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Localization error estimation approaches of wireless sensor network

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Abstract**- *The practical difficulties of setting up a wireless sensor network (WSN) and analysing its performance have made simulation essential study of WSNs. The network simulator is one of the most widely used tools by researchers to investigate the properties of WSNs. Network simulator has the basic properties to support simulations of different localization techniques. The localization algorithm calculates location accuracy and localization performance under particular level demonstrated by both Theoretical and simulation results. The enhanced performance of the proposed model calculates and compared to other algorithms using the network simulator. Results show that enhancement is obtained with the proposed algorithm when measuring metrics such as distance and localization error while varying other simulation parameters such as the number of sensors and the distance measurement error.***

Keywords**- *Approximate Point-in-Triangulation (APIT), Distance Vector (DV), Wireless sensor networks (WSN).***

I. INTRODUCTION

Location information plays a critical role in wireless sensor networks. Most of the sensor applications and techniques require that the positions of the sensor nodes be determined. Localization algorithms follow several approaches to estimate positions of sensor nodes. One approach is to use special nodes, called beacons, which know their own location, e.g. through a GPS receiver or manual configuration. More localization schemes have been developed to autonomously pinpoint the locations of normal nodes with the assistance of anchors which have perfect location information. These localization schemes fall into range based schemes or range-free schemes. Three main approaches exist to determine a node's position: using information about a node's neighbourhood (proximity-based approaches), exploiting geometric properties of a given scenario (triangulation and trilateration), and trying to analyse characteristic properties of the position of a node in comparison with premeasured properties (scene analysis). The common feature of range-based localization schemes is that each normal node calculates the distances or directions to the anchors or neighbours based on the following signal measurements: received signal strength, time of arrival, time difference of arrival, and angle of arrival.

II. SYSTEM MODEL

A. Approximate Point-In-Triangulation

APIT algorithm does not have any specific model like circle, rectangle etc., Assume that in a network there are 5 anchors such as A_1, A_2, A_3, A_4, A_5 Figure. 2.1. The concerned normal node is marked as N_x The basic principle of APIT algorithm is: N_x can form triangles using any three anchors, as shown in Figure 1. If N_x can determine whether it is inside or outside of these triangles, the overlap of the triangles (N_x inside) is where N_x resides. The anchors periodically broadcast beacon signals to its neighbour nodes. In this algorithm, it is necessary for each anchor to equip with a power full transceiver, so that its signal can be received by all normal nodes in the Network. Receiving the signal from an anchor A_i each normal node detects and notes down the received signal's RSSI value, as well as the position of A_i.

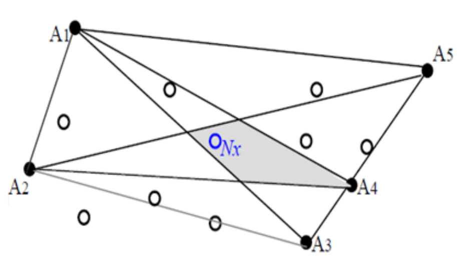

Fig. 1 Triangles Formed by Any Three Anchors

The RSSI information is used to estimate whether a node is inside a triangle formed by three anchors in the PIT testing step.

Location estimation is performed to determine whether a normal node N_x is inside a triangle formed by three anchors.

The Perfect PIT can be performed by moving N_x along any direction, as shown in Figure. 2a. N_x moves in every possible direction, and compares its distance to anchors with the distance before moving. The distance is measured based on RSSI. After moving a tiny step towards an every direction, N_x finds that its distance to the anchors never increase or decrease simultaneously. Assume, when N_x moves towards to A_1, its distance to A_1 becomes less, but its distances to A_2 and A_4 both is high. Thus, N_x is judged to be inside the triangle $\Delta A_1 A_2 A_4$. On the contrary, N_x will be judged outside a triangle if there is a direction such that when N_x is moved a little, its distances to the three vertexes of the triangle increase or decrease simultaneously. For example, in Figure 2b. When N_x moves a little, its distances to three anchors decrease simultaneously. Therefore, N_x is outside the triangle $\Delta A_1 A_2 A_3$.

