Comprehensive Review on localization techniques for Wireless Sensor Network

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Abstract – Wireless sensor network is one of the most developing areas. Various WSN applications are being used worldwide. In WSN, autonomous devices using sensors are being employed to monitor various physical and environmental conditions. The flexibility of wireless sensor networks comes with a wide range of challenges. Security, cost optimization, energy efficiency, accuracy are the major areas of study in this field. The most important challenge with WSN is the localization of nodes that needs optimization. Localization concept revolves the determination of the position of an object. Apart from the localization the problem also arise with the requirement of hardware which is costly and energy consuming. This paper presents comprehensive study done on various localization algorithms and a detailed study of Dv-Hop algorithm. Also, a concept of RSSI with Dv- hop will be a part of study later in this paper.

Index Terms – Wireless Sensor Network, localization, algorithms, Dv-Hop, anchor nodes.

1. INTRODUCTION

A **sensor** is a device which is used for sensing some particular characteristics and then converting those into signals which can be further measured using some devices. For instance, a thermocouple will sense heat energy at one of its junction and produce equivalent output voltage which can be measured by a voltage read by the voltmeter. A good sensor has the characteristic of high sensitivity, linearity, less power consumption, less noise and disturbances and many more. Thus, in a wireless sensor networks a number of autonomous devices using sensors are spatially distributed in an area which monitor physical or environmental conditions, such as temperature, sound, vibration, pressure and many more at different locations.[1] It involves use of numerous wireless sensors from a few to several miles, where each node is connected to some nodes or several sensor nodes.

A. APPLICATIONS OF WSN

Wireless sensor networks are used in many civilian application areas, including environment and habitat monitoring, healthcare applications, home automation, traffic control systems, fire detectors, security sensors. Also, it is used in the field of medical and healthcare monitoring, disaster area monitoring, emergency rescue, disaster relief, patient monitoring in addition to industrial applications such as distributed structural health record and environmental control, and military applications such as target identification and tracking, area monitoring, Environmental Monitoring, Industrial Monitoring, Traffic Control System, Underwater Acoustic Sensor Networks, Environmental/Earth sensing, Air pollution monitoring, landslide detection, water quality monitoring.[2]

B. ISSUES RELATED WITH WSN

Wireless sensor networks have various issues namely hardware and Operating System for WSN, deployment, Localization, Synchronization, Calibration, Network Layer, Transport Layer, Architecture, programming Models for Sensor Networks, Middleware, Quality of Service, Security and many more. [2] In this paper I will be mainly focusing on the issue of localization in WSN.

2. CONCEPT OFLOCALIZATION

Localization is one of the very fundamental and difficult problems that have a requirement to be solved for WSN. Localization is basically finding the location of an object. Importance of localization is to find the locality of the sensor node in WSN environment and then there arouses it needs an event, geographic aware routing, node coverage, node ID, ubiquitous computing. It is a very complex issue.

Problem: Basic problem in wireless sensor environment is localization .e. finding the physical location of the sensor nodes. Also, problem arises with the requirement of hardware which is quite costly in terms of cost and energy consumption.

Solution: Marking the location of each node as deployed which is impractical for large number of nodes and limited mobility. Also, GPS has the capabilities on all nodes but it is expensive, large in terms of volume and consumes more energy. This technique or method is also known as direct approach. Apart from the direct approaches, indirect approaches have also been proposed.

Indirect approach which is further bifurcated into two: Range free and range based algorithm.

In range-based algorithms, nodes calculate their distance to other nodes using some hardware .Range-based algorithms require the sensors that contain specialized hardware to make range measurement. Examples of Range Based Localization Algorithms are Received signal strength (RSS),Time of Arrival

of signals Angle of Arrival of signals Time Difference of Arrival (TDoA).

