Maximization of Network Lifetime with Coverage and Connectivity Improvement Using Network Partition

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Abstract: Coverage of interest points and network connectivity are two main challenging and practically important issues of Wireless Sensor Networks (WSNs). Although many studies have exploited the mobility of sensors to improve the quality of coverage and connectivity, little attention has been paid to the minimization of sensors' movement, which often consumes the majority of the limited energy of sensors and thus shortens the network lifetime significantly. To fill in this gap, this paper addresses the challenges of the Mobile Sensor Deployment (MSD) problem and investigates how to deploy mobile sensors with minimum movement to form a WSN that provides both target coverage and network connectivity. To this end, the MSD problem is decomposed into two sub-problems: the Target Coverage (TCOV) problem and the Network Connectivity (NCON) problem. We then solve TCOV and NCON one by one and combine their solutions to address the MSD problem. The proposed method uses the concept of Network Partition to improve network lifetime and coverage. The combination of the solutions to TCOV and NCON, as demonstrated by extensive simulation experiments, offers a promising solution to the original MSD problem that balances the load of different sensors and prolongs the network lifetime consequently.

Keywords: *Network Connectivity, Target Coverage, WSN.*

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Introduction

Overview

Wireless Sensor Networks (WSNs) are at present utilized as a part of an extensive variety of uses including ecological checking [1] and question following [2]. Target coverage and connectivity are two principle testing and for all intents and purposes essential issues of WSNs. Target coverage means to cover an arrangement of indicated purposes of enthusiasm for the sending locale of a WSN. It portrays the observing nature of the network [3]. Connectivity is vital for sensors in a WSN to gather information and report information to the sink hub. Be that as it may, WSNs framed by randomly circulated remote sensor hubs regularly can't give acceptable coverage quality and can't ensure the connectivity of the network. Lately, sensor versatility has been misused to enhance the coverage quality and connectivity in randomly conveyed WSNs by moving some portable sensors to new positions to improve the coverage quality and the connectivity of the network [4], [5], [6], [7], [8].

In this paper, we address a for all intents and purposes essential issue of minimizing sensors' development to accomplish both target coverage and network connectivity in portable sensor networks. As sensors are typically fueled by vitality restricted batteries and in this manner seriously control compelled, vitality utilization ought to be the top thought in versatile sensor networks. Uniquely, development of sensors ought to be minimized to draw out the network lifetime since sensor development devours significantly more vitality than detecting and correspondence do [6], [9]. Be that as it may, a large portion of the current studies went for enhancing the nature of target coverage, e.g., recognizing targets with high recognition likelihood, bringing down false caution rate and discovery delay. Little consideration has been paid to minimizing sensor development. To fill in this hole, this study concentrates on moving sensors to cover discrete targets and shape an associated network with least development and vitality utilization.

Versatile Sensor network is the gathering of moving sensor hubs. Portable sensor networks have extra limit of Mobility. Portability comprises of various capacities in sensor network like better network lifetime, better utilization of assets, movement, and so forth. In the versatile sensor networks, Sensor hubs may change their area after beginning arrangement. Versatility can apply to all hubs or just to subgroups of hubs. Portability can be dynamic or aloof. In dynamic versatility the sensors can discover their way and move while in latent sensors they might be moved by human or natural help. Versatility of the sensor hubs can influence the general execution of the network. Sensor Deployment is another issue in versatile sensor networks, since it not just decides the cost of developing the network additionally influences how well an area is observed by a sensor hub. Sensor sending can influence the nature of coverage and connectivity.

Target coverage and Network connectivity are two noteworthy issues of Mobile sensor networks. Target coverage covers a s set of intrigued focuses in sending zone of versatile sensor networks. It ensures that each target is secured by no less than one versatile sensor. Network Connectivity ensures that there must be adequate steering ways between sensors. Target Coverage is influenced by a sensor‟s detecting range, while Network Connectivity is chosen by a sensor‟s correspondence run. Target coverage and Network connectivity may likewise influences the execution of Network.

With the previously mentioned framework demonstrate, the formal meaning of the MSD issue can be given as takes after.

Mobile Sensor Deployment (MSD) problem

Given m targets with known areas and n versatile sensors conveyed randomly in the assignment zone, the MSD issue looks for the base development of portable sensors to such an extent that the accompanying goals are accomplished after portable sensors achieve their new positions:

- Every target is secured by no less than one portable sensor.
- The network framed by all the moved sensors is associated.