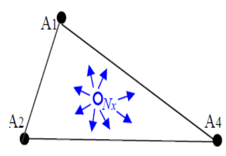

Fig. 2a inside $\Delta A_1A_2A_4$

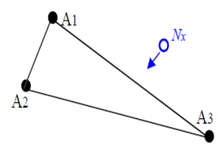

Fig. 2b outside $\Delta A_1A_2A_3$

In terms of implementation, the Perfect PIT has two problems. First, it is impossible to test all directions, because there are infinite directions around the normal node N. Second, the Perfect PIT requires that normal nodes can move, however, normal nodes may be fixed in some applications. Therefore, instead of Perfect PIT, an Approximate PIT (APIT) is performed. The APIT assumes that normal nodes are static. Although normal nodes cannot move, the APIT method imagines that they could move, and regards their neighbour nodes as their positions.

For example, as shown in Figure 3, N_x has three neighbour normal nodes T, U and V. Like N_x these three nodes have also received signals sent from anchors, and noted down the corresponding RSSI values. N_x can communicate with its neighbour's, and obtain their RSSI values. The RSSI values are not used to calculate the exact distance, the difference between the RSSI values of two nodes is used to determine whether a node is further to an anchor than the other node.

Let us consider the triangle $\Delta A_1 A_3 A_4$. In order to determine whether N_x is inside the triangle, the Perfect PIT controls N to move a very step and then observes the change of its distances to anchors. However, here, in APIT test, the static N_x virtually moves to its three neighbours T, U, and V. Among the three nodes (T, U, and V), N_x checks whether there is one node that is farther from A_1, A_3 and A_4 simultaneously. N_x compares its RSSI value to A_1 with T's RSSI value to A_1. Normally (i.e., if RSSI values are relatively stable, not much influenced by the environment), T is closer to A_1 than N_x. In the same manner, it can be tested that T is farther to A_3 and A_4 than N_x. So, compared with N_x, T is not farther from $A_1 A_3$ and A_4 simultaneously. As for U, the same phenomenon can be observed. If N_x had only two neighbour nodes T and U, then through this APIT test, N_x could have determined that it was inside $\Delta A_1 A_3 A_4$.

However, in reality, N_x has the third Neighbour V. Unfortunately, compared with N_x V is farther from A_1 A_3 and A_4 simultaneously. Thus, by the APIT, finally, N_x will judge itself to be outside of the triangle, although it is actually inside the triangle. This test error is caused by the big virtual moves in APIT test as shown in Figure 3, if V was V', then N_x could have determined to be inside the triangle.

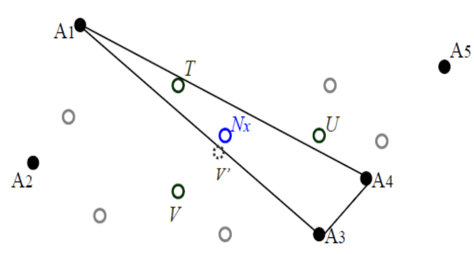

Fig. 3 Example for APIT test

An overlap is formed by the triangles inside which the normal node N_x locates. Then, the centre of this overlap is calculated as the position of N_x. The APIT algorithm may achieve good accuracy. However, it requires anchors have high power Transmitters. And the APIT test can sometimes cause serious errors. Furthermore, the RSSI is necessary in this algorithm the RSSI is usually not stable. Considering these dis advantages, the APIT algorithm is rarely practiced for localization.

B. DV-Hop Localization System

The Distance Vector by Hop counting (DV-Hop) is the most known distributed algorithm. It was proposed as an ad-hoc positioning system (APS) in which sensors exchange distance vectors that contain hop counters that signifies the number of hops between the sensor receiving this vector and the sending anchor. DV-Hop assumes that every anchor *i* has a hop counter, Hop-Count$_i$, and every sensor in the network stores the hop counter corresponding to every anchor; the value of the Hop-Count$_i$ that a sensor stores about anchor *i* represents the minimum number of wireless hops between that sensor and the anchor *i*. In the first phase, an anchor *i* floods a message containing its ID, coordinates, and the variable Hop-Count$_i$ initialized to zero. Sensors store and exchange anchor hop counters.

