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Hop-Count Based Localization Algorithms-A Review

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Abstract— localization in wireless sensors networks is one of the important issues. In WSN because of the constraints of energy efficiency and cost of network, Range-free algorithms has become an important research topic as Range-free algorithms are cost effective and no additional hardware is required in range-free algorithms. In Range-free algorithms distance estimation is done by hop count between the nodes. Hop count based algorithms are multi-hop, distributed algorithms. This paper provides a review on hop count based algorithms.

Keywords— WSN, localization, Hop-count metric, anchor nodes, normal nodes, GPS

I. INTRODUCTION

Wireless sensors networks consists of several sensor nodes that are deployed in some geographical area for monitoring and controlling purpose. The number of nodes in a WSN could be from few hundreds to millions of nodes depending upon the application for which these sensor nodes are deployed. Sensor nodes sense the physical quantities in the real world like pressure, humidity, temperature, vibrations. A sensor network is composed of a large number of sensors nodes that are densely deployed [1]. A sensor node has embedded processing capabilities and on-board storage. A node can have a single sensor or array of sensors that operate in acoustic, seismic, radio, infrared or optical domains. Communication links between the nodes is wireless. The sensor node also has location and positioning knowledge that is acquired by global positioning system or localization algorithm. Each of the distributed sensor nodes collects and analyses data and route them to a sink point for appropriate processing

WSN is used in various fields such as surveillance, military affairs, medical field, target tracking, environmental and habitat monitoring, disaster management and many more applications where data gathering is done at proximity of origin of data. In all the WSN applications sensor nodes detect events or gather data from particular locations. Therefore event gathering without the knowledge of locations is meaningless. Therefore sensor nodes localization [2] is very important issue in WSN. In WSN node localization is essential for proper operation of a sensor network. Localization is required to detect events of interest in the environment under observation.

II. LOCALIZATION

The process to know the locations of senor nodes in WSN is localization. Localization of sensor nodes is important to know the physical location of sensor nodes, from where data is being collected. Localization of nodes is also required for network operations like routing, quality of coverage, load balancing and self- organisation of network.

The easiest way to know the position of sensor nodes is global positioning system (GPS). But GPS equipped sensor nodes become very costly and consume large energy. Line-of-sight with satellite is also a problem of GPS. Therefore for large scale wireless sensor networks GPS is not a good solution. As energy efficiency and cost are constraints of large scale wireless sensor networks, Localization algorithms are used to localize the sensor nodes in WSN. The nodes with knowledge of their position are known as anchor nodes. Anchor nodes are equipped with GPS or are manually configured. Other nodes those do not have position knowledge are called unknown nodes or normal nodes. Normal nodes make reference of anchor nodes to know their position. Normally localization is done in two phases. First is distance estimation and second is coordinate calculation to know the position of sensor node. The distance estimation phase involves measurement techniques to estimate the relative distance between the nodes. Then coordinates of the normal nodes are calculated using multilateration [13] or angulation. On the base of distance estimation technique, localization algorithms are classified [3] as Range-free and Range-based algorithms.

Range-based approaches use absolute point-to-point distance or orientation information between nodes to estimate the location of normal nodes. To measure the distance or angle between the nodes various techniques like TOA (Time of arrival), TDOA (Time difference of arrival) and RSSI (Received signal strength) are used. These techniques use additional hardware like directional antenna, therefore these techniques are expensive and require additional energy for localization but give accurate results.

.On the other hand Range-free approaches are not based on distance or angle information between nodes, but use information of connectivity or number of hopes between nodes as distance metric. Accuracy of Range-free approaches is less as compared to range based techniques. As no additional hardware is required for localization in Range-free techniques, these techniques are cost effective and energy efficient. Because of cost effectives, energy efficiency and scalability these techniques have become important topic in research. DV-Hop [4], Centroid, APIT (Approximate point in triangulation) [5], Amorphous are some typical Range-free algorithms.

III. HOP COUNT BASED LOCALIZATION ALGORITHMS

In a wireless network Hop count metric between source node S and destination node D can be defined as number of intermediate nodes between source node S and destination node D including the source node. Localization techniques which are based on hop count information need less number of anchor nodes because the position of anchor node is propagated in the network by packet forwarding. Amorphous, DV-Hop and other improved DV-hop algorithms are based on hop count metric. Hop count approaches are simple to implement but accuracy is less than the approaches based on ranging techniques. Simplicity, scalability, energy efficiency and cost effectiveness are good features of hop-count based algorithms. Because of these characteristics hop count algorithms are suitable for ad hoc networks and large scale WSN. As ad-hoc networks are comprised of inexpensive nodes without additional hardware for localization. Accuracy of hop count based techniques is affected by node density. Accuracy of these approaches is good in dense and uniform nodes networks.

