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TRACKING the LOCATION of MOBILE NODE in WIRELESS SENSOR NETWORK

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Abstract: Tracking of mobile node in WSNs (Wireless Sensor Networks) is an active topic of research and many techniques in WSNs have been proposed. Among the proposed techniques, the popular approach is RSS (Received Signal Strength) and is useful in estimating the distance because it is simple and no extra hardware is required. In this paper, a method that uses RSSI approach is presented to locate the position of mobile node (node that is moving in WSN in Static 2D and Dynamic 2D environment and are not aware of its position in the network) among the other Positioned Nodes or Anchor Nodes in the network. The distance between mobile node and the Anchor Node is estimated by measuring the RSSI (received signal strength indicator). Anchor Nodes are positioned at the vertices of square and mobile node is moving randomly inside the square. The goal is to track the location of mobile node by applying Heron's Formula on the triangles formed inside the square.

Keywords*:* Tracking, Static, Dynamic, Wireless Sensor Network, RSSI, Mobile Node, 2D.

I. Introduction

Wireless Sensor Network (WSNs) has been considered widely as one of the most important technologies of the twenty – first century [1]. A WSN consists of a large number of small, low-cost, low-power and multifunctional sensor nodes that are deployed in a region of interest [2], placed randomly and connected by wireless media to form a sensor field. Each node has special capabilities such as wireless communications with its neighbours, sensing, data storage and processing. WSN has been widely used in many areas [3] such as pipeline monitoring, battle field surveillance, industry process control [4], environmental monitoring [5] and control [6], healthcare and medical research [7], national defense and military affairs [8] [9], etc. WSNs have unique characteristics such as node positioned at denser level, sensor nodes are unreliable and severe energy [10], which presents many new challenges in the development and application of WSNs. WSN, has the ability to dynamically adapt to changing environments. Sensors will be cheaper and deployed everywhere in future.

In the key application areas of Wireless Sensor Networks (WSN), Localization plays an important role. WSN localization is the process of estimating the locations of sensors with reference to some local or global coordinate system by using the knowledge of inter-sensor node measurements like distance and/or angle. Some localization techniques like hop count [11], [12], APIT [13] do not even need these measurements but these techniques are very prone to errors due to obstructions [14] in the deployment region and are therefore least accurate.

For a WSN consisting of few nodes, individual locations can be programmed manually. However when the number of nodes in a WSN is hundred or thousand or nodes are placed randomly in an environment, a procedure for localization of nodes is required. Since the very important process in WSN is localization, therefore any solution proposed for localization must be accurate and efficient. To begin the localization, some sensor nodes with known locations are needed and are known as Anchor Nodes. The locations of these Anchor nodes can be determined by placing these Anchor nodes at points with known coordinates or by using a global positioning system (GPS). But using GPS equipment on all nodes is not feasible as localization is not the only goal of a WSN application, it is a step in the formation of WSN and using costly GPS equipment on each node would add the hardware and energy cost which does not gel with the wireless sensor networks idea of having small, low energy and low cost sensor nodes for efficient sensing and communication. Issues related to the use of GPS have been already been discussed in detail in [15], [16], [17]. Considering all these issues, GPS cannot be proposed to be used for all the nodes in a network.

One of the most challenging and significant applications for Wireless Sensor Network in which wireless sensors network are involved is the task of tracking a moving object. Factors considered while developing algorithms for tracking moving objects include stationary or mobile nodes, target motion characteristics, single or multiple targets, energy efficiency and network architecture. Node Tracking is widely used in many applications like military application, commercial applications, field of surveillance, intruder application and traffic applications. In mobile node tracking, the Sensor nodes which can sense the mobile node at a particular time are kept in active mode while the remaining nodes are to be retained in inactive mode so as to conserve energy. To continuously monitor mobile node, a group of sensors must be turned in active mode. The sensor nodes detect the moving object and find its location.

Localization algorithm mostly works on 2-dimensional plane, i.e. x and y plane where the x and y coordinates are the same as the real position of the surface and height is fixed. 2D localization requires less energy and time and its complexity is less. It provides good accuracy on flat areas and it is difficult to estimate in harsh areas. It provides accurate distance when the number of nodes is more and anchor nodes are present [18].

II. PROBLEM FORMULATION

We examine the problem of tracking a single mobile node using RSSI (received signal strength indicator) in Static 2D and Dynamic 2D Environment. Prior signal strength data is gathered. The mobile node starts with no idea about its location and moves in the environment. In Static 2D, the stationary Anchor points in square shape are taken and the mobile node moves in that particular region whereas in Dynamic 2D, there is no fixed region for the mobile node to move and the points are randomly taken to form the shape of a square.

A. *Assumptions*

We make a number of assumptions in our approach. We assume that nodes are distributed randomly on a two dimensional network area. Wireless signals in any given area of the environment are assumed to be time-invariant in the absence of interference and signal absorption by humans. We assume there are no large variations in signal strength over small distances. The mobile node is assumed to move in a smooth, continuous manner and is constrained to be somewhere inside the square. The side of the square should be parallel to any axis. Observations are assumed to be independent. Considering these assumptions, the results from experiments are quite encouraging.

