

Improving Target Coverage and Network Connectivity of Mobile Sensor Networks

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Abstract - Target coverage and Network connectivity are two main challenging issues of mobile sensor networks. Target coverage covers a set of specified points of interest in the randomly deployed MSNs. Target coverage is usually interpreted as how well a sensor network will cover an area of interest. Coverage of interest points and network connectivity are two main challenges of Wireless Sensor Networks (WSNs). MSD problem has again two problems i.e., Target coverage (TCOV) and Network connectivity (NCON). For general cases of TCOV, two heuristic algorithms, i.e., the Basic algorithm based on clique partition and the TV-Greedy algorithm based on Voronoi partition of the deployment region, are proposed to reduce the total movement distance of sensors. For NCON, an efficient solution based on the Steiner minimum tree with constrained edge length is proposed. The combination of the solutions to TCOV and NCON, as demonstrated by extensive simulation experiments.

Key words- Wireless sensor networks, target coverage, connectivity, mobile sensors, energy consumption

I. INTRODUCTION

Wireless sensor networks are used in many application. In this paper WSN has been used for environmental monitoring and object tracking. Target coverage and connectivity are two main challenging and practically important issues of WSNs. Target coverage aims to cover a set of specified points of interest in the deployment region of a WSN. A wireless sensor network is a set of physically distributed sensor nodes. For network connectivity sensors are used to performs the task of collecting important data, processing the data, monitoring the environment, etc.

1. For the case of TCOV, Basic algorithm and TV greedy algorithms are used. In case of Basic algorithm, it is used to reduce the total movement distance by minimizing number of sensor. In case of TV Greedy algorithm, it will minimize the distance by grouping and dispatching the sensors.

2. For NCON problem first an edge length constrained Steiner tree is constructed. It will determine the Steiner points and these points are used to connect coverage sensors in the selected area and then the extended Hungarian method is used to find the optimal sensors to move to these points.

3. Extensive simulation experiments are conducted to evaluate the performance of the proposed algorithms. The simulation result gives the combination of the solutions to TCOV and NCON.

4. Related Work

Movement of sensors consumes more energy than sensing. So the movement of sensors need to be reduced to conserve energy. Target coverage is divided into two cases: special and general case. Special is done by using Hungarian method and general case is done by using both Basic and TV Greedy algorithm. Up to this we first formulate mobile sensor deployment (MSD). This MSD problem leads to Combine the solution of TCOV and NCON.

II. METHODOLOGY

Node Deployment:

The Node Deployment is the algorithm which is used to place the nodes in the network in the given area of $x*y$

Group Formation Time Based: This is used to group the set of nodes under a target based on REPLY time of the node to the Target

Group Formation Random Based: This is used to group the set of nodes under a target based on random selection of the node to the Target

Group Formation Distance Based: This is used to group the set of nodes under a target based on distance of the node to the Target and also used to adjust the position of the targets

Route Discovery Based on Time:

Source node, destination node & Transmission Range acts as an input parameters. The set of nodes are found which have the distance within transmission range known as neighbor's nodes. If the set of neighbors has the destination node then stop the process otherwise pick a node which sends REPLY in less time as the next forward node Repeat steps until destination is reached

Route Discovery Based on Random:

Source node, destination node & Transmission Range acts as an input parameters. The set of nodes are found which

have the distance within transmission range known as neighbor's nodes. If the set of neighbors has the destination node then stop the process otherwise pick a node randomly as the next forward node Repeat steps until destination is reached

Route Discovery Based on Probabilistic Fashion:

Source node, destination node & Transmission Range acts as an input parameters. The set of nodes are found which have the distance within transmission range known as neighbor's nodes. If the set of neighbors has the destination node then stop the process otherwise pick a node based on maximum coverage. Decrement the Time to Live period. The process is repeated until destination is reached or TTL expires, Once TTL expires Min Hop Routing is used.

Comparison:

End to End Delay:

End to End Delay is the time taken for the RREQ to go from the source node to destination node and then send back the RRPLY from destination node to source node.

$$E2E_{delay} = t_{stop} - t_{start}$$

Where,

t_{stop} = This is the Time at which RRPLY is recieved

t_{start} = This is the Time at which RREQ is send

Number of Hops:

The Number of intermediate links from the source node to destination node is called Number of Hops.