Indeed, every time a sensor receives a message containing a Hop-Count$_i$ corresponding to an anchor *i*, it checks the value of the Hop-Count$_i$ that it maintains about anchor *i*. If this value is less than the received one, then the latter is ignored; otherwise the receiving sensor increments the value of the received Hop-Count$_i$, updates its stored Hop Count, then floods it in the network. In the second phase, anchor *i* computes the average hop length from its perspective, Average Hop Length, using Equation 2.1 which is given as:

$$Avghoplength_i = \frac{\sum_{j=1.i\neq 1}\sqrt{(x_i - x_j)^2} + \sqrt{(y_i - y_j)^2}}{\sum_{j=1,i\neq 1} Hopcount_{i,j}} \quad (2.1)$$

Where M is the number of anchors in the network, *j* identifies other anchors, Hop-Count$_{i,j}$ is the distance in hops between anchor *i* and anchor j, (x_i, y_i) and (x_j, y_j) represent the coordinates of anchors *i* and *j*, respectively. After computing Average Hop Length, anchor *i* flood it in the network for other anchors and sensors. A sensor maintains only the average hop length flooded by the closest anchor to it. For example where each of the three anchors A1, A2 and A3 calculates its average hop length. Then sensor node S with unknown position maintains the one that was received from A2 (i.e., the closest to S). S uses the received Average-Hop Length$_i$ to compute the distance d_j between S and every anchor *j* using Equation 2.2 which is given as

$$d_j = Avghoplength_i \times Hopcount_j \quad (2.2)$$

Where, Hop Count$_j$ is the hop counter that S maintains for anchor *j* and Average Hop Length$_i$ is the average hop length that sensor S obtained from the closest anchor, say *i*. In the third phase, a sensor uses the Least Square (LS) technique to trilateration its position. In basic trilateration, only three distances from anchors are necessary for an unknown sensor to find its location. The more distances available leads to better localization accuracy. The circle intersection of basic trilateration which numerically, trilateration is done by solving a system of equations.

DV-Hop localizes sensors while minimizing power consumption in the WSN, and without depending on any extra hardware. Moreover, the localization information can be used as an alternative for routing protocols to route the sensed data to the base station. The driving force behind the proposed protocol can be summarized mainly by the following three facts they are Computation and communication constraints on sensors, Perimeter deployment of anchors, Flooding phases.

Using all the calculated distances from all the anchors to be porting sensor the base station utilizes a trilateration algorithm to find the coordinates of this sensor. DV-Hop localizes sensors while minimizing power consumption in the WSN, and without depending on any extra hardware. Moreover, the localization information can be used as an alternative for routing protocols to route the sensed data to the base station. Where M is the number of anchors in the network, *j* identifies other anchors, Hop-Count$_{i,j}$ is the distance in hops between anchor *i* and anchor *j*, (x_i, y_i) and (x_j, y_j) represent the coordinates of anchors *i* and *j*, respectively.

III.SIMULATION RESULTS

More localization schemes have been developed to autonomously pinpoint the locations of normal nodes with the assistance of anchors which have perfect location information. These localization schemes fall into range based schemes or range-free schemes. When measuring metrics such as distance and localization error while varying other simulation parameters such as the number of sensors and the distance measurement error.

The results are based on the implementation of range free algorithms which shows the enhanced performance metrics than the existing model. The result shown below localization performance under various parameters is shown in graphs and takes the number of iterations to improve the performance metrics.

The input parameters for the implementation of localization system such as APIT and DV HOP algorithms are shown in table the parameters are common for specific scenario.

