An approach for solving target coverage problem in wireless sensor network

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Abstract— Target coverage is considered as a major problem in case of wireless sensor network. This kind of condition can consequentially reduce the minimum energy consumption. One of the well known technique for this problem is non disjoint set cover problem. In this paper we are trying to realize this target coverage problem in a wireless sensor network environment. Basically we need to consume the energy in various nodes so that the critical period can be handled. A Euclidean based approach is taken where the concept of non disjoint set cover is used for efficient energy consumption. Then a greedy algorithm based approach is proposed where we introduce a uncovered function to find the best solution among a no of solutions (i.e. the nodes) with an aim to maximize the network lifetime with minimum no of utilized sensor nodes.

Keywords-non disjoint set cover, wireless sensor network, Euclidean approach, Greedy algorithm, target coverage

I. INTRODUCTION

From last few years wireless sensor network [1] became an rising trend. It enables the sensor node to combine sensing, processing and communicating capabilities into small low cost sensor devices. Once these nodes get deployed , they self organize to form wireless sensor network (WSN) and communicate via wireless links to perform a specific task of real world [3,6].Availableness of sensor nodes with varieties of sensing capabilities results in hundred of applications including National Security[1,2], Habitat Monitoring[2,7,8],Environment observation and forecasting[2,19],Health Applications[1,2,10],Home and Office Applications[2,11].Therefore WSN's are becoming an practical research field with different activities carried out every year to research and solve different constraints.

Target coverage problem [3] is a major problem which is concerned with the coverage of specific targets by the sensor nodes. These nodes require energy for performing the coverage task. Since, the sensor nodes are usually battery powered, therefore judicious management of energy is an important concern so that coverage task can be performed for a maximum duration.

There are some solutions [3] to handle the problem of target coverage and the researchers are seeking solutions such as:-

1. No. of sensors
2. No. of targets
3. The distance between the sensor i and target k.
4. The distance between the sensor j and target k.

To handle target coverage it is hard to anticipate about the reduce in energy consumption when it is going to reduce, for how long it will last. So supplying of extra resources is not an efficient solution to this problem. This is the reason we need a set cover problem that can statically reduce minimum energy consumption when needed, so that it can perform the coverage task.

When going for handling target coverage problem, we have to face three major problems [3]:

1) Discovering of the sensor nodes and their allocation to the respective targets statically.
2) How to make the target coverage process non disjoint in order to quickly react to the sudden reduce in energy consumption and hence maintain the energy availability even during a critical period.

3) How to overcome the bottle necks in the sensor network infrastructure.

For solving the problem energy consumption with static contentment are considered. For static contentment energy consumption the most common bottleneck is the access network bandwidth.

The remaining of the paper is organized as follows: Section 2 describes the detailed related work done. Section 3 describes the proposed Greedy based approach towards the solution of the target coverage problem . Section 4 gives the comparison with the related work and Section 5 concludes the paper.

II. RELATED WORK

Target coverage being a major problem and can reduce the minimum energy consumption. To find a solution and then deploying the technique to find the result is very important.

Manual control on this whole process would surely affect the energy consumption so we have to find an set cover problem that can find an solution instantaneously and appropriately.

Purnima Khuntia et.al [3] proposed an algorithm to perform the coverage task with minimum participation of sensor nodes to cover the targets, thereby consuming minimum energy. The author has proposed an energy efficient method for target coverage is to make the sensor nodes be part of more than one set cover .With the sensor nodes altering between the active and sleep modes several non-disjoint set covers of active sensor nodes are made to activate successively where each set cover is capable of keeping track of all the specific targets until the energy exhaustion of sensor nodes. This procedure is much more energy efficient as compared to disjoint set cover method of target coverage , thus maximizing the network lifetime to some more extent.

Mihaela Cardei et.al [4] proposed an efficient method to extent the sensor network life time by organizing the sensors into a maximal number of set covers that are activated successively. Only the sensors from the current active set are responsible for monitoring all targets and for transmitting the collected data ,while all other nodes are in a low energy sleep mode . By allowing sensors to participate in multiple sets, our problem formulation increases the network life time , that has the additional requirements of the sensor sets being disjoint and operating equal time intervals.