B. Squarical Model

This section presents the model that can used to find the 2D Cartesian coordinates of the mobile node. Received Signal Strength Indicator (RSSI) is used to measure the distance between mobile node and localized sensor nodes. Determining the location of mobile node constitutes the localization problem. However, some sensor nodes are aware of their own position through manual configuration or by placing it in an already known position. These nodes are known as anchor or beacon nodes. All other nodes that are not aware of their position are called blind node or mobile node. These nodes localize themselves with the help of location references received from the anchors.

It is assumed that there are A_n Anchor nodes among the **N** sensors and their positions are (xi, yi) for all i= (1: n) Є **A**. The positions (x, y) of blind nodes n Є **N** would be found. The localization system model is comprised of the Squarical model, signal model and the power model. Squarical model is used when there is an accurate estimate of distance between the nodes which is calculated using RSSI. This method draws a perpendicular from mobile node on both the axis and by finding the length of perpendicular on axis, the coordinates(x, y) or location of mobile node is calculated.

Considering the figure1 shown:

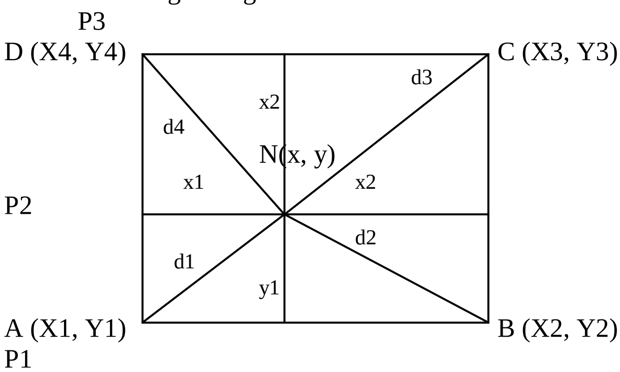

Fig. 1 Squarical Model in 2D

Using Heron's Formulae, calculate the area of all triangles since three sides are known as:

Area of Triangle=$\sqrt{g(g-k)(g-l)(g-m)}$ - (1)

Where k, l, m are the three sides of a triangle

g=Semi perimeter of a triangle and is calculated as:

g= (k+l+m)/2.

Also, we know that area of a triangle= (1/2*Base of triangle*Length of Perpendicular).

Since, area of triangle and Base of Triangle are known, so we can easily compute the Length of Perpendicular as x1, x2, y1, y2.Taking A as a reference point we conclude that the location of mobile node (x, y)= (X1+ x1, Y1+ y1). Reference point can be any of the vertices of triangle but care should be taken which length of perpendicular should be added and which should be subtracted from to the reference points.

In general, the range-based ones offer good accuracy but additional hardware is often needed. Moreover, in 2D Algorithms, altitude is fixed.

The values for x and y gives us the accurate position in two dimension (2D) for the mobile node. This Model is developed using MATLAB. Once the mobile node can calculate RSSI from the anchor nodes, it can localize its position. But these values cannot be obtained without the signal model and Power Model.

C. Signal Model

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This model assumes that the receiver can receive the signal only within the communication range. One way is by measuring the received signal strength of signal. Measuring the RSS's is time consuming process; however, it is essential for the calculation of the distance. The idea behind Received Signal Strength (RSS) is that the configured transmitted power (P_{tra}) at the transmitter device directly affects the received power (P_{rec}) at the receiving device. In [19], the detected signal strength decreases quadratically with the distance to the sender as

$$P_{rec}(d) = P_{tra}\, G_{tra}\, G_{rec}\, \lambda^2 (4\pi d)^2 \quad \text{--(2)}$$

where P_{rec} = Power received at the receiver
P_{tra} = Power transmitted by sender
G_{tra} = Transmitter gain
G_{rec} = Receiver gain
λ = Wavelength
d = Distance between the sender and the receiver
Normally Gtra = Grec = 1 embedded devices.

D. *Power Model*

Based on empirical data, a fairly general model has been developed for signal propagation. This model predicts that the mean path loss PL (*di*) [dB] at a transmitter receiver separation *di* is:

$$PL(di)\ [dB] = PL(d0)\ [dB] + 10n \log10(di/d0)$$

where PL(di) is the path loss function with respect to the distance measured in decibels, PL(d0) is the path loss over a reference distance measured close to transmitter, n is the loss exponent which defines the rate at which the loss increases with the distance. This constant depends on the environment conditions, and is usually ranged from 2 to 6. Using the signal strength to determine the distances usually yields to a number of errors because the actual path loss depends on many factors related to the environment such as refractions, diffraction, scattering and antenna orientation.