The MSD issue concerns two issues, in particular target coverage and network connectivity. In this way, we partition it into two sub-issues and vanquish them one by one. In the first place, we concentrate on sending versatile sensors to cover targets with least development. These portable sensors are called coverage sensors. Next, we convey the rest sensors to give connectivity between coverage sensors and the sink.

Target Coverage (TCOV) issue

Given m targets with known areas and n versatile sensors conveyed randomly in the errand region, move sensors to new positions to such an extent that every one of the targets are secured and the aggregate development of sensors is minimized.

Network Connectivity (NCON) issue

Given a sink, the arrangement of coverage sensors, and the rest versatile sensors after the TCOV issue is settled, NCON looks for the organization of the rest portable sensors to interface coverage sensors and the sink with least development.

Literature Review

With the development of versatile sensors, broad explores have been advanced on target coverage of WSNs. In the paper entitled "Minimizing Development for Target Coverage and Network Connectivity in Portable Sensor Networks" by Zhuofan Liao, Jianxin Wang, Jiannong Cao concentrates on issue of minimizing the development of sensor hubs to accomplish target coverage in versatile sensor networks. Target coverage is partitioned into two cases: uncommon and general case. In an uncommon instance of Target Coverage, targets scatter from each other more wireless than twofold of the coverage range. For this case, a correct calculation in view of the Hungarian technique is proposed to locate the ideal arrangement. For general instances of Target coverage, two heuristic calculations, the Essential calculation in view of inner circle segment and the television Insatiable calculation in view of Voronoi parcel of the arrangement area, are proposed to lessen the aggregate development of sensor hubs. [1]

In the paper entitled "Circulated Organization Calculations for Enhanced Coverage in a Network of Wireless Versatile Sensors" the creators acquaints productive sensor sending systems with increment coverage in wireless portable sensor networks. The sensors discover coverage openings inside their Voronoi polygons and after that move in a fitting course to minimize them. Novel edge-based and vertex-based systems are presented, and their exhibitions are contrasted and existing strategies. The proposed development procedures depend on the separations of every sensor and the points inside its Voronoi polygon from the edges or vertices of the polygon. Reproductions affirm the adequacy of the proposed organization calculations and their prevalence over the procedures reported in the writing.

In the paper entitled Self-Arrangement Calculations for Field Coverage in a Network of Nonidentical Portable Sensors: Vertex-Based Approach, effective sending calculations are proposed for a versatile sensor network to develop the coverage zone. The proposed calculations compute the position of the sensors iteratively in light of existing coverage openings in the field. To this end, the multiplicatively weighted Voronoi (MWVoronoi) outline is utilized for a network of portable sensors with various detecting ranges. Under the proposed methods, the sensors move in a manner that the coverage openings in the network are lessened. Reproduction results are given to show the viability of the arrangement plans proposed in this paper.

In the paper entitled "Disseminated Investigating Repetition in Sensor Organization to Expand Network Lifetime and Coverage" the creators presents best sending calculation for sensors in a given arrangement area to give focused on coverage and connectivity to a wireless sensor network. In this paper, the proposed strategy parcels the given region of interest into two unique locales: focal and edge districts. In every locale, a solitary strategy is utilized to figure the number and area of sensors to cover the whole coverage while keeping network connectivity.

Portable sensors are utilized to enhance vitality proficiency of sensors in region coverage in the paper entitled "Enhancing network lifetime with versatile wireless sensor" networks. In this paper portable sensors are intended to move along the briefest way to minimize the vitality utilization when goals have been resolved.

In the paper entitled, "Conveyed sending plans for portable wireless sensor networks to guarantee multilevel cover-age," Given assigned goals, k-coverage is concentrated on. In this work, an opposition plan is proposed to minimize vitality utilization in development.

Proposed System

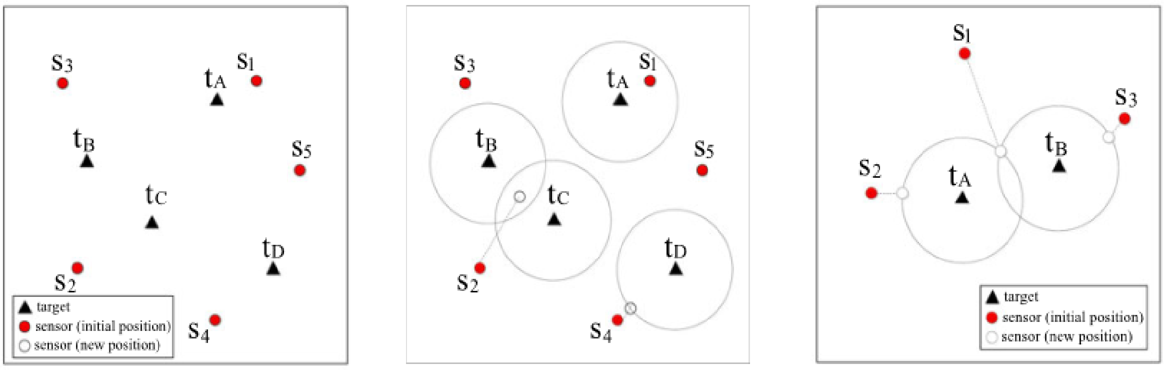
For Target coverage problem, two algorithms are used: basic algorithm based on clique partition and TV-greedy algorithm based on Voronoi diagrams and Delaunay triangulation.

