Analysis of Node Localization Parameters on DV-Hop Algorithm in WSN

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Abstract-One of the practical issues in Wireless Sensor Networks (WSN) is to determine the exact position of the sensor nodes deployed in the network to perform some specific tasks, this process of determining position of these sensor nodes is called localization. The experimental approach is taken to investigate these challenges. This paper focuses on one of the localization algorithms called DV-Hop. Here this paper explains, evaluates and analyses the performance of this algorithm based on different parameters like anchor node (AN), unknown node (UN) and communication range (R) of sensor nodes. The results of experiments are presented and analysed.

Keywords: Anodes, DV-Hop, Localization, Unknown nodes (UN), WSN.

I. INTRODUCTION

A wireless sensor network (WSN) consists of controller, sensor nodes, communication device, memory and power supply or battery [1]. These components enable the wireless connectivity in the network. Sensor nodes are the main component of WSN. Through a transparent data path information is exchanged between application platform and the physical world which has one or more sensor nodes. These nodes can be active or passive; they can be narrow beam or omidirectional [2]. To transfer the data from source to destination, multi hop data path is followed where packet is transferred from node to another node until it reaches destination. These nodes are usually deployed randomly in different environment for measuring, computing and monitoring task especially for disaster relief, wildlife etc. WSN uses different network topologies to form a network. Topologies can be star, tree mesh or hybrid networks or these can be combined together to form a network [3].

There are many issues in WSN such as routing that how the routes are discovered and how to deliver data from source to destination even if the routes are broken. Another important issue is localization in WSN [4]. This paper focuses is on localization issue.

Localization or to find actual location of the nodes is very necessary in WSN and applicable in almost every application related to sensor networking. Sensor nodes can be deployed manually or randomly, in many cases, sensor nodes are deployed randomly without the knowledge of their location as manual deployment is time consuming [5]. For meaningful information related to any application, it is required to locate particular position where that event originally occurs. Sensor nodes can be differentiated on the basis of known and unknown position in WSN, Anchor node (Anode) whose location is known and Unknown Nodes (UN) nodes or blind folded nodes whose location is not known [6][7]. Different localization algorithms are used to calculate location of UN nodes from the Anode.

Many localization methods have been proposed that is categorized into two main categories [8][9], range based and range free. Range based method consist of different algorithms where these algorithms uses node to node distance estimation or angle estimation for coordinates calculation [10]. Range free methods also have some algorithms which uses hop information for calculating location of UN sensor nodes [11]. Former method gives higher precision than range free method but it requires additional hardware due to which bulkiness and cost increases [12]. Later method requires less cost, less energy consumption as it does not require any hardware support [9][10], due to which more attention is given to this method as compared to former. It includes different technology [13][14] such as DV-Hop, Centroid, APIT algorithms. Among all algorithms, DV-Hop [15] is most popular, simple, feasible algorithms which provides accuracy with high coverage quality, and does not require any additional hardware. This paper presents the analytical study of DV-Hop [16][17][18][19][20][21] algorithm with change in different variable on simulating result and choosing the node strategy of nodes that reduces the location error and improves accuracy.

II. ANALYSIS OF TRADITONAL DV-HOP LOCALIZATION ALGORITHM

A. DV-HOP Algorithm

Niculescu and Nath [17][18] proposed DV-Hop algorithm in which hop with least value is obtained and the UN nodes location coordinates are calculated using Anodes. It can be summarized by following three steps [20][21]:

First Step: Calculating minimum hop count

Anodes broadcast the information containing own-location coordinate's information and hop count to the whole network i.e. its other nodes in the network$(x, y, hop\ count)$, the initial hop count value taken is zero$(x, y, 0)$. All the receiving nodes in the network records the minimum hops to each Anode and ignores the message with larger hop count. All receiving node adds one to the hop count and forwards it to all other nodes. Through this minimum hop count is recorded by all the nodes.

