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RESEARCH ARTICLE

Target Detection and Tracking in Mobile Sensor Networks

Prof. P.V.Kavitha, N.Sandhiya, V.Suganya, S.Vidya

Information Technology, Sri Ramakrishna Engineering College, Coimbatore, India

kavitha.krishna@srec.ac.in, sandhiyanatraj@gmail.com, suganya040893@gmail.com, vidyasasi19@gmail.com

Abstract: Target Tracking is an important problem in sensor networks, where it dictates how accurate a targets position can be measured. This problem becomes particularly challenging given the mobility of both sensors and targets, in which the trajectories of sensors and targets need to be captured. The spatial resolution refers to how accurate a target position can be measured by sensors, and defined as worst case deviation between estimated and actual paths in wireless sensor networks. The shortest path for tracking the target is determined using Ad-Hoc On Demand Distance Vector(AODV)Protocol. We derive the minimum number of mobile sensors that are required to maintain the resolution for target tracking in an MSN. The performance evaluation is done using the metrics like spatial resolution, average end to end delay, packet arrival time and control overhead. The simulation results demonstrate that the tracking performance can be improved by an order of magnitude with the same number of sensors when compared with that of the static sensor environment.

Keywords: Mobile Sensor Network (MSN), Target tracking, Ad-Hoc On demand Distance Vector (AODV) protocol.

I. INTROCUTION

The development of sensor network technology has enabled the possibility of target detection and tracking in a large scale environment. There has been an increased interest in the deployment of mobile sensors for target tracking, partly motivated by the demand of habitat monitoring and illegal hunting tracking for rare wild animals [2]. In this paper, we are primarily interested in target tracking by considering both moving targets and mobile sensors specifically; we are interested in the spatial resolution for localizing a target's trajectory. The spatial resolution refers to how accurate a target's position can be measured by sensors, and defined as the worst-case deviation between the estimated and the actual paths in wireless sensor networks [3]. Our main objectives are to Make the sensor and the target mobile and to formulate spatial resolution to find the average deviation between the estimated and the actual target path. Given an initial sensor deployment over a region and a sensor mobility pattern, targets are assumed to cross from one boundary of the region to another. We define the spatial resolution as the deviation between the estimated and the actual target travelling path, which can also be explained as the distance that a target is not covered by any mobile sensors. Furthermore, we are also interested in determining the minimum number of mobile sensors that needs to be deployed in order to provide the spatial resolution in mobile sensor networks. It turns out that our problem is very similar to the collision problem in classical kinetic theory of gas molecules in physics, which allows us to establish and derive the inherently dynamic relationship between moving targets and mobile sensors. The binary sensing model of tracking for wireless sensor networks has been studied in several prior works. The work in [4] showed that a network of binary sensors has geometric properties that can be used to develop a solution for tracking with binary sensors. Another work [5] also considered a binary sensing model. It employed piecewise linear path approximations computed using variants of a weighted centroid algorithm, and obtained good tracking performance if the trajectory is smooth enough. A follow-up work explored fundamental performance limits of tracking a target in a two-dimensional field of binary proximity sensors, and designed algorithms that attained those limits in [6]. Prior works in stationary wireless sensor networks have studied the fundamental limits of tracking performance in term of spatial resolution. Our focus in this paper is completely different from all prior works. There are two distinctive features of our work: 1) we try to identify and characterize the dynamic aspects of the target tracking that depend on both sensor and target mobility, using AODV protocol shortest path is identified; 2) we consider tracking performance metrics: spatial resolution in a mobile sensor network.