Sung-Yeop Pyun et.al [5] proposed an energy-efficient sensor-scheduling algorithm for multiple-target coverage (MTC) that considers the transmitting energy according to the number of targets covered by the sensor and removes the redundancy of overlapped targets. We design a sensor scheduling algorithm by constructing the maximum number of joint sets for a given coverage relationship. Then, by determining the active time of each joint set, the lifetime of the network can be maximized while ensuring that all the targets are completely covered. Once the active time of the joint sets has been determined, each joint set is activated in order. Only the sensors in the activated joint set go into active mode for the purpose of observing all the targets and transmitting the sensed data to the sink node. Sensors in joint sets that have not been activated remain in sleep mode, to conserve power.

III. OUR PROPOSED WORK

3.1 Greedy algorithm based target coverage problem:

Greedy algorithm is basically a searching algorithm that is used to select a sensor which has the maximum no of uncovered nodes for n number of sensors so that the minimum energy consumption is possible. In case of a tie two sensor has to sense equal no of targets so that it can select the sensor with higher remaining energy life. Energy consumed by a sensor are sensing energy and communication energy. The sensing energy is the energy spent in sensing whereas the communication energy is the energy spent in communication between two sensors for transferring the data and hence we can say that sensing energy is less than the communication energy and the remaining energy left in the sensor is known as the residual energy. It combines the exploitation of past results with the exploration of new results to get an optimum solution. By using the uncovered function , greedy algorithm can implement innovative searching about the sensor nodes.

The structure of the greedy algorithm can be described as a loop consists of a sensor followed by a sequence of sensing range and the remaining battery life of a sensor. In a loop the the rate of sensing range and the remaining battery life of a sensor are fixed. The loop continues until it meets some stopping condition like execution time, optimal result etc.

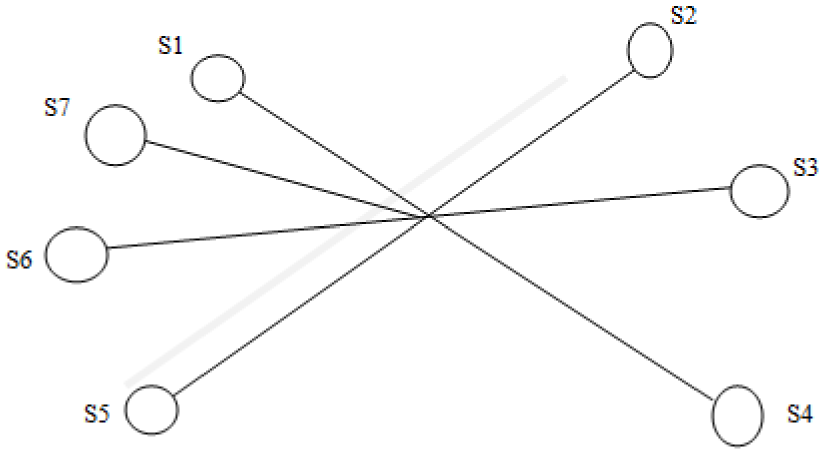

Figure 1: A sensor target coverage scenario.

Assumptions:

1 .We assume targets and sensors are static.

2. All sensors have uniform sensing range.

S1=u1, u2,….,u7

Here 7 no of uncovered nodes.

S2=u2, u3,u4,u8

Here 1 no of uncovered node.

S3=u7,u8, u10,u11

Here 2 no of uncovered nodes.

S4=u7, u8,u10,u11

Here 0 no of uncovered nodes.

S5=u3,u4,u5,u6,u7,u8

Here 0 no of uncovered nodes.

S6=u8,u9,u12

Here 2 no of uncovered nodes.

S7=u2,u4,u5,u6

Here 0 no of uncovered nodes.

