Energy Efficient Target Tracking in Wireless Sensor Networks

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Abstract - Wireless Sensor Network provide reliable and accurate information regarding the environment in which the sensors are deployed. Among the various applications of a sensor network, recent advances are with respect to target tracking. Target tracking is a challenging task due to failure of sensor nodes, high mobility of the target, processing of data acquired from multiple targets and sensors. There are mainly two types of localization algorithms. The Range-based localization algorithm has strict requirements on hardware, thus is expensive to be implemented. The Range-free localization algorithm reduces the hardware cost. However, it can only achieve high accuracy in ideal scenarios. In this paper, we locate multiple target nodes by incorporating the advantages of these two types of methods and propose a new hybrid algorithm using RSSI, DV-Hop and PIT testing. This Algorithm use acoustic signal generator and acoustic signal sensor while simulation in OMNET ++ and improves the localization error compared with another hybrid algorithms.

Keywords: Received signal strength indicator, Wireless Sensor Network, Tracking, PIT Test, Localization

I. INTRODUCTION

A Wireless sensor network (WSN) [1] is composed of Number of sensor nodes. These nodes have the ability of sensing, processing, and wireless communication. In various domains, such as national defense and military affair, environment inspection, traffic management, long-distance control of dangerous region, and so on, WSN has shown its significance and capability in application. In WSN, the position information is crucial. When an abnormal event occurs, the sensor node detecting the event needs the position information to locate the abnormal event and report to the base station. Without position information, WSN cannot work properly. Therefore how to obtain the position information of unknown nodes, which is called localization problem, has become a hot topic in WSN. Recently, many localization algorithms for sensor networks have been proposed.

WSN localization mainly divided into two classes' Range-based algorithm and Range-free algorithm. The range-based schemes are based on using range measurement techniques for location estimation. The range-free schemes ignore the using of range measurement techniques. Thus, in Order to estimate the location of unknown nodes, these schemes are based on the use of the topology information and connectivity, i.e.," who is within the communication range of whom [5]. Range- free approaches are expected to be alternative solutions to range-based approaches. They do not require any extra hardware, because they do not rely in any distance measurements. The main advantages of range-free approaches are its simplicity and low cost. However, the localization error is highly dependent on the density of nodes, on the number of beacon nodes and on the network topology. They are suitable for applications where location accuracy is less critical.

In this paper we proposed a Hybrid algorithm incorporating the benefits one of the Rang-based and the range-free algorithm. Here, we will use RSSI, DV-Hop and Trilateration to achieve the objective of multiple target tracking.

The rest of the paper is organized as follows: Section II discusses previous work in localization. Our Proposed algorithm is described in Section III. Section IV depict result and analysis. And section V draws a conclusion and future scope.

II. RELATED WORK

Tracking a mobile target has attracted many research interests. Various algorithm has been proposed based on different methods. Time of Arrival (TOA) [2] [3], Time Difference On Arrival (TDOA) [4] , Angle Of Arrival (AOA) [4] are all popular Range-based method They require additional hardware support and thus, are very expensive to be used in large scale sensor networks. Huafeng Wu [7] designed a Real Time MEMS localization

algorithm which uses Rssi, cross circle area of circles and weighted localization in order to draw the results. Shuang Tian [6] developed a hybrid algorithm whose performance is better than earlier DV Hop algorithm.
RSSI [4] is the most fundamental method. Both theoretical and empirical models are used to translate signal strength into estimated distance. Due to its easy implementation and there is no need for additional hardware, RSSI has been widely used. It is also used in this paper. In the RSSI method, the sender's transmitting intensity can be known, and the receiver can compute the signal loss after receiving

DV-hop algorithm which is Range-Free algorithm works like this. Firstly, anchor nodes broadcast beacons including their position information and a flag which is initialized as 1 to figure out the number of hops away from the other nodes. When the beacons are forwarded, the hop number is increased by 1. So each node will know the hop distances from itself to all anchors. Secondly, the anchor nodes will compute the average distance per hop after receiving the beacon message.

III. PROPOSED WORK

A network of sensors in a 2D plane is considered. A triangular network is considered i.e. the sensors are placed in a triangular fashion. Each sensor node is aware of its physical location and that of its neighboring sensors. All the sensors have a processor, a memory and required hardware to support sensing, information gathering and communication capabilities. Each sensor has a sensing radius, r which is equal to the length of the side of the triangle. Three sensors nodes are used to determine the location of the target node. The methodology used in this case is the triangulation technique of detecting the spatial coordinates. The sensors in this case are assumed to have different sensing radii. The work presented aims to track the moving path of a target in the network. The sensors nodes have an overlapping region of sensing which is known as the 'working area' and the areas surrounding these are known as 'backup areas' which imply that as soon as the target node moves into these areas a 'handover' should take place. As soon as a movement is detected, an election process is conducted among the sensors node based on their distance from the target node. The sensor node closest to the target node is chosen as the master agent while the next two are chosen as slave agents.