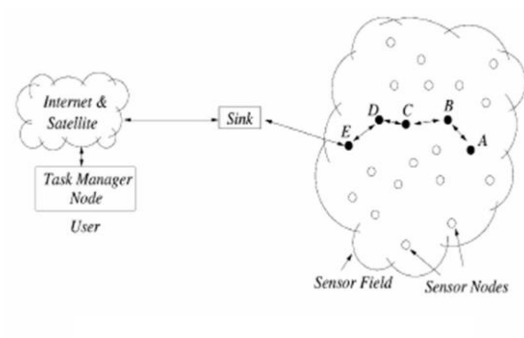

Fig 1.Mobile Sensor Networks

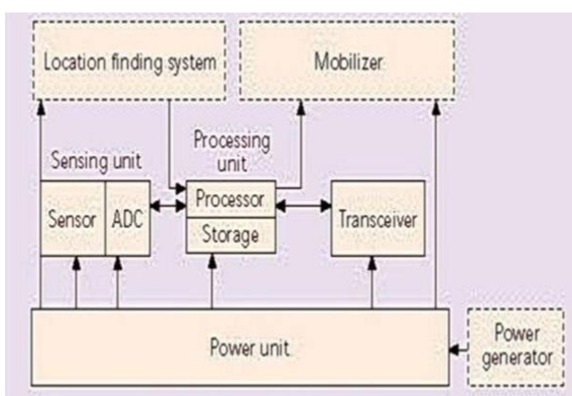

Fig 2.Components of sensor networks

II. TARGET TRACKING

Target tracking is one of the most important applications of wireless sensor networks, such as healthcare, building and military monitoring, home security. So a lot of useful application can benefit greatly from accurate tracking. Considering the problem of single target tracking in controlled mobility sensor networks, researchers in have proposed a novel strategy which is based on the interval based estimation for managing sensors mobility to improve the estimation of the position of the target. Mobile sensors are able to move to a new position at each step, using AODV protocol. The movement decision is made upon whether the new position will improve the estimation while minimizing the energy consumption or not. The proposed approach uses a hybrid sensor network. While mobile sensors are not only used for optimizing the performance of the target tracking but also maximizing the lifetime of the network, static sensors guarantee the whole coverage of the network. Usually, a target can be divided into two classes, i.e., cooperative target and non-cooperative target. The former one can broadcast cooperative signals (e.g., radio frequencies, vibrations, and sound, etc.) from time to In this case, the sensors have to actively detect the target by frequently broadcasting certain signals, it can be detected. In this paper, we mainly focus on tracking a non cooperative target. The performance is measured by the scope of the uncertainty for the targets position. In addition, velocity constraints on mobile sensors are also considered. Different from precious work, the impose constraints on the minimum distance at which the mobile sensors are allowed to be close to the target. Our previous work propose an integrated control approach which allows the mobile sensors adjust their positions according to sensing quality, communication quality and area coverage. In addition, considering the velocity constrains on the target and the mobile sensors, in this to improve the tracking performance by increasing packet delivery ratio, control overhead and decreasing end to end delay. In this paper, our objective is to design the coordinative moving strategy which guarantees the target can be detected in each observed step while minimizing the amount of moving sensors. Specifically, in order to reduce the energy consumption throughout the network, we aim to minimize total travelled distance at each step. The major contributions of this paper can be summarized as follows:

Different from previous work, we take sensing quality, the number of moving sensors and the total travelled distance at each time step into consideration. We formulate the problem into one which aims to ensure the target will not be lost while minimizing the amount of sensors to move and then the total travelling distance of all moving sensors each step.

1. Target which is covered or uncovered from the region is detected by using mobile sensors.

2. Mobile sensors distance are calculated by using Euclidean distance.

3. The performance of the proposed method is evaluated by using performance metrics

III. CHALLENGES IN TARGET TRACKING

The challenge of target tracking and mobile sensor navigation arises when a mobile target does not follow a predictable path. Successful solutions require a AODV protocol. Target tracking can be viewed as a sequential location estimation problem. One of the most important areas where the advantages of sensor networks can be exploited is for tracking mobile targets. Scenarios where such network may be deployed can be both military (tracking enemy vehicles, detecting illegal border crossings) and civilian (tracking the movement of wild animals in wildlife preserves). Typically, for accuracy, two or more sensors are simultaneously required for tracking a single target, leading to coordination issues. Additionally, given the requirements to minimize the power consumption due to communication or other factors, we would like to select the bare essential number of sensors dedicated for the task while all other sensors should preferably be in the hibernation or off state. In order to simultaneously satisfy the requirements like power saving and improving overall efficiency, we need large scale coordination and other management operations. These tasks become even more challenging when one considers the random mobility of the targets and the resulting need to coordinate the assignment of the sensors best suited for tracking the target as a function of time. The power limitation due to the small size of the sensors, the large numbers of sensors which need to be deployed and coordinated, and the ability to deploy sensors in an ad-hoc manner give rise to a number of challenges in sensor networks.

1. ***Scalable Coordination:*** Sensors nodes may not be physically accessible, nodes may fail and new nodes may join the network. In such dynamic and unpredictable scenarios, scalable coordination and management functions are necessary which can ensure a robust operation of the network.

2. ***Tracking Accuracy:*** To be effective, the tracking system should be accurate and the likelihood of missing a target should be low. Additionally, the dynamic range of the system should be high while keeping the response latency, sensitivity to external noise and false alarms low. The overall architecture should also be robust against node failures.

3. ***Ad Hoc Deploy ability*****:** A powerful paradigm associated with sensor networks is their ability to be deployed in an ad hoc manner. Sensors may be thrown in an area affected by a natural or manmade disaster or air dropped to cover a geographical region. Thus sensor nodes should be capable of organizing themselves into a network and achieving the desired objective in the absence of any human intervention or fixed patterns in the deployment.