The Basic Algorithm

A basic heuristic to minimize the development separation of sensors is to minimize the quantity of sensors that need to move. Really, after the sensors are sent, a few targets may have as of now been secured. Mean the arrangement of targets that have as of now been secured by Tinitcov, and signify the arrangement of revealed targets by Tneedcov. At that point we have

Tneedcov =T n/Tinticov

Keeping in mind the end goal to minimize the quantity of versatile sensors that need to move, we first build a chart of targets speaking to whether targets can be at the same time secured, then discover the goals of portable sensors by utilizing faction parcel. Nonetheless, in spite of the fact that the Basic calculation minimizes the quantity of sensors to move, it might build the aggregate development separation of sensors. The chart is built as takes after. For each target in Tneedcov, there is a vertex in the chart. There is an edge between two vertices if and just if the relating targets could be all the while secured by a similar sensor. After the diagram is built, we locate a base inner circle parcel of the developed chart. Each apportioned inner circle speaks to a subset of targets that can be secured by a similar sensor. In this manner, for targets having a place a similar inner circle, we have to dispatch just a single portable sensor to cover them. With this strategy, the quantity of portable sensors that need to move is minimized. After the inner circle parcel is gotten, the stretched out Hungarian calculation is utilized to figure out which sensor ought to be dispatched to cover the targets in every clique.



(a) Initial positions (b) Result of Basic (c) Suboptimality of Basic

The Target Based Voronoi Greedy Algorithm

Target based Voronoi Greedy calculation (TV-Greedy) to minimize the aggregate development separation of sensors to cover targets. The essential thought of TV-Greedy is to send the closest sensor to cover the targets that are revealed. Since sensors situated in a target's Voronoi polygon are nearer to this target than to others, we utilize Voronoi outlines of targets to gathering sensors as indicated by their closeness to the comparing target. To start with, the Voronoi chart of targets is created by utilizing the organize data of targets which is known to sensors.

In light of the vertices data of Voronoi polygons, the neighbors of every target are resolved. Second, the own server group OSG of every target is resolved. In each OSG, the possess servers (sensors in the OSG) is sorted by their separations to the customer (the target of the OSG) in rising request, as indicated by which the central server is distinguished as the first in the sorted rundown. For the rest claim servers, we distinguish the guide server for every neighbor of the customer through separation examination and sorting, as appeared in Fig.

Third, for every target, in the event that it is secured at first, sensors in its OSG stand by and sit tight for requests. In the event that the target is not secured at first, then its CSG will be framed, which is a coherent server assemble converged with the central server of the target and all the guide servers from its neighbors. Television Greedy begins from the era of targets' Voronoi graphs, which isolates sensors into autonomous gatherings for every target. With help of targets' Voronoi outlines, we can build a sensor gather for every target, which incorporates sensors in closeness to this target.

The essential thought of TV-Greedy is to convey the closest sensor to cover the targets that are revealed. Since sensors situated in a target's Voronoi polygon are nearer to this target than to others, we utilize Voronoi graphs of targets to gathering sensors as indicated by their closeness to the relating target.

For clarity, the definitions and documentations that will be utilized as a part of the calculation portrayal is exhibited underneath:

1) If a sensor is situated in a target's Voronoi polygon, the sensor is characterized as a server to this target, and the target is viewed as a customer of its servers. The arrangement of a target's servers is called that target's own server group (OSG). The sensor in target's OSG that is closest to the target is known as the central server of that target and different sensors are called non-boss servers of the target.

2) Two targets are neighbors if their Voronoi polygons share an edge. For two neighboring targets An and B, the sensor in An's OSG that is nearest to B is called a guide server to B.

