes are over. In some cases it may not give best result many times.

For example

We have 4 sensors W; X; Y; Z and 7 targets as A; B; C; D; E; F; G.

Consider the sensors are covering the targets as follows:

- W = A, B, C, D
- X = D, E, F, G
- Y = E, F, G
- Z = A, B, C
- If we go through the Greedy MSSC for set cover generation:
- In first sensor it has to select either W or X because both are covering 4 uncovered targets, let us consider it select W in first iteration now we have sensor-set as W. And covered targets as A, B, C, D, while uncovered targets as E, F, G.

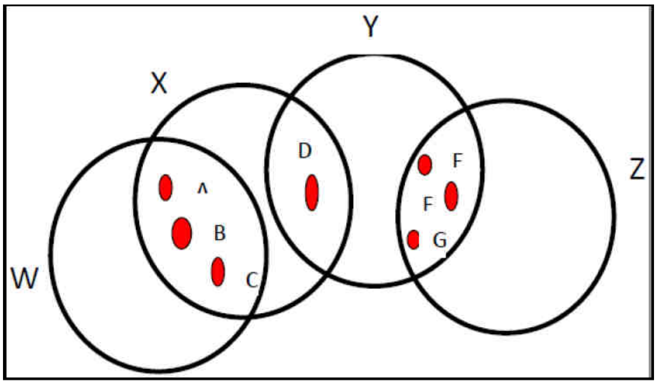

Figure 1: Efficient SDSG

- Now for second sensor selection this method has two choices X and Y because both are covering same number of uncovered targets 3. If it selects X then it gives sensors-set W; X. Now covered targets are A, B, C, D, E, F, G, and set of uncovered targets is NULL.
- If we go for another set cover generation, it is not possible.
- This method gave one set cover.

Now we propose an efficient method over greedy using MSSC that always gives either better or equal result than to Greedy using MSSC. The Greedy maximum sensor set cover generation finds all the sensors which are covering maximum number of uncovered targets, and selects one either first one or randomly and add it to set-cover and repeat this process until either set-cover is generated or all sensors are over. While here we also find all the sensors which are covering maximum number of uncovered targets. If only one sensor is covering maximum targets then it selects that sensor and add it to set-cover, Else if more than one sensors are covering same number of targets then we see the total numbers of targets being covered by the each sensor and then select the sensor which is covering minimum targets in comparison to other sensors.

Now we will generate set cover for the above example using Efficient SDSG:

- In first it has two choices so it has to select either W or X because both are covering 4 uncovered targets, let us considers it select W in first iteration now we have sensor-set as W. And covered targets as A,B, C, D, while uncovered targets as E, F, G
- For second sensor selection this algorithm has 2 choices X and Y both are covering 3 uncovered targets. Now we have two sensors so we finds the total number of targets being cover by the X and Y, that is as follows: X covering 4 targets and Y covering 3 targets
- This method will select Y as second sensor and add it to set cover. Now it gives sensors-set/set-cover W, Y. Now covered targets are A, B, C, D, E, F, G, and set of uncovered targets is NULL.
- If we go for another set cover generation, this method will again generate another set cover as X, Z.
- This method gives 2 set cover while previous one is giving only 1.

A. Algorithm: Efficient Superlative Disjoint Sensor Groups (SDSG) of Target Points

Input: Set of targets $Z=Z_{1,} Z_{2,} Z_{3, \ldots,} Z_n$
Set of sensors $S= S_1, S_2, \ldots, S_m$
Result: C=Number of set covers.
Begin

```
        Generate s[m][n]=covering matrix by sensors;
        Uncovered=Z, C=NULL;
        While (Uncovered≠NULL) or (S≠NULL) do
                Pi=find all the sensors which are covering
        same as well as maximum number of    uncovered
        targets;
```


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if Pi==1 then
ind=index of sensor;
Else
ind=Index of sensor covering minimum number of targets;
[End if]
[End While]
X=find the sensor which is covering maximum uncovered targets;
C=C U S_{ind};
tar=set of targets being cover by the ind;
Uncovered=Uncovered – tar;
Si=Si-X;
Return C;
End

VIII. RESULTS

I have implemented my proposed work in MATLAB. I have taken 20 targets in an area of 1000 X 1000 m^2 with their fixed and pre-defined locations.