In the case of range-free algorithms, radio signal strengths, angle of arrival of signals or distance measurements does not demand any special hardware requirement. Range-free algorithms wants that each node must be aware of which nodes are within radio range, their location estimates, and the ideal radio range of sensor. Thus, range free techniques are more economic than the previous one because they do not require any special hardware requirement. Examples of Range-free Localization algorithms are Centroid localization, APIT, and DV-Hop algorithm. [5]

A. PARAMETERS FOR EVALUATION OF LOCALIZATION ALGORITHMS

We have certain parameters which we need to care of before selecting any localization algorithm. Some of them are listed below:

Accuracy: It is the most important parameter for location evaluation and most of the application needs high accuracy. After all we need accuracy when we have to localize any of the nodes.

Scalability: Scalability is one of the factors for the judgment of the localization algorithm.

Robustness to Failure and Error: Localization algorithm should be robust against node failure and Error and noise in the input data. Error free algorithm will automatically produce high accuracy.

Coverage: It means how much of the network can be localize with the algorithm. Or we can say that how much area would be covered under the respective localization algorithm. A good localization algorithm covers a larger distance.

Cost: The cost of localization technique refers to several factors including everything whether it is the hardware or the software requirements. Cost is one of the important factors in selection of a localization algorithm.

Security in the Network: Lastly, we have a very important parameter which is security. A good algorithm comes with a high level of security. For instance, an algorithm would provide a high accuracy but maybe after implementing it could lead to attacks. Thus, security and privacy of nodes need to be taken on priority. Work has been done in this area but till problem needs to be resolved. [1]

B. TECHNICAL ISSUES WITH LOCALIZATION

Localization is one of the main challenges wireless sensor network. There are many technical issues. Some of the issues are:

Non-Line of Sight Problem (NLOS) - It is one of the major issues as it leads to an existence of some physical obstacle the hinder the detection of nodes. Thus, it may lead to loss of important connectivity information.

Sparse Node Problem- The connectivity information available to the network, especially in networks of low density, may not be enough for the construction of a unique solution.

Geometric Dilution of Precision (GDOP) - The case where a node that is far from, and only connected to, a dense cluster of nodes; this can lead to large errors in distance measurements.

Range Error Problem- Localization is based on distance, or connectivity, information that is prone to error. Distance information may contain errors as large as 50% of the measurement.

3. RANGE FREE ALGORITHMS

As mentioned earlier range free algorithms do not require any special hardware. It does not use radio signal strengths, angle of arrival of signals or distance measurements rather it just needs to know that its nodes are within radio range, their location estimates, ideal radio range of sensors. Therefore, these do not require sensors to be equipped with any special hardware which makes them as cost effective techniques. Some of the known range-free Localization algorithms are Centroid localization, APIT, and DV-Hop, Amorphous localization.

(a) Centroid Algorithm

In this method the unknown sensor node localizes itself by calculating the Centroid of position of all the adjacent connecting anchor nodes, The Centroid algorithm differs from trilateration as it is a range-free algorithm.

Range free algorithms do not depend entirely on RSSI distance measurements for localization. In case of Centroid algorithm, a node will get signals from all other anchor nodes that are in already in the range. The node is then localized to the center of gravity of the intersection of the circles formed by the propagation model of each anchor node. This is accomplished by simply averaging the x and y coordinates. The uses anchor beacons, containing location information (Xi, Yi), to estimate node position. After receiving these beacons, a node estimates its location using the following Centroid formula: [9]

$$(X_{est}, Y_{est}) = \left(\frac{X_1 + \cdots + X_N}{N}, \frac{Y_1 + \cdots + Y_N}{N} \right)$$

The advantage of this Centroid localization scheme is its non-complexity, cost-effective and ease of implementation. The disadvantage of this algorithm is it also estimates large no of errors produced. Later improvements were done on this using

by HEAP N. Bulusu by adding anchors nodes to reduce the errors.