3) A target's candidate server assemble (CSG) is the union of its own central server and help servers from neighbors. For a target, just sensors in its CSG will be dispatched to cover it.

Delaunay triangulation

In this segment, we show the Delaunay calculation which is utilized to put the hubs in appropriate areas. Delaunay calculation in light of the standard of fascination and repugnance.

Repulsion
Repulsionof the hubs happens when the hubs are out of their detecting reach to each other.

Proposed Algorithm

Target Coverage
To cover uncovered targets, basic algorithm constructs the graph of targets. After the graph is constructed, minimum clique partition of the constructed graph are determined. Thus, for the targets from same clique, only one mobile sensor is dispatched to cover those targets. Hence, the basic algorithm minimizes the number of sensors that need to be moved, but it may increase the total movement of sensors. TV-greedy algorithm minimizes the total movement by grouping the sensors according to proximity to targets. TV-Greedy algorithm determines the Voronoi diagrams according to static targets. Since targets are statics, re-computation after every operation is not needed. Voronoi diagrams group sensors according to proximity of sensors to the targets. After that the sensor which is very close to sensor is selected to cover that target. Target coverage aims that at least one sensor can cover the one or many targets. TV-greedy algorithm finds the sensor which is on the intersection of two targets and close to both target than other sensor nodes.

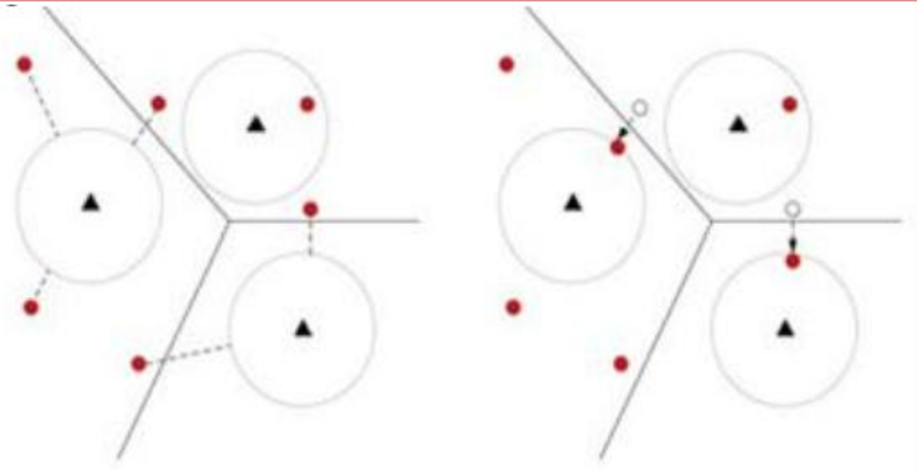


Fig Voronoi Diagram

Network Connectivity

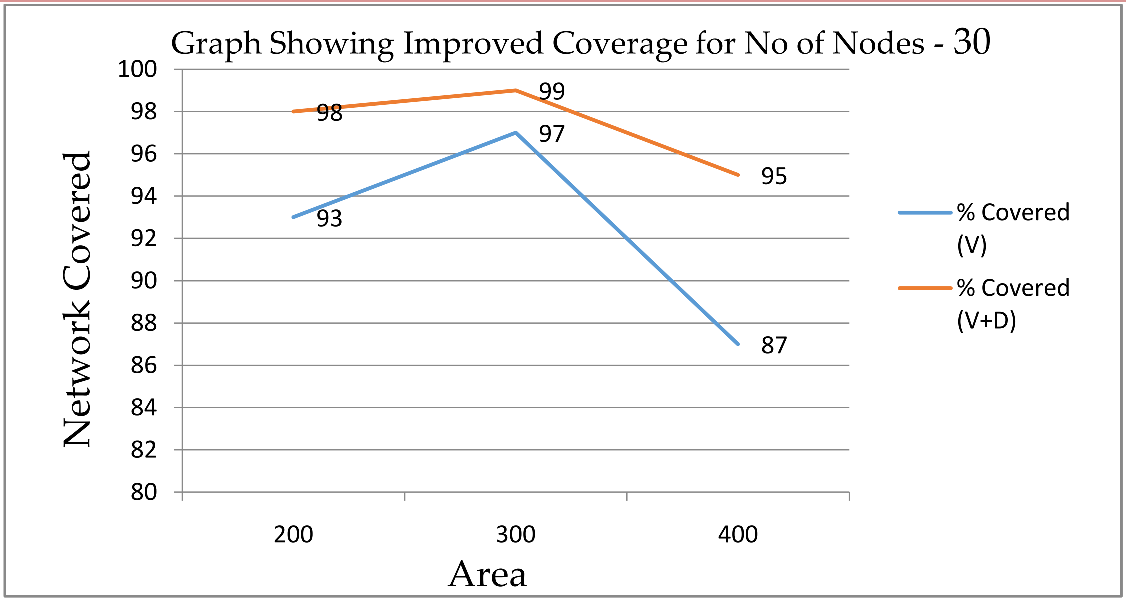
The essential thought behind network connectivity is to utilize rest of portable sensors to look after connectivity. The essential thought behind network connectivity is to utilize rest of portable sensors to look after connectivity. Network connectivity is fundamental for sensor hub to gather information and send it to the sink hub. Network connectivity expects to locate the ideal course for sensor hub to speak with sink hub or base station. Here Steiner tree idea is utilized to keep up network connectivity, where Sink hub or base station is root and every one of the sensors are leaf hubs. Here First, an edge length obliged Steiner tree spreading over all the coverage sensors and the sink is developed, with the end goal that every tree edge length is not more noteworthy than the correspondence range rc. At that point the rest versatile sensors are migrated to the created Steiner focuses to associate the sensors and the sink hub. Sensor hub gathers the information from targets and send that information to the sink hub. This requires the greatest vitality and time. Here LZW pressure calculation is utilized to pack information and thus to minimize vitality utilization and amplify the calculation speed of transmission.