Niculesu and Nath [4] proposed the DV-Hop algorithm which was based on hop count metric. The algorithm is of three steps. In the first step, anchor node broadcast a beacon throughout the network containing anchor node location and hop count value initialized at one. Each receiving node then maintains the minimal hop count to every anchor node. In the second step average size for one hop is calculated at anchor node and broadcasted to entire network. After receiving first hop size message normal nodes with unknown locations multiply the hop size by the hop count value to get the distance to the anchor nodes. Normal nodes also transmit the hop size to their neighbour nodes. Finally normal nodes compute their location by trilateration.

Chen et at [6] proposed an improved DV-Hop localization algorithm for WSN. Location accuracy of the algorithm was improved by modifying the second and third step of the DV-Hop algorithm. In the second step normal node receives hop sizes of every anchor node, then calculates average hop size using hop sizes of different anchor nodes. In the third step 2-D hyperbolic function is used instead of multilateration to calculate the location of normal nodes.

Sharwan kumar et al [7] proposed an advanced improved algorithm. First step was same of the DV-Hop to calculate the number of hops between the nodes. In the second step ID and hop size of each anchor node is maintained in a table at normal node. Then distance for an anchor node is calculated by multiplying hop count with hop size of respective anchor node. In the third step inherent error in estimated distance is reduced by modifying the basic multilateration. Accuracy of algorithm is further improved by weighted least square algorithm. Finally location of the nodes is refined.

Sharwan kumar et al [8] proposed PERLA that is power efficient range-free localization algorithm for WSN. In the algorithm Distance estimation is based on hop count metric. Algorithm was developed to reduce the communication between the anchor nodes and normal nodes to make it power efficient. Hop size of anchor nodes is calculated and refined at the normal node. Then distance is estimated between the anchor nodes and the normal nodes.

Sarita Gurung et al [9] proposed a hop-count based positioning algorithm for wireless ad-hoc networks. In the proposed algorithm hop count metric is used as a proximity indicator, then this proximity indicator parameter is used for localization of normal nodes.

Sungwan Yaang et al [10] proposed an energy efficient and more accurate localization algorithm based on hop-count ratio. Hop-count-based localization algorithm (HCRL) is a range-free, energy efficient, cost effective localization scheme. The proposed localization algorithm used the information of hop-count-ratio instead of average hop size information between the anchor node anchor nodes and unknown nodes. Communication overhead between the nodes is also reduced as flooding of information is done only once. Therefore in HCRL algorithm transmission overhead is reduced as compared to other hop-count based localization algorithms, that results in more energy efficient algorithm.

Typical hop count based localization methods assume that the hop size for different hop count is same. Although for real scenario distances of different hop count from normal nodes to anchor nodes vary in a certain range. For optimal distance estimation many efforts have devoted to the mathematical analysis of various statistical relations between the distances and hop count.

Quanrui Wei et al [11] Proposed localization algorithm based on multi-hop distance unbiased estimation (MDUE). In the proposed algorithm for all the hop counts an approximate unbiased estimation of distance is done. Because of MDUE better distance estimation is done and localization accuracy of algorithm is increased.

Multi-hop range-free approaches are suitable for isotropic networks. In isotropic networks the hop count of the shortest path between two nodes is assumed to be proportional to the Euclidean distance between them. The performance of hop count based algorithms deteriorates considerably in anisotropic networks. Anisotropic networks are characterised by obstacles, sparse, and non-uniform node distribution and irregular radio propagation.

Sangwoo lee et al [12] Presented range-free localization algorithm that tolerates network anisotropy with a small number of nodes. In the proposed algorithm each normal node approximates the shapes of the shortest paths to two arbitrary anchor nodes with a virtual hole and estimates the distances to the anchors by considering how much their approximate shortest paths are detoured. By the proposed algorithm distance estimation accuracy is increased and localization performance is improved.

IV. CONCLUSION

Localization of sensors nodes is one of the important issue in WSN. As GPS is not the feasible solution for energy constrained large scale wireless sensor networks. Localization algorithms are developed for locating sensor nodes. On the base of distance estimation technique used in localization approach, localization algorithms are broadly classified as Range-based and Range-free algorithms. Range free algorithms are suitable for large scale wireless network or ad hoc networks because of the features like energy efficiency, cost effectiveness, scalability and simplicity. Range-free

approaches are based on hop count metric. As hops between the nodes are of varying sizes, this adds to ranging error, therefore accuracy of hop count based algorithms is less compared to other algorithms in which distance estimation is based on ranging techniques. Hop count based approaches are important research topic. Various techniques are developed to increase the accuracy of hop count based algorithms. Performance of hop count based approaches deteriorates in anisotropic networks. Research work is being done to increase the performance of the hop count based algorithms in anisotropic networks.

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