(b) APIT Localization Algorithm

APIT Stands for approximate point in triangulation .In APIT algorithm, anchor nodes gets information of the location from Global positioning system. Un-localized node gets locality information from overlapping triangles. In APIT, an Un-localized node creates and maintains a table after getting beacon messages from anchor nodes. The table maintains the information of the anchor ID, its location, and the strength of the signal. An un-localized node then randomly choose any thee anchor nodes from the concerned area and then makes a check of whether a formation of an triangle has taken place or not, this is known as point in triangulation test. This test continues till the accuracy of un-localized node locality is discovered by any of the combination of three anchor nodes. At last the center of gravity also known as COG is calculated, which is intersection of all triangles where an un-localized node is held responsible to find its estimated location or position. In this algorithm, there is possibility of errors in the case where the node is close to the edge of the respective triangle. To overcome this, a new APIT algorithm was also given which overcomes this error by calculating individual areas of the triangles formed in both in-case and out-case and then comparing it with total area. APIT is more accurate than simple Centroid method but has slightly larger communication overheads compared to Centroid. More the no. of anchor nodes, more the triangles formed around unknown node and hence more the accuracy.

(c) DV HOP Algorithm

DV-Hop also known as distance vector-hop localization algorithm was initially proposed by Dragos Niculescu, is one of the most prototypical algorithms of range-free localization algorithms category. The basic idea is that the distance between the unknown nodes and the reference nodes is given by the compound of average hop distance and the hop count. In this way, the un-localized nodes can then detect number of hops away from anchor node. All anchor nodes tries to estimate the shortest path from other nodes, and un-localized nodes also estimates the shortest path from all anchor nodes. Average hop distance formula [9] is calculated as follows:

$$HopSize_i = \frac{\sum \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum h_j}$$

It has a medium level of accuracy and cost. It was not suitable for sparse networks. So, more lately improved DV-HOP algorithms were made to increase the accuracy of the original DV-Hop algorithm.

RSSI Based DV HOP Algorithm

RSSI stands for Received Signal Strength Indicator. A RSSI-based DV-hop localization algorithm locates the unknown nodes by assimilated both i.e. the concept of RSSI and DV-hop which aimed to reduce the estimated error of the nodes which are near to the anchors, calculated by DV-hop localization algorithm. By utilizing the concept of received signal strength, RRSI based DV-Hop acquires more accurate estimation of the average single hop range by improving the second phase of DV-Hop algorithm with range quantization method. [8]This algorithm has more accuracy than any other algorithm yet discussed but it need of hardware support is an extra requirement.

IMPROVED DV-HOP

The main objective of different localization algorithms is accuracy. To boost the accuracy of localization in DV-Hop algorithms some more improved DV-Hop methodologies have been proposed. Improved DV-Hop, improves the node position estimation in the third phase of DV-Hop algorithm by using the measured distances to its bystanders and the complementary positions. However, this had improved accuracy but need of the extra hardware still continued. Improved DV-Hop can reduce the nodes average localization error significantly in different communication ranges and reference node ratios. It is simple, robust, distributed and scalable, accuracy increases with increase in the number of beacon nodes, needs high connectivity, error prone selecting wrong distance.

Improved DV-Hop Algorithm Based on Artificial Bee Colony

In order to reduce the error of a node position in DV-Hop algorithm in WSN environment, the artificial bee colony algorithm has been added to the DV-Hop algorithm. A new ABCDV-Hop (Artificial Bee Colony DV-Hop) algorithm has been proposed. Based on the traditional DV-Hop algorithm, by using the minimum no. of hops of nodes and position information of anchor nodes, the average distance per hop is solved by artificial bee colony algorithm to make it more close to the original value. With comparison to the traditional DV-Hop algorithm, this method an effectively reduce the positioning errors, improved accuracy. ABCVDV-Hop algorithm thus improved the locality accuracy without booming the communication overhead and as well as supplementary hardware which was required in all other DV-Hop algorithms.

4. CONCLUSION

In this paper, various problems related to WSN have been mentioned. This paper can be helpful for researchers who are working in this field. Localization, accuracy, costing, security are the major areas of study in this field. Among the all, most important challenge with WSN is the localization of nodes. Efforts have been made by many researchers and numerous

algorithms also have been proposed. In this paper, some algorithms have been mentioned. Each algorithm has its own advantages and disadvantages. Furthermore work can be done in this field and an optimum algorithm could be proposed to overcome the problem of localization in wireless sensor network.

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