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Table .1 Simulation Parameters for APIT and DV HOP system

Scenario parameters	Values
Node Radio Range	20 meters
Wireless radio propagation model	Propagation/Two ray ground
Wireless interface direction	Omnidirectional
Topology area	40m×40m Square Area
Receiving power consumed	4 m-W
Anchor’s initial energy	7 k-J
Sensor’s initial energy	2 k-J

The simulation results and comparisons of the proposed system were executed and analysed using NS version 2.34 the localization performance parameters accuracy and precision estimated through various values of iterations.

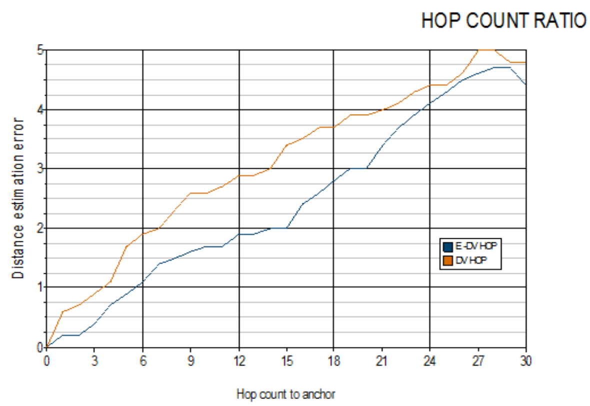

Fig. 4 Localization performance graphs of distance estimation error

Figure 4 shows the comparison between the existing APIT and DV HOP and the proposed E-APIT and E-DV HOP based on parameter Hop count ratio deployed over in the sensor network. It shows that the enhancement done over the existing DV HOP model on Hop count ratio parameter.

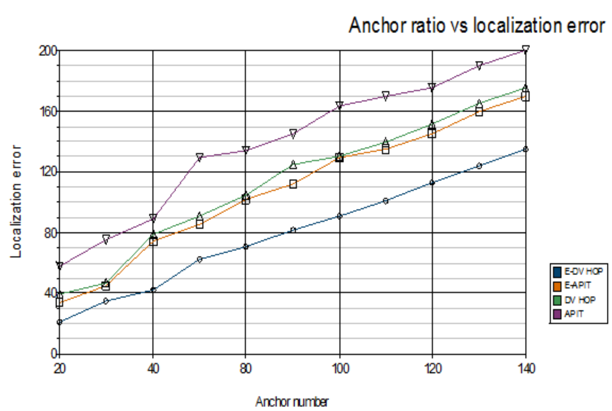

Fig. 5 Localization performance graphs of anchor ratio vs error

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Figure 5 shows the comparison between the existing APIT and DV HOP and the proposed E-APIT and E-DV HOP based on parameter anchor ratio deployed over in the sensor network. It shows that the enhancement done over the existing DV HOP and APIT model on anchor ratio.

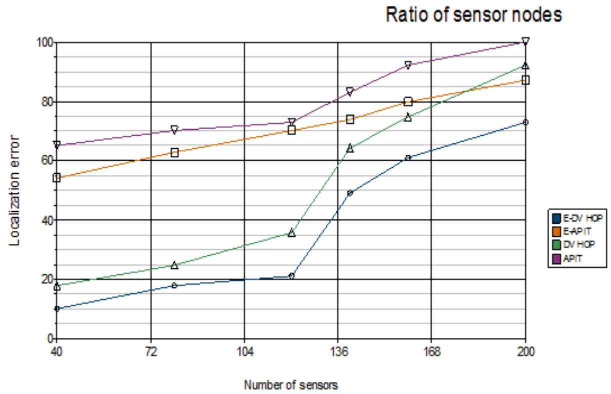

Fig. 6 Localization performance graphs of sensor ratio vs error

Figure 6 shows the performance comparison of localization system based on sensor ratio deployed over in network and localization error. It shows that the enhancement done over the existing DV HOP and APIT model on sensor ratio.

IV. CONCLUSIONS

Range free is proposed for Localization system for improving the system performance in terms of accuracy. It enhances the performance with a hardware complexity and precision complexity with respect to range free models. The simulation results and comparisons of the proposed system were executed and analysed using NS-2.34. Localization performance of range free model various values of iterations are also analysed. It was observed that the accuracy and precision performance of the system increases with the number of iteration at the cost of latency.