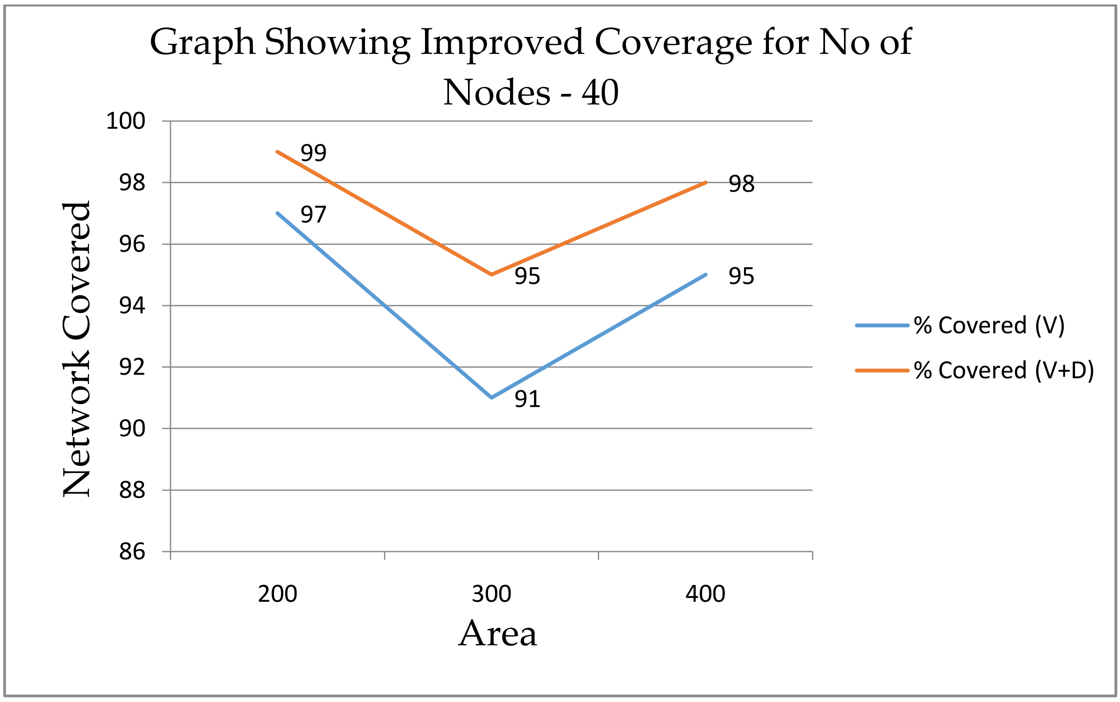
Result Analysis

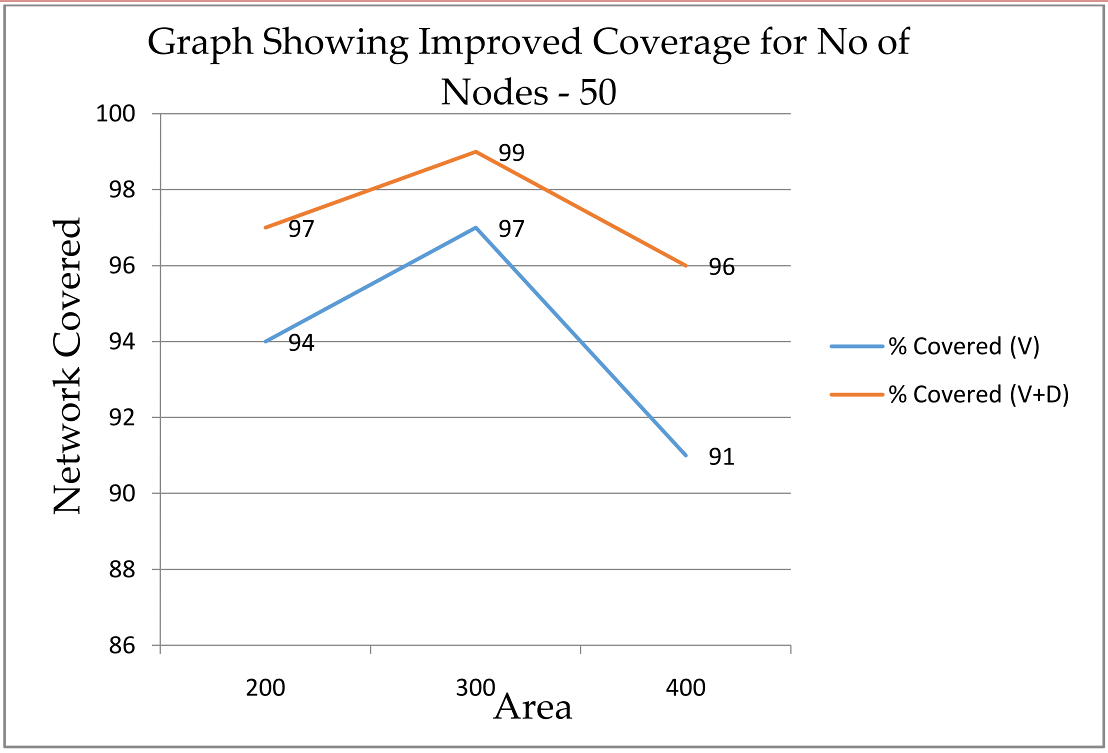
To evaluate the performance of the proposed algorithms, a set of simulation experiments by using NS-2 is conducted. First the performance of solutions to the TCOV problem using TV-Greedy normally is evaluated and then coverage obtained using voronoi with Delaunay algorithm is examined.

Table 1: Network Covered using Voronoi and Delaunay Triangulation

No of Nodes	Area	Range in Meter	% Covered (V)	% Covered (V+D)
30	200	10	93	98
30	300	10	97	99
30	400	10	87	95
40	200	10	97	99
40	300	10	91	95
40	400	10	95	98
50	200	10	94	97
50	300	10	97	99
50	400	10	91	96


Graph Showing Improved Coverage for No of Nodes - 30
Network Covered
100
98
96
94
92
90
88
86
84
82
80
98
99
97
95
93
87
200
300
400
Area
% Covered (V)
% Covered (V+D)


Graph Showing Improved Coverage for No of Nodes - 40
Network Covered
100
98
96
94
92
90
88
86
99
97
98
95
95
91
200
300
400
Area
% Covered (V)
% Covered (V+D)

