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Tracking A Dynamic Target in Wireless Sensor Network Using Enhanced Polygon Based Framework

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***Abstract*— The Main objective of a Wireless Sensor Network is to 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 multiple sensors at sink, communication between the sensors using wireless medium. Many approaches have been developed to address the issues of target tracking and provide the solution for the same. In this paper we present the various mechanisms developed for the purpose of target tracking using the target signal parameters such as Received Signal Strength(RSS) and Time of Arrival(ToA). Finally we propose a target tracking framework considering the flaws in existing system and combining the advantages of various mechanism with energy of a sensor node being the main constraint.**

Keywords—Target Tracking, Wireless Sensor Network , Brink Detection Framework, mobile target, cluster.

INTRODUCTION

Wireless Sensor Network (WSN) is used to bring about the interaction between humans and the environment. Wireless Sensor Network was originally developed for applications in battlefield. The sensors are deployed in regions where human intervene is not possible. Due to the success of the network in military area, the application has been extended to health care, remote monitoring, industrial applications etc. Recent advances in Wireless Sensor Network have to led their use in monitoring potential targets [1] [2]. Sensors are deployed in remote locations. Through communicating with neighbor nodes using wireless as medium a self organizing network is created. Based on the functionality for which the nodes are deployed, they organize themselves. The various functions for which the sensor nodes are deployed vary from simple temperature monitoring to complex tracking of unauthorized entry of target in De-Militarized Zone(DMZ). We consider the application of sensor nodes for target tracking mechanism. On detection of target, the sensor node communicates the information regarding the target signature to the neighbor nodes along with the sink. The neighboring nodes are activated on reception of the message and takeover the tracking responsibility of the target. In order to detect node failure, a hello packet is sent by nodes to their neighboring nodes and expects a reply. If reply is not got within the predetermined time interval, the neighbor node is marked as failure. There are three common procedures involved in the various mechanism developed for the purpose of target tracking [1],[2],[3],[4],[5],[6],[7].

1. Sensor nodes must know their location with minimal ranging and estimation error and the distance between the target and sensor node must be calculated accurately.
2. Sensors must form self organizing groups(clusters). The cluster head should communicate to the sink regarding the target's location.
3. The target detection information should be passed to the central sink for processing. The sensor nodes must detect node failures and avoid such path to communicate with the sink. Data redundancy must be avoided.

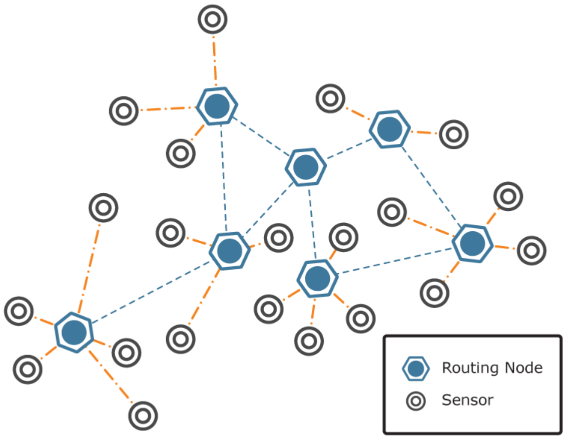

Fig 1 : Wireless Sensor Network

Fig 1 depicts a Wireless Sensor Network. In WSN the sensor nodes are classified into either a sensing node or a routing node. The sensing node is responsible for collecting the information regarding the functionality for which the network was deployed. The routing nodes are responsible for forwarding the detected information to the sink and share the information among the clusters. Based on the requirement the node can act as a routing node as well as a sensing node. In case of failure of the routing node, the sensing node closer to the sink or the neighboring cluster performs the routing operation. The sensors are initially programmed before deployment to organize themselves into cluster and select the corresponding routing nodes.

1. RELATED WORK

Tracking a mobile target has attracted many research interests. P Vicaire[7] designed a real time tracking scheme which adopts a power management protocol to reduce the energy consumption. The sensors are either in active or sleep state. Q Huang[8] suggested a new protocol in name of Mobicast to estimate the direction of target mobility. Kaplan[9][6] addressed node selection algorithm, Autonomous Node Selection(ANS) and Global Node Selection(GNS) algorithms as solution for target tracking problem. Zong [3] proposed target tracking using unreliable node sequences. It converted the problem of tracking the target to finding the shortest optimal path to follow the target. In Tree based approach for target tracking such as Dynamic Convoy Tree based Collaboration (DCTC) [4][10] technique, the hierarchical structure management overhead is more. As the target moves, the nodes in tree may become far from the root with respect to the distance and more energy is spent in communicating the information to the root. The various target localization techniques are based on the following parameters.

1. Received Signal Strength Indicator(RSSI) [12]
2. Time of Arrival (ToA) [13]
3. Time Difference of Arrival (TDoA)
4. Angle of Arrival (AoA)
5. Global Positioning System (GPS) [11]

These parameters are easily affected by noise and interference along with the processing overhead at the sensor nodes to avoid data redundancy. These techniques require the sensor nodes to learn their location and determine the target location relative to the node position. Several other mechanism involve predicting the movement of target based on pre-computed data and algorithmic functions. In real time the mobility of target with respect to the speed and the direction are unknown and such solutions aren't robust if the prediction is not handled properly.