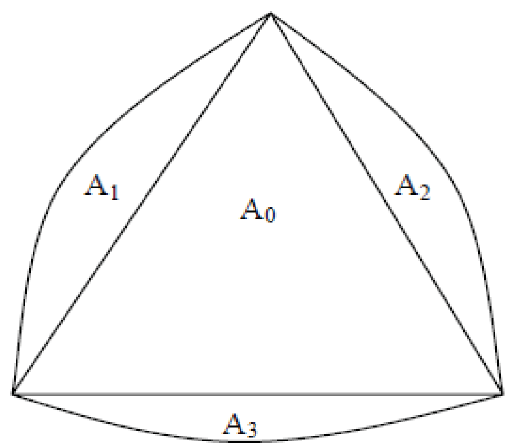

Figure 4.1: Working area and backup areas

As soon as the election process is done, all the other sensors are prohibited from tracking the target node by sending them blocking messages. Using the trilateration technique, these three sensors node calculate the position of the target. From time to time the slave agents report their results to the master and the tracking histories are recorded. They are reported by the master as and when required. To reduce the amount of overhead, a master may choose to pass on the gathered information to the location server from time to time. A master agent can revoke and reassign a slave based on the movement of the target. Certain signal strength thresholds govern this. Also, in case the target moves out of the sensing area of the master agent, there is a provision for a reelection process and selection of a new master agent. The above process can be understood by Fig.4.1 in which till the time the target moves in the working area (A0), the elected nodes do the sensing, while as soon as the target moves to the backup areas defines (A1, A2 and A3), the sensor node farthest from the target is revoked since the signal strength falls below the threshold level.
It has been assumed that the sensors can distinguish target which may be due to the unique ID transmitted by targets. Thus, the environment considers multiple targets easily. Sensors usually have four modes of operation: Transmit, Receive, Idle and Sleep based on the operation they are performing. Each of the nodes has a different

level of power consumption. Initially, all the sensors operate in the idle mode of operation in which they continuously detect any target within their sensing scope.
The variance of signal strength with distance is measured and smoothed out using a regression quadratic polynomial. Signal strengths can vary and the measurements are not very accurate. Thus, there are always some errors between estimated distances and actual distances. The trilateration technique used basically uses the intersection of three circles to find out the exact spatial coordinates of the object. In a real world scenario, the three circles never intersect at a common point .Hence, to minimize error, an approximation algorithm has been used in which the difference function is minimized. The difference function, x, y, z is calculated as

$$\sigma_{x,y} = \left| \sqrt{(x - x_A)^2 + (y - y_A)^2} - r_A \right| + \left| \sqrt{(x - x_B)^2 + (y - y_B)^2} - r_B \right| + \left| \sqrt{(x - x_C)^2 + (y - y_C)^2} - r_C \right|$$

Where A, B and C are the sensor nodes and
(xA, yA), (xB, yB) and (xC, yC) are their center coordinates and rA, rB and rC are the distances to A, B and C from any point (x, y) on the plane.
The algorithm uses acoustic signal generator and acoustic signal sensor in simulation environment as it absorb less moisture and hence error reduce.

Algorithm Process

In the first step, each WSN node broadcasts a packet to be flooded throughout the network containing the packets location with a hop-count value initialized to one. Each receiving node maintains the minimum hop-count value per packet of all packets it receives. Packets with higher hop-count values to a particular anchor are defined as stale information and will be ignored. Then those not stale packets are flooded outward with hop-count values incremented at every intermediate hop. Through this mechanism, all nodes in the network get the minimal hop-count to every packet node. In the second step, once a node gets hop-count value to other nodes, it estimates an average size for one hop, which is then flooded to the entire network. After receiving hop-size, blindfolded nodes multiply the hop-size by the hop-count value to derive the physical distance to the packet.
The algorithm used to narrow down the possible area in which a target node resides is called the Point-In-Triangulation Test (PIT). In this test, a WSN node chooses three anchors from all audible anchors (anchors from which a beacon was received) and tests whether it is inside the triangle formed by connecting these three anchors. Node repeats this PIT test with different audible anchor combinations until all combinations are exhausted or the required accuracy is achieved. At this point, APIT calculates the center of gravity (COG) of the intersection of all of the triangles in which a target node resides to determine its estimated position.
Then estimation error is calculated with the help of actual position and estimated position of the target node.
If the actual position of the target is (x, y) and estimated position is (xe, ye) then the estimation Error is

$$ER = \sqrt{(x_e - x)^2 + (y_e - y)^2}$$

IV. RESULT AND ANALYSIS

The Implementation was done in OMNeT++ IDE, OMNeT++ includes an integral development environment (IDE) that enables programming that is c debugging of simple modules, as well as graphical and textual editing of NED files.