Energy Consumption:

The energy wasted for delivering the packets from the source node to destination node. The total energy consumption is given as follows

$$TE_c = \sum_{i=1}^l E_i$$

Where,

l = number of links

E_i = Energy consumed by the i^{th} link

The energy consumed by the i^{th} link given by

$$E_c = 2E_{tx} + E_{amp} d^\gamma$$

E_{tx} = energy required for data transmission

E_{amp} = energy required for data generation

d = distance between two intermediate nodes

γ = environment factor

$$0.1 \leq \gamma \leq 1$$

The Standard environment factor

Number of Alive Nodes:

This is defined as the count of set of nodes whose battery level is greater than or equal to B/4 Where B is initial Battery Power.

Number of Dead Nodes:

This is defined as the count of set of nodes whose battery level is less than B/4. Where B is initial Battery Power.

V. COMPARISON OF ALGORITHMS.

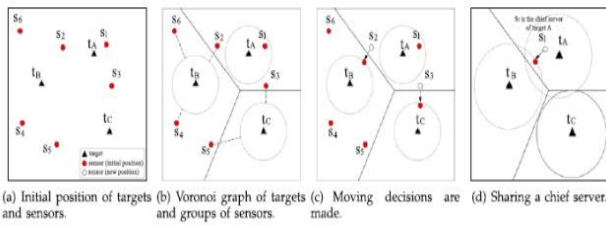


Fig.3: Illustration of the TV-Greedy algorithm.

3.2.3 TV-Greedy Algorithm:

Input: $T = \{t_1; t_2; \dots; t_m\}$ //The position of all targets
 $S = \{s_1; s_2; \dots; s_n\}$ //The position of sensors
 r_s //The coverage radius
 Output: tmc //The total moving cost

- 1 Generate the Voronoi diagram (VD) of targets;
- 2 Determine neighbors for each target according to their Voronoi polygon;
- 3 Determine the OSG for each target according to S and VD;
- 4 for each OSG do
- 5 Determine the chief server;
- 6 Identify the aid server for t_i 's neighbor;
- 7 for each t_i do
- 8 if t_i has already been covered then
- 9 Return $cost(t_i) = 0$;
- 10 else
- 11 Produce CSG of t_i ;
- 12 if $CSG_i \neq \emptyset$; then
- 13 Move the nearest server to cover t_i ;
- 14 return $cost(t_i) = \text{moving distance}$;
- 15 else
- 16 if there exist neighbors' chief servers that could be shared then
- 17 move the nearest chief server to cover t_i ;
- 18 Return $cost(t_i) = \text{moving distance}$;
- 19 else
- 20 Regenerate the CSG of t_i by searching aid servers of the t_i 's 2nd or higher order neighbors;
- 21 Move the nearest aid server to cover t_i ;
- 22 Return $cost(t_i) = \text{moving distance}$;
- 23 $tmc = tmc + cost(t_i)$
- 24 return tmc

IV. SOLUTIONS TO THE NCON PROBLEM

There are steps to solve NCON problem. The first step is seeking an edge length constrained Steiner tree T spanning coverage sensors and the sink. Since the Steiner tree problem is NP-hard, we propose an approximate algorithm as follows: (1) constructing an euclidean minimum spanning tree (ECST), and (2) separating each edge of the spanning tree into the sections with length.

Figure.3 shows the comparison between three algorithms: Basic, TV-Greedy and EX-Hungarian method. The movement distance increases when targets increase. Ex-Hungarian and basic algorithm performs very close to each other. Basic algorithm uses the minimum number of coverage sensors. The number of coverage sensors used by TV-Greedy is between the other two algorithms.

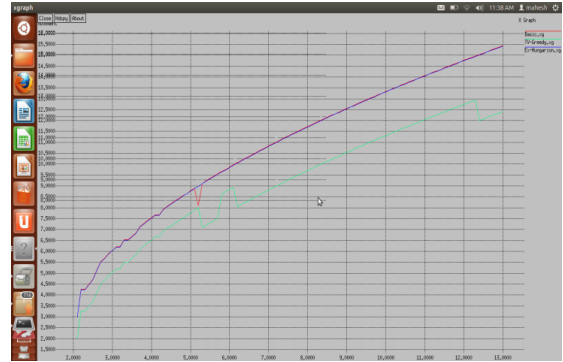


Fig.4: Comparison of Basic, TV-Greedy and Ex-Hungarian method

TV-Greedy achieves less movement than other two algorithms. This is because of TV-Greedy uses smart strategy to choose coverage sensors. This algorithm groups sensors according to their proximity to the targets, and uses the nearest sensor to cover a target. This effectively minimizes the total movement distance to cover all the all the targets

VI. SIMULATION EXPERIMENTS.

6.1 Simulation Settings and Performance Metrics.

We evaluate the performance of algorithms and conduct a set of simulation experiments using matlab. TV-Greedy algorithm performs the best among the three algorithms, we also investigate the performance gap between TV-Greedy and the optimal solution in a small network to get an impression of how close TV-Greedy approaches the optimal solution. Fig 5 shows a network topology generated by different combinations of algorithms.