In RSSI [12] mechanism the sensor nodes regularly exchange messages and in case of target detection the signal strength of the sensor node varies due to interference by target and hence a reduction is received signal strength is used as an indication of target in the network. As the received signal strength varies from node to node the target mobility is determined accordingly. Received signal strength can vary as the energy is consumed in the node. The node can be programmed to reduce its transmission power and range to conserve energy and in such cases the node is made to believe the presence of target even in absence of the target.

In ToA [13] mechanism neighboring nodes exchange information regarding at what time was the node able to sense the target signal. The time stamp is forwarded to every node in the cluster. As the target moves away from the node the time of arrival of signal increases with respect to one node and reduces with respect to another node which is in target's path. Hence a variation in Time of Arrival is used to detect the movement of the target. Time of Arrival of signal at a node can be delayed due to interference by other nodes and limited queue buffer along with low speed of processing at the node. In such cases the target is determined to be in motion although it might be stationary.

Guojun Wang[14] developed a technique called FaceTrack which uses Brink Detection Algorithm to track the target. The node organize themselves inform of polygons on detection of target. The movement of target is detected by the variation in Received Signal Strength at the sensor node with respect to the signal emitting target. As the target reaches the edge of the polygon(brink) due to its mobility, a neighboring polygon is created and the newly constructed polygon takes over the tracking. The brink is detected by constructing the following regions and determining so as to in which region does the target exist.

1. Square Spot
2. Rectangular Spot
3. Crossing Spot

As the target moves towards the edge of polygon, square spot is created and the edge nodes of the polygon take over tracking and construct the rectangular region. Once the target crosses square spot and enters the rectangular spot, neighboring polygon is created. On occurrence of crossing spot , the new polygon tracks the target and the previous polygon is deleted. The working of the 3 critical regions along with the target movement is as depicted in Fig 2.

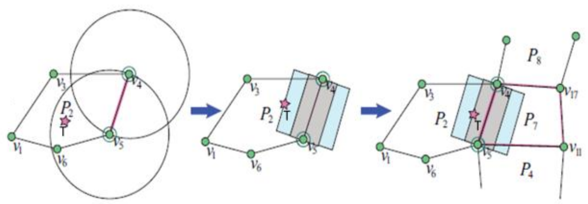

Fig 2 : Target Tracking using FaceTrack Mechanism

From Fig 2, V_1, V_3, V_4, V_5 and V_6 are the sensor nodes that form the polygon P_2 .T is the signal emitting target node. As the target node moves towards the edge of the polygon, the brink nodes V_4 and V_5 keep track of the target and create square spot. Once the target moves towards the square spot , rectangular spot is created in confirmation to the fact that the target is moving away from the polygon and hence a new polygon is created. After the target crosses the rectangular spot, a crossing phase occurs and new polygon P_7 is created and the old polygon is deleted. The same procedure is repeated whenever the target crosses the brink/edge of the polygon and enters the new polygon. The information regarding the target is sent to sink .

2. PROPOSED WORK

In the FaceTrack[14] mechanism, the process of polygon reconstruction and deletion takes place every time the target crosses and edge/brink. The target's movement is random in nature and can follow any path. If the target follows a cyclic path i.e retracing the same path again and again, the polygons are reconstructed again and again and energy is wasted in exchanging messages to create new polygons. To overcome this, an enhanced polygon based brink detection framework is developed.

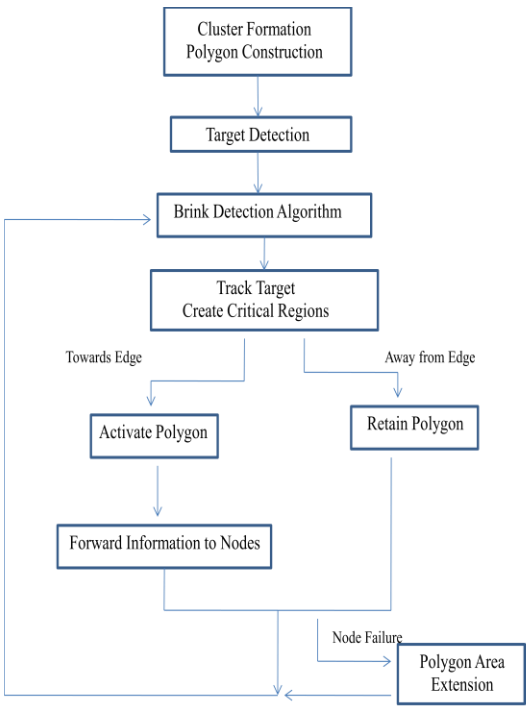

Fig 3 : Enhanced Polygon Based Tracking Framework

In enhanced polygon based framework, sensors on deployment organize into clusters. Polygons are created initially in form of clusters to avoid polygon reconstruction again and again. Each sensor in the network exists in either active or sleep state. The sensors are programmed such that at least one sensor stays active at any instant of time in the polygon to detect the target. Once the target is detected and it crosses the edge of polygon, the nodes of the neighboring polygon is activated. The activated polygon takes over the tracking of target. Thus energy of the sensor nodes are conserved as polygon is not created and deleted, instead activated. In case of node failures, new polygon is constructed communicating with the next nearest neighbor. The mechanism followed by the enhanced polygon based brink detection framework is as show in Fig 3.

3. CONCLUSION

One of the main applications of Wireless Sensor Network is to track an unauthorized target in the surveillance field. Energy is one of the most important constraint in Wireless Sensor Network. We proposed an enhanced framework to detect and track the movements of the target. The proposed framework is energy efficient as the nodes are made to move into sleep state when they are not sensing the target. It is robust against node failure as the polygon area is extended in case of failures.

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