However, on the basis of empirical evidence that it is reasonable to model the path loss PL (di) at any value of d at a particular location as a random and log-normally distributed random variable with a distance-dependent mean value [20]. That is:

$$PL(di)\ [dB] = PL(d0) + 10n\log(di/d0) + Xp \qquad (3)$$

where Xp is a zero-mean Gaussian random variable with a standard deviation p. In particular, it should be noted that choosing the proper probability distribution function to represent radio irregularities is not trivial. It should be verified that the real statistical data fit into the chosen distribution.

To determine the path loss coefficient n of the test bed area/ environment. Equation (3) can be used to manually compute as:

$$n = (PL(di) - PL(d0))/\ 10\log10\ (di/d0)$$

Received Signal Strength and distance are related using the equation below.

$$RSSI\ [dBm] = -10n \log10\ (d) + C\ [dBm]$$

Where n is propagation path loss exponent, d is the distance from the sender and C is the received signal strength at one meter of distance.

By using these distances and already known APs location with the help of Squarical model, the location of mobile node is calculated. Once the relation between RSSI levels and reference distances is determined, the distance between a mobile node and the reference nodes can be estimated by collecting the RSSI levels of packets transmitted by the target node and received at each reference node.

III. Simulation And Results

The objective is to simulate the process that shows a sound level of accuracy in order to widely test the proposed methodology in real-time scenario. It was also necessary to maintain a certain degree of realism while ensuring the possibility of occurrence of worst case scenario without design. Accordingly, maximum randomness was incorporated in throughout the process whereas randomness was within the limits of the MATLAB software used.

We assume that the trajectory of the mobile node is random (Figure 2 and 4 is Statically and Dynamically Tracked Locations of mobile node respectively whereas Figure 3 and 5 is Static and Dynamic Trajectory of the mobile node respectively).In Static, n*n square is taken and the mobile node is moved inside it randomly as in figure 2 and figure 3 whereas in Dynamic, the mobile node is moving inside the squares of different sizes as shown in figure 4 and figure 5. These figures are formed using the anchors at the vertices of square forming a boundary box. The unknown node assumes its location to be at any place inside this box and using the above discussed models, the location of mobile node and its trajectory is find out.

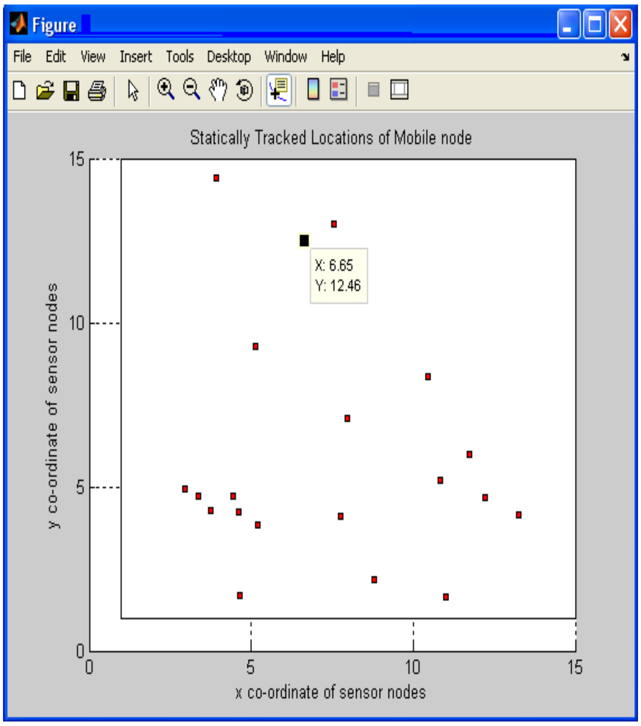

Fig. 2 Statically Tracked Locations of Mobile node

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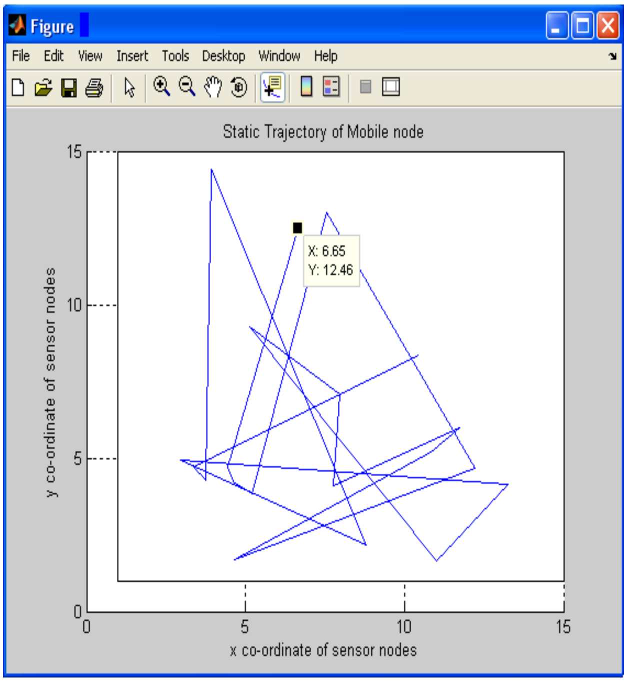

Fig. 3 Static Trajectory of Mobile node