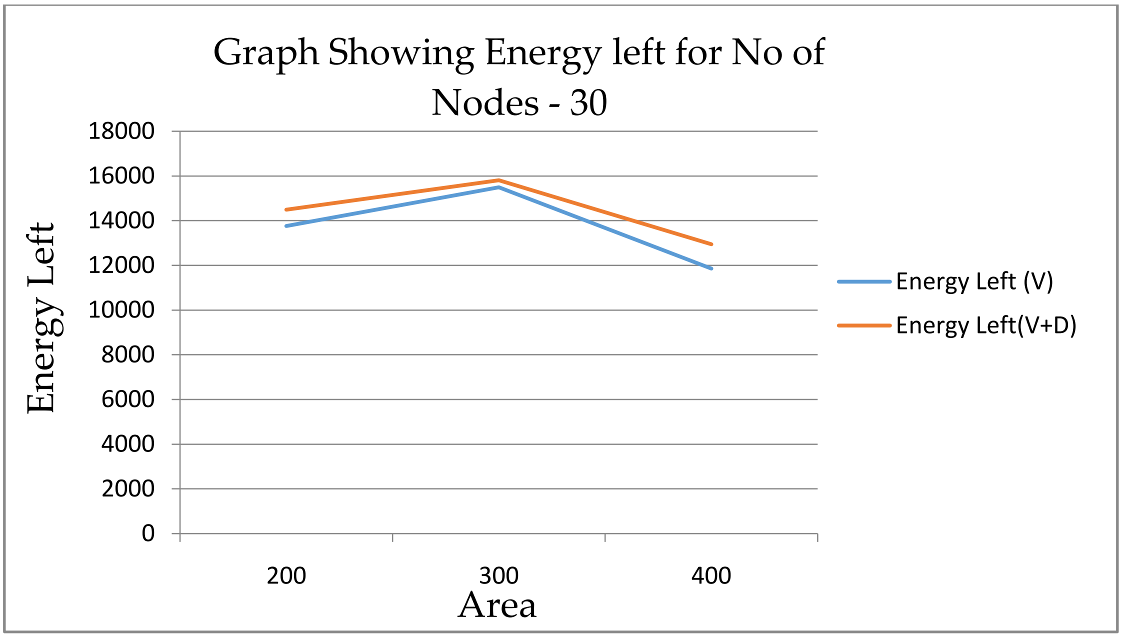


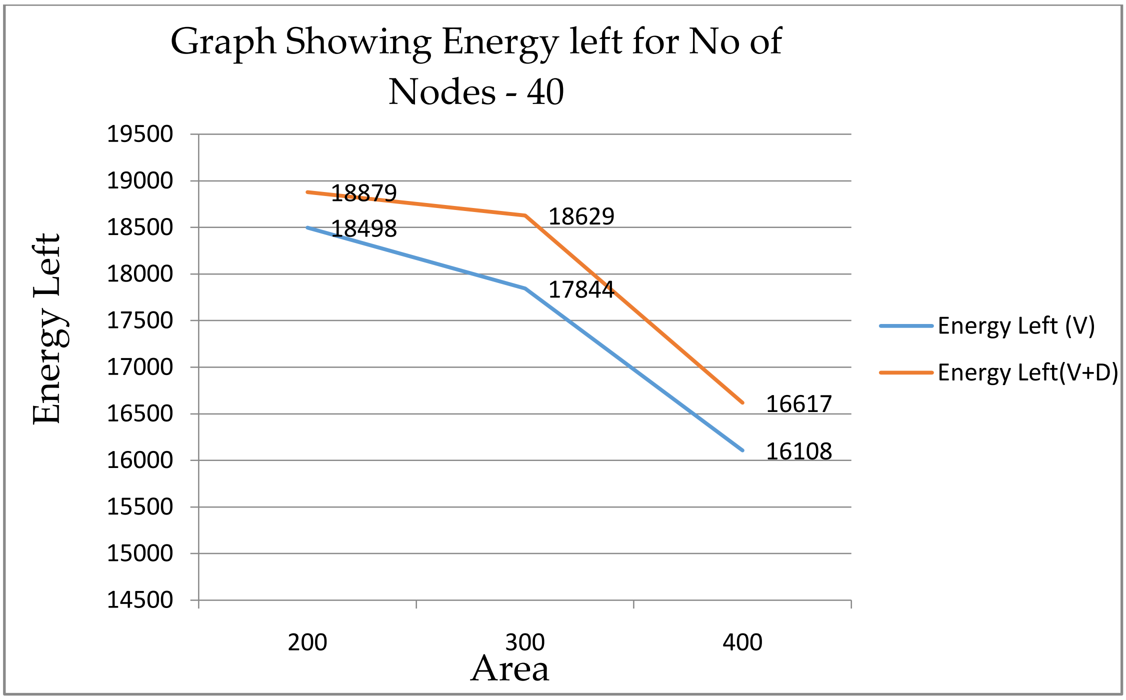
The table no.1 and graph shows the comparison between coverage obtained normally and coverage obtained using voronoi with Delaunay algorithm. The graph shows that there is improvement in coverage after using the voronoi with Delaunay algorithm. After using only voronoi algorithm the area is divided into number of parts but the sensors are also sensing or detecting the targets which are not in their area means the targets situated in the neighboring area is also sensed or detected.
The energy is wasted in detecting the neighboring targets so now we have to again minimize the movement of the nodes so that the sensor nodes sense the targets which are only in their area. For this purpose we are using the Delaunay triangulation method which place the nodes into proper places so that the movement of the nodes range is up to the boundaries of the region.