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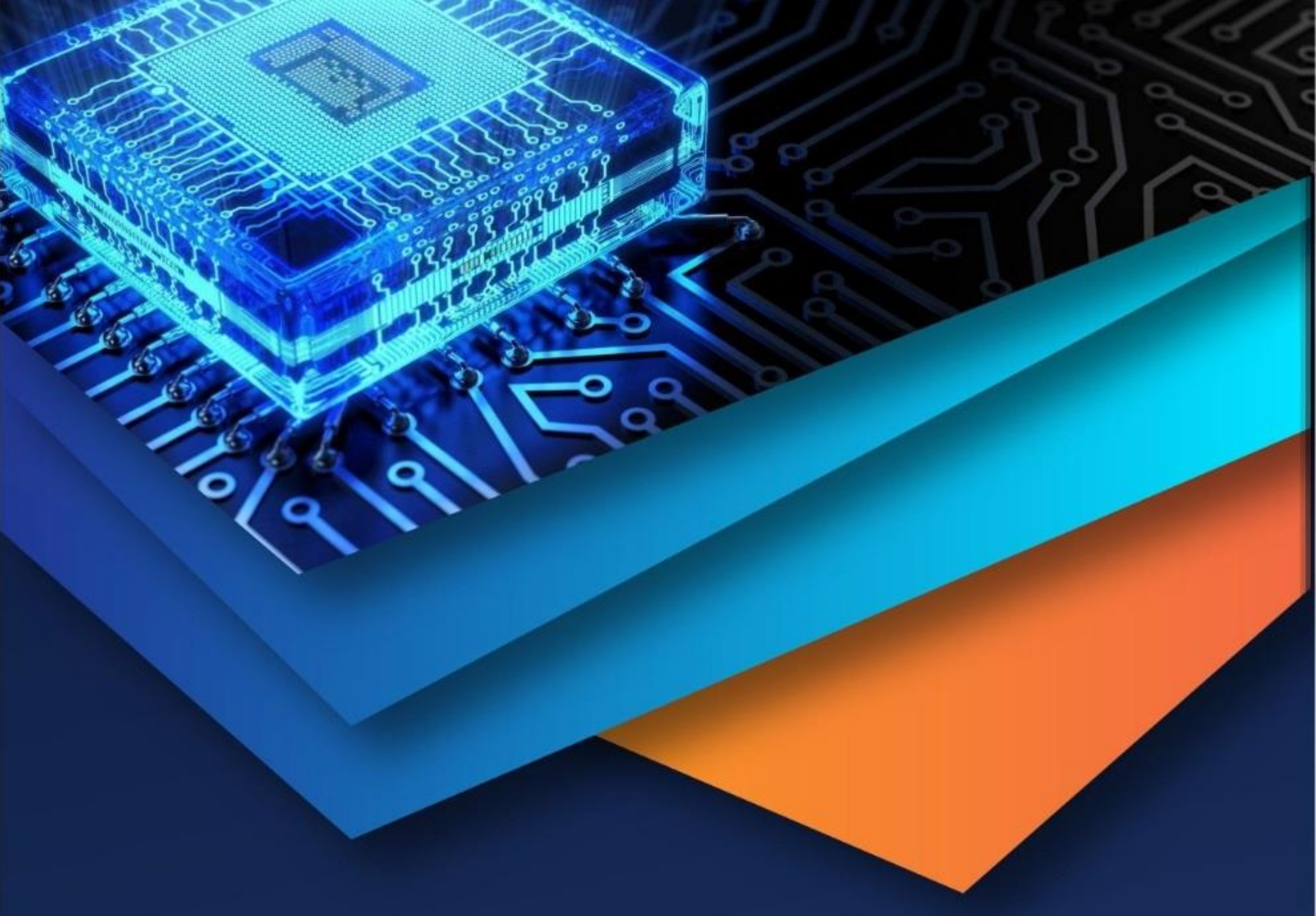

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