Second Step: Calculating average hop size distance. All the Anode gets minimum hop count to other anchor it estimates. Equation (1) shows the average hop size which calculates the hop size for one hop by measuring the distance between the Anodes for hop in between those nodes can be defined by formula shown below

$$AvgHopSize = \sum \frac{\sqrt{(X_i - X_j)^2 + (Y_i - Y_j)^2}}{\sum h_{ij}} \qquad (1)$$

Where (X_i, Y_i), (X_j, Y_j) are coordinates of Anode i and j. h_{ij} is the no. of hops between anchor i and j. Then each Anode broadcasts to entire network using control flooding technique. And all other nodes collects all Anodes hop size with respect to another and each node selects only that hop size with the minimum value.

$$d_i = AvgHopSize_i\ x\ HopCount_i \qquad (2)$$

Where d_i is distance of Anode point $i\ to\ (x, y)$. After receiving minimum hop size value, distance of all other UN nodes to Anode is calculated by multiplying hop size by its minimum hop count as shown in equation (2).

Third Step: Calculate the self-position coordinates with help of anchor nodes. The each UN nodes computes its own location coordinates using the estimated distance recorded above; a group of linear equations can be achieved through (3)

$$\left.\begin{array}{l} \sqrt{(x - x_1)^2 + (y - y_1)^2} = d_1 \\ \sqrt{(x - x_2)^2 + (y - y_2)^2} = d_2 \\ \quad \dots\dots\dots\dots\dots\dots\dots\dots \\ \sqrt{(x - x_m)^2 + (y - y_m)^2} = d_m \end{array}\right\} \qquad (3)$$

Where (x_m, y_m) are the location coordinate of Anode m; (x, y) are location coordinates of UN node, and d_m is distance computed between UN nodes and the Anodes.

The least square can be used to estimate values using following equation (4):

$$X = (H^T H)^{-1} H^T B \qquad (4)$$

III. SIMULATION AND RESULTS

To verify the efficiency, accuracy of DV-HOP Algorithm, simulation experiment has been conducted in MATLAB and results of experiment are presented here.

A. Experiment Environment Settings

Figure 1 shows an example which shows network of $100 * 100m^2$ area is taken into consideration. The coordinates of Anodes and UN nodes are deployed randomly in this network area. UN nodes are represented by Red dots and Anodes are represented by blue dots and calculated location error is represented by red lines.

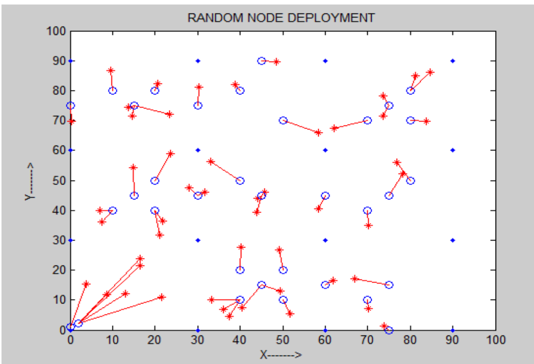

Figure 1: Random Deployment of nodes

In network environment, the density of network nodes can be changed by changing number of sensor nodes and its communication range (R) of the nodes.

The R is settled on 30, 40, 50, 60, 70, 80 and Anodes are settled as 5, 10, 15, 20, 30, 35.

B. Experiment Results and Analysis

Positions of UN nodes are measured through the DV-Hop. Then it is simulated to find coordinates of UN nodes and error [14] is given by (5):

$$Error = \sqrt{(X_2 - X_1)^2 + (Y_2 - Y_1)^2} \qquad (5)$$

Where (X_1, Y_1) are the actual coordinates, and (X_2, Y_2) are the estimated coordinates one.

Accuracy is used to describe location efficiency. Accuracy [14] can be calculated through (6):

$$Accuracy = \ Error/R \qquad (6)$$

Where Error represents the average value of Error, and R represents communication range.

Simulation results of error and accuracy for different parameters i.e R and Anode are shown in both tables, Table 1and 2 respectively.