4. ***Computation and Communication Costs*****:** Any protocol being developed for sensor networks should keep in mind the costs associated with computations and communication. With current technology, the cost of computation locally is lower than that of communication in a power constrained scenario. As a consequence, emphasis should be put on minimizing the communication requirements.

*5****.*** ***Power Constraints:*** The available power in each sensor is limited by the battery lifetime due to the difficulty or impossibility of recharging the nodes. As a consequence, protocols which tend to minimize the energy consumption or power aware protocols which adapt to the existing power levels are highly desirable. Additionally, efforts should be made to turn off the nodes themselves if possible in the absence of sensing or coordination operations. In the next section, we present our proposed architecture for scalable and accurate tracking of mobile targets. The protocol specifically aims at minimizing the communication and control overheads in the network.

IV. SENSITIVITY ANALYSIS AND SIMULATION RESULTS

The formulation in the previous section mainly presents the dynamic aspects of the target tracking problem in an MSN. In this section, we investigate the correlations and sensitivity of the spatial resolution from a number of critical system parameters. Specifically, in this section we study the relationships between spatial resolution, the density of sensors and sensor mobility. We first study the correlation between the density of mobile sensors and the tracking performance. From the spatial resolution is inversely proportional to the density of sensors (*nA*) and the sensing range (*R*).

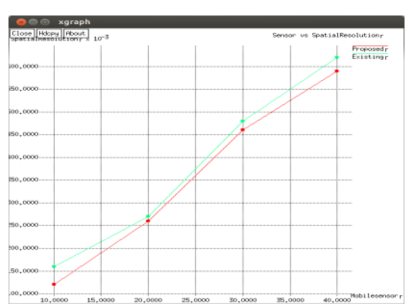

Fig 3:Spatial resolution Vs No of Sensor nodes

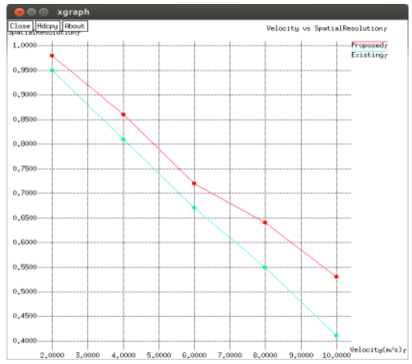

Fig 4:Spatial Resolution Vs Velocity

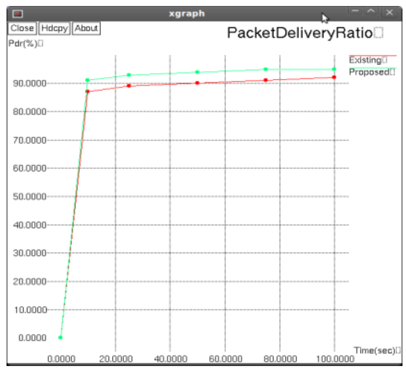

Fig 5:Packet Delivery Ratio

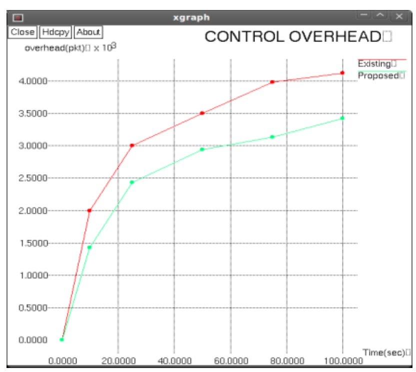

Fig 6:Control Overhead

Unless otherwise specified, we use the following default settings: we deploy 200 mobile sensors randomly distributed in an area of size 50×100 with the coverage range of sensors $R = 1$. Figs 4, 5 and 6 illustrate the spatial resolutions against density of sensor, ratio of target speed to sensor speed, and ratio of sensor speed to target speed, respectively. The calculated spatial resolutions are also almost the same as the simulation results. The results also show that sensor mobility can be exploited to compensate for the lack of sensors and improve tracking performance.

V. CONCLUSION

In this paper, we have studied the target tracking problem in mobile sensor networks. Specifically, we introduce performance metrics: spatial resolution and we investigate the resolution against moving targets. By modelling the dynamic aspects of the target tracking that depend on both sensor and target mobility, we derive the inherent relationship between the spatial resolution and a set of crucial system parameters including sensor density, sensing range, sensor and target mobility. The results demonstrated that mobility can be exploited to obtain better spatial resolution. There are several avenues for further research on this problem: (1) to consider the detection error of mobile sensors under varying sensor speeds. This can be formulated into an optimization problem for target tracking; (2) to refine the sensor mobility model, the network model, and the communication model among sensors in order to enable effective detection and tracking. For example, a practical distributed target tracking and sensing information exchange protocol becomes an interesting future research topic when sensors are required to trace the target paths.

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