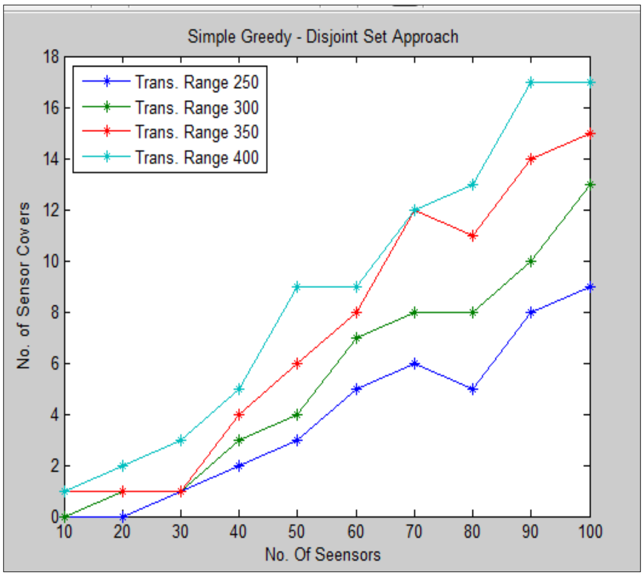

Figure 2: Simple Greedy

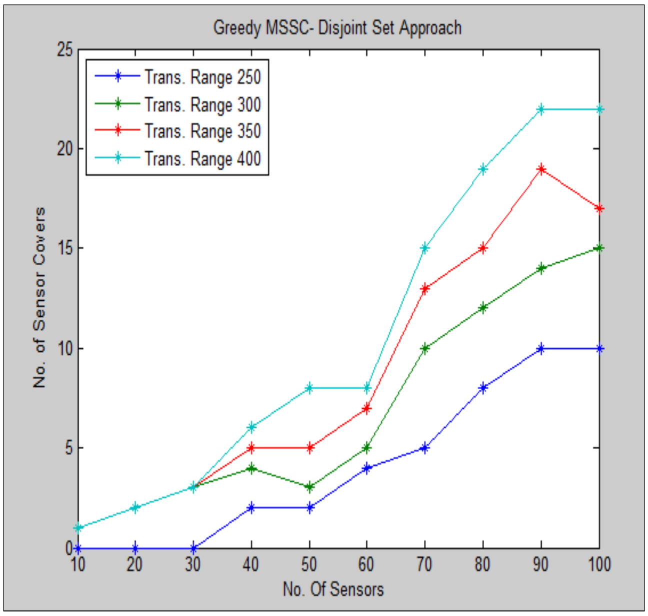

Figure 3: Greedy MSSC

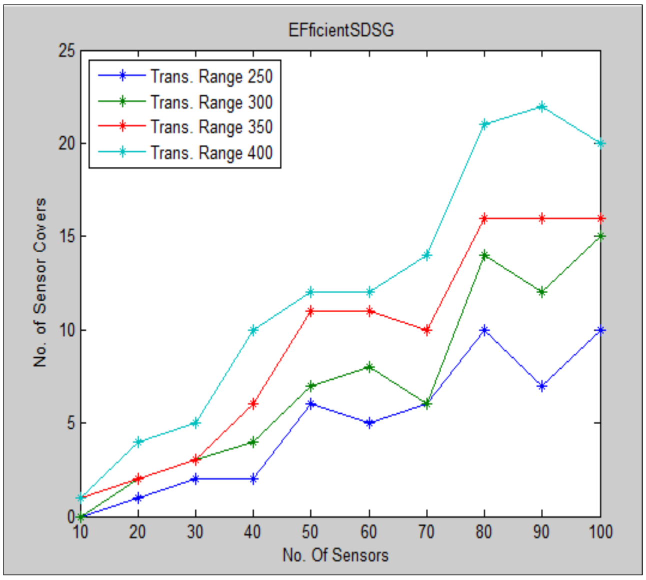

Figure 4: Efficient SDSG

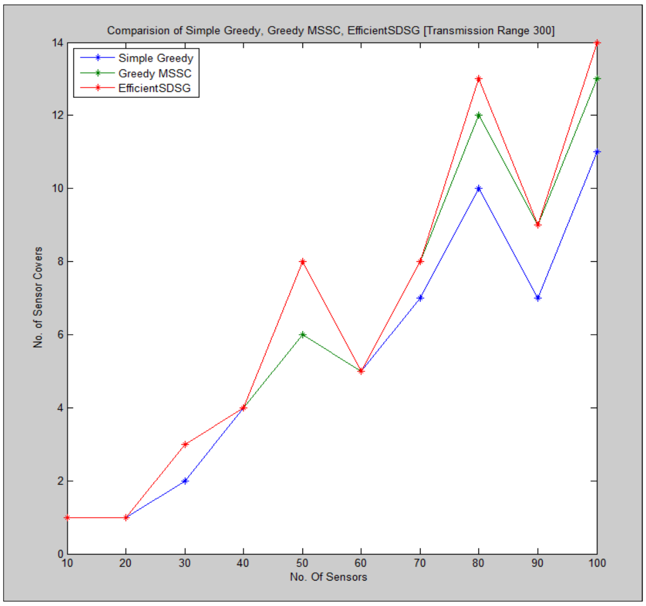

Figure 5: Comparison of Simple Greedy, Greedy MSSC and Efficient SDSG.

IX. CONCLUSION

I have proposed the scheduling of the sensors for WSNs with the coverage constraint is that all the targets must be covered all the time continuously. There are many schemes for maximizing the life time of the wireless sensor networks, and found dividing the sensors into various disjoint sets is an effective and good approach. Find the maximum number of the disjoint sensor covers from set of all sensors, and let the sensor cover active/work one by one. As the number of sensor cover increase the lifetime also increases. This problem can be discussed using combinatorial optimization theory. In this work three sensor cover scheduling algorithms are presented, the Simple greedy, Improvised Greedy using MSSC, and the efficient SDSG algorithm, to solve the DSC problem.

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The simulation has performed for the various numbers of sensors to observe the effect of the algorithm on the performance towards the lifetime maximization problem. The results of simulation shows that the efficient SDSG scheme generates more number of the sensor-covers than Greedy MSSC and thus increases the lifetime of the network.

X. FUTURE SCOPE

For the future work we are trying to combine Efficient SDSG method with sensors placement techniques for reaching closer to more optimal solution.

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