TABLE 1 ERROR AND ACCURACY W.R.T RANGE

COMMUNICATION RANGE	ERROR	ACCURACY
30	34.2697	1.1423
40	24.3154	0.6079
50	25.9916	0.5198
60	51.8226	0.8635
70	29.9065	0.4272
80	35.1365	0.4392

TABLE 2 ERROR AND ACCURACY W.R.T ANODE

ANCHOR NODES	ERROR	ACCURACY
5	35.9985	1.1999
10	41.5313	1.3844
15	28.0071	0.9336
20	27.8357	0.9279
25	24.5010	0.8167
30	28.1006	0.9367

For the above Table 1 graphs are represented below in Figure 2 and Figure 3 where we can see that when R and Anodes are varied, localization error can be calculated. In this case, there is a trend that localization error first decreases to a threshold value and the error increases with increase in communication range. The algorithm mentioned make localization according to the average hop size and the hop count. Similar with the Anodes, error first increases to a threshold value and the decreases as Anodes increases and then error again starts increasing.

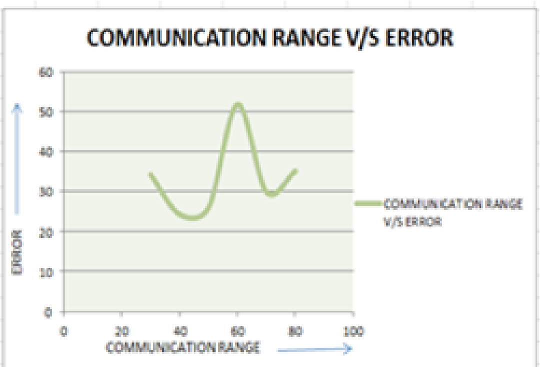

Figure 2: Communication Range V/s Error

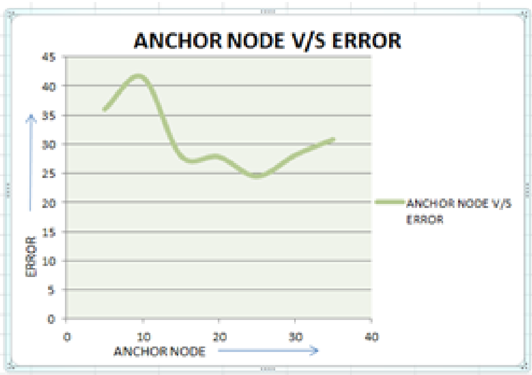

Figure 3: Anchor Node V/s Error

For the above Table 2 graphs are represented below in Figure 4 and Figure 5 where we can see that when communication range and Anodes are varied, accuracy can be measured.

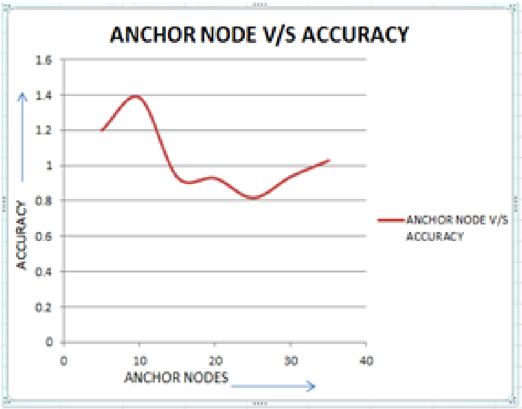

Figure 4: Anchor Node V/s Accuracy

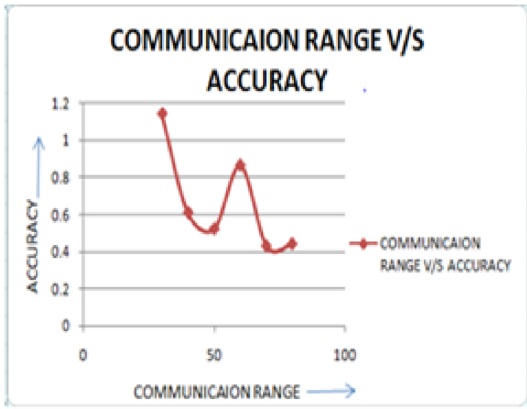

Figure 5: Communication Range v/s Accuracy

IV. CONCLUSION

This paper presents an analysis to verify the efficiency and accuracy of DV-Hop algorithm in WSN in which error over the multiple hops is calculated. Through simulation experiment, the DV-Hop performance is measured and is analysed by measuring error and accuracy by varying different parameters in the network area. Analysis shows that it is one of the effective and one of the best schemes for node localization with only few errors in accuracy.

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