Deployed Location Tracking WSN in OMNET++

The figure2 below shows the Simulation of 400 nodes in Tkenv, Tkenv is a tool that is GUI monitoring simulation flow, featuring animation of message flow on network charts, visualizing node state changes, displaying debug output of modules or module groups, viewing and manually changing state of simulation objects etc.
Neighbor discovery is a component of Localization Mechanism and performed while algorithm. Wireless sensor networks often must operate under a more severe low-power regimen than do traditional ad hoc

networks, notably by turning off radio for extended periods. Turning off a radio is problematic for neighbor discovery, and a balance is needed between adequate open communication for discovery and silence to conserve power. Node discovery process take place by broadcasting messages to neighbors.

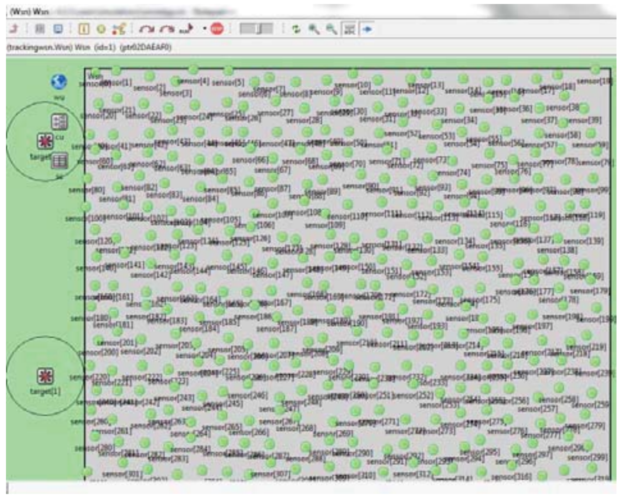

Figure 2: Deployment of 400 WSN nodes in OMNET++ scenario

The Localization algorithm considers wireless sensor networks composed of a large number of battery operated nodes. Nodes share a common radio channel and are organized as a multi-hop network communication between nodes requires relaying packets by intermediate nodes. The wireless multi-hop sensor network is dense to ensure that all nodes can find the resources they looking for, in such a network, collisions may happen when a Node is within the transmission range of two Nodes that are locating the same node simultaneously so that the node locates neither. As each collision represents unnecessary energy dissipation.

The Huafeng Wu [7] have developed and proposed the mechanism and procedure to model the location estimation for object tracking in large-scale WSNs. The designed modeling was a simple scheme without complex processing which uses range free positioning technology as well as centralized data. The designed modeling was a simple scheme without complex processing. They have uses MATLAB to conduct the simulation and numerical analyses to find the optimal modeling variables.

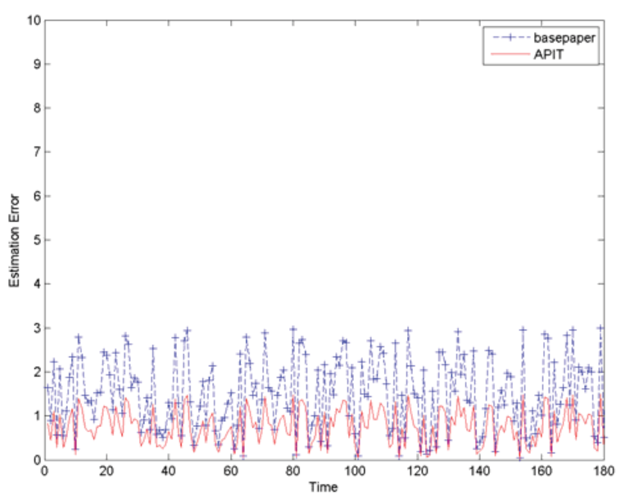

Fig: 3 Estimation Error with Respect to time compared with Base paper (blue) and Proposed work APIT scheme (red).

Compared with our work their localization error is on average larger.

V. CONCLUSION AND FUTURE SCOPE

Wireless sensor networks are tremendously being found in different environments to perform different tasks that are monitoring as search, rescue, disaster relief, target tracking and a number of tasks in smart environments. A new proposed localization Mechanism utilizes the Approximate Point in Triangulation (APIT) method. In this process, node trace-back procedure including all phases associated with the localization process and calibrates the actual position of the node.

As a result of harsh aqueous environments, non-negligible node mobility and large network scale, localization for large-scale mobile underwater sensor networks is very challenging. This research work ended up being about Hop by Hop trace-back mechanisms, through the use of the flexibility patterns of WSN nodes.

In future, work can be done on Underwater Acoustic Sensor Networks. Underwater acoustic sensor companies comprise of sensors and vehicles deployed underwater and networked via acoustic links to perform monitoring that is collaborative. The issue of constant node mobility cannot be neglected, especially in the scale that is big. However, these techniques are not suitable for managing underwater mobility due to UWSN's nature that is 3d.

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