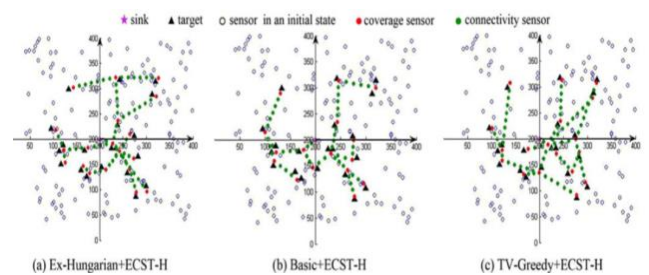


Fig.5:. Network topologies generated by different combinations of algorithm.

6.2 Performance of Different Algorithms to TCOV

We will compare three algorithms

6.2.1. In case of number of mobile sensors

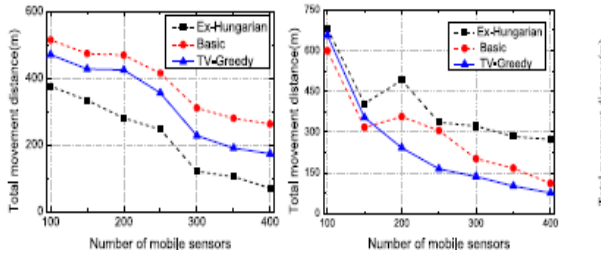


Fig.6: Impact of the number of mobile sensors

6.2.2. In case of number of targets

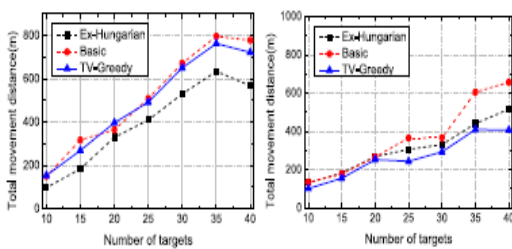


Fig.7: Impact of the number of targets

6.3 Further investigation of TV Greedy

6.3.1 Impact of different network parameters

Fig 8: shows the impact if different network parameters on TV Greedy algorithm

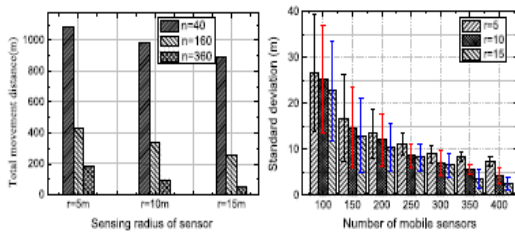


Fig.8: Impact if network parameters on TV Greedy algorithm

5.3.2. Impact of sensors initial position on TV Greedy algorithm

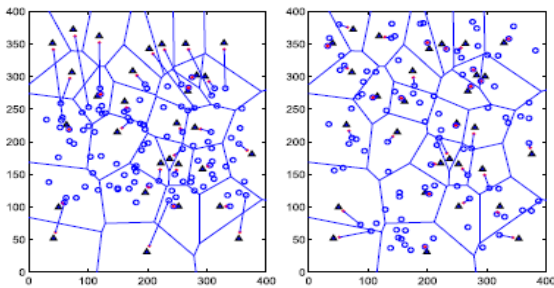


Fig.8 Impact of sensors initial position on TV Greedy algorithm

VII. FUTURE WORK

In the future, we plan to extend our work to address the problem of target coverage and network connectivity in MSNs in a distributed way. A distributed solution to the MSD problem is very attractive because it takes advantage of robustness when facing network changes and sensor failures. The main challenge is that, in the distributed manner, mobile sensors can communicate only with sensors in proximity. Similarly, the moving decisions need to be made Locally

VIII. CONCLUSION

In this work, we have studied the Mobile Sensor Deployment (MSD) problem in Mobile Sensor Networks (MSNs), This problem is divided into two sub-problems, Target Coverage (TCOV) problem and Network CONnectivity (NCON) problem. For the TCOV problem, we prove it is NP-hard. For a special case of TCOV, an extended Hungarian method is provided to achieve an optimal solution; for general cases, two heuristic algorithms are proposed based on clique partition and Voronoi diagram, respectively. For the NCON problem, we first propose an edge constrained Steiner tree algorithm to find the destinations of mobile sensors, then use the extended Hungarian to dispatch rest sensors to connect the network.

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