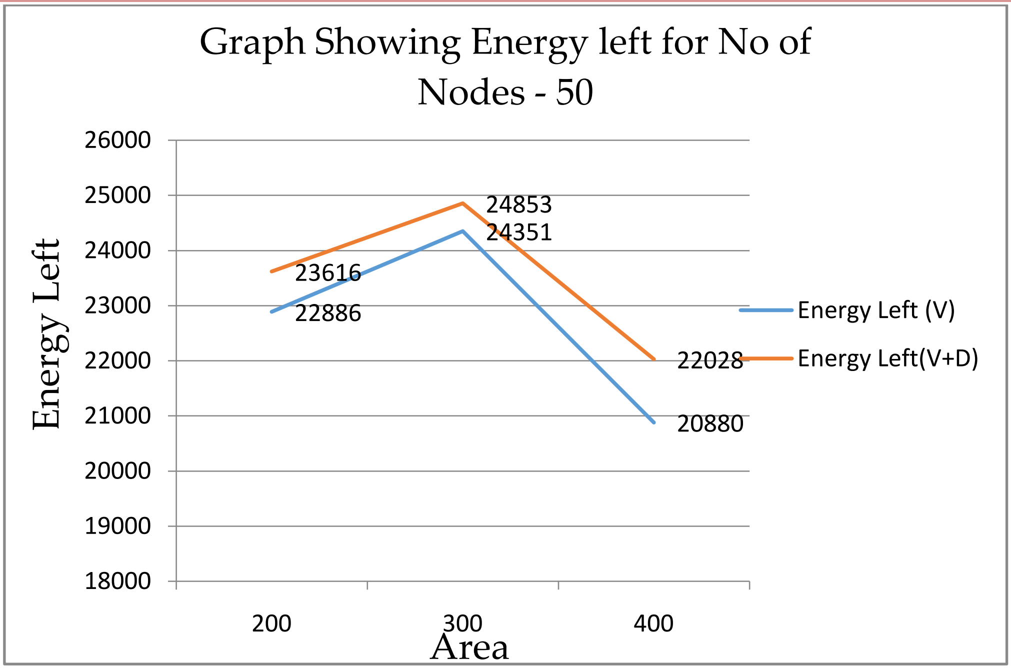
Table no.2 and graphs shows the comparison between energy left normally and energy left using voronoi with Delaunay algorithm. By using the Delaunay algorithm maximum amount of energy is left. In this way we can minimize the movement and save the energy which is wasted in the movement of nodes and also increase the lifetime of the network.

Table 2: Energy left using Voronoi and Delaunay Triangulation

No of Nodes	Area	Range in Meter	Energy Left (V)	% Energy Left (V+D)
30	200	10	13759	14499
30	300	10	15495	15814
30	400	10	11858	12948
40	200	10	18498	18879
40	300	10	17844	18629
40	400	10	16108	16617
50	200	10	22886	23616
50	300	10	24351	24853
50	400	10	20880	22028


Graph Showing Energy left for No of Nodes - 30
Energy Left
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
200
300
400
Area
Energy Left (V)
Energy Left(V+D)


Graph Showing Energy left for No of Nodes - 40
Energy Left
19500
19000
18500
18000
17500
17000
16500
16000
15500
15000
14500
18879
18498
18629
17844
16617
16108
200
300
400
Area
Energy Left (V)
Energy Left(V+D)



Conclusion and Future Scope

Coverage of interest points and network connectivity are two main challenging and practically important issues of Wireless Sensor Networks. Target coverage covers a set of interested point in the deployment area of mobile sensor networks. Network connectivity is necessary for sensors to communicate with sink node. To solve the Target Coverage problem two algorithms are proposed: Basic algorithm based on clique partitions and TV Greedy algorithm based on Voronoi diagrams and Delaunay triangulation, using this sensors movement is minimized. TV Greedy algorithm achieves less movement than basic algorithm because it selects the sensor which is very close to target to achieve that target. Use of Voronoi diagrams and Delaunay triangulation minimize the energy needed for movement of nodes, improve coverage area and lifetime of the network is increased. The concept of Voronoi diagrams to divide the entire network into regions of varying nodes. So a node will only have the responsibility to improve the coverage of the area in which Voronoi diagram has placed it. Thus the node movement is restricted. So the energy needed for movement will be reduced and the coverage area will be improved. This will allow the network to retain energy for longer time duration.

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. However, localized algorithms face the potentially complicated relationship between local behavior and global behavior. Algorithms that are locally optimal may not perform well in a global sense. It remains our future work to design a distributed variant of the proposed algorithms to solve the MSD problem.

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