(a) for i=1 to n
{check which sensor has maximum no. of uncovered nodes
S1 is selected
[A] in case of tie (i.e. same no of uncovered nodes)=(then target nodes set covered has more battery life remaining choose the target one.
S3= u7,u8,u10,u11, P= {u10,u11}
S6= u8, u9 ,u12, P={u9,u12}
2 no. of uncovered nodes
then compare the uncovered nodes of the two sensor set S3 and S6.
If same then choose sensor with higher battery.
If separate then also choose S with the battery but sensor having less battery =uncovered node set

3.2 Our Proposed algorithm:

Greedy algorithm based target coverage problem can be executed in the following steps:

1. Let S={S1,S2,S3,……..SN} denotes the set of sensor nodes in the wireless sensor network.
2. Let U={U1,U2,U3,…………..UK} denotes the set of target nodes that have to be accessed.
3. Let r=0 is a sensing radius where the set of all sensors to sleep mode t.
4. Now our aim is to select the sensor which has maximum no. of uncovered nodes i.e. S1 is selected.

5. In case of a tie (two sensor sense equal no. of targets).
6. Then select sensor with highest remaining energy life.
7. For remaining 2 to n no. of sensors.
8. Select the another set li which has less than maximum no. of uncovered nodes than li.
9. Check no. of targets covered.
10. Reduce the sensing range gradually and check how many uncovered targets.
11. If all the targets same (covered) by another sensor then set to sleep mode and r=0.
12. Battery reduction

    f(b)=f(t, radius no. of targets)

    b=b-f(b)
13. If battery level of any one sensor si in the set cover goes below a threshold value =repeat f(b) <=threshold value.
14. First check the next six neighbours of the sensor Si which are in sleep mode.
15. Till all the targets covered=set cover.
16. Now formed set cover formation look done whether the sensor energy life of any of the sensor is the set cover fall below the total life time.

IV. COMPARISON WITH RELATED WORK

In the design model of non disjoint set cover problem [3] a cost effective mechanism was applied to handle the minimum energy consumption. By using the redundant node concept where a particular node a target is covered by the sensor nodes and that monitors the targets for a maximum duration we assume that the sensor node covers the target if the Euclidean distance between the sensor node and the target is smaller or equal to the sensing range of the node. According to it different sensor nodes can form a mutual aid community of sensor network, so that in case of critical period[4] more targets have to be covered and it can use the spare capacity of other sensor nodes in the community both in terms of number of sensors as well as with the regard to the residual energy of those sensors. Once the critical target has been selected , the heuristics selects the sensor with the greatest contribution that covers the critical target.

Sensor-scheduling algorithm [5] for multiple-target coverage (MTC) that considers the transmitting energy according to the number of targets covered by the sensor and removes the redundancy of overlapped targets. A sensor scheduling algorithm is designed by constructing the maximum number of joint sets for a given coverage relationship. Then, by determining the active time of each joint set, the lifetime of the network can be maximized while ensuring that all the targets are completely covered. Once the active time of the joint sets has been determined, each joint set is activated in order. Only the sensors in the activated joint set go into active mode for the purpose of observing all the targets and transmitting the sensed data to the sink node. Sensors in joint sets that have not been activated remain in sleep mode, to conserve power.

For my work by using the non disjoint set cover problem we are using the uncovered function to find the best solution among a no of solutions (i.e. the nodes) with an aim to maximize the network lifetime with minimum no of utilized sensor node.

V. CONCLUSION AND FUTURE WORK

In this paper , at first we have defined the problem of target coverage in a sensor network community and have analysed the probable solutions to this problem. A simple overview of non disjoint set cover problem showed an efficient way to solve the problem .

For realization of target coverage in a wireless sensor network we introduced two approaches : one is Euclidean based approach and another one is the Greedy algorithm based .

The Euclidean based approach describes how we can implement the concept of Euclidean for target coverage problem. In the Greedy algorithm based approach, the process is executed through the following steps, by defining a uncovered function to evaluate the best solution.

Our future work involves the implementation of both the approaches in a wireless sensor network environment. The Euclidean based approach will be compared with the Greedy Algorithm based approach and a comparison will be done . In my next paper a simulation study will be performed for both the approaches considering the parameters –uncovered node , remaining battery life of a sensor ,the sensor target distance and the no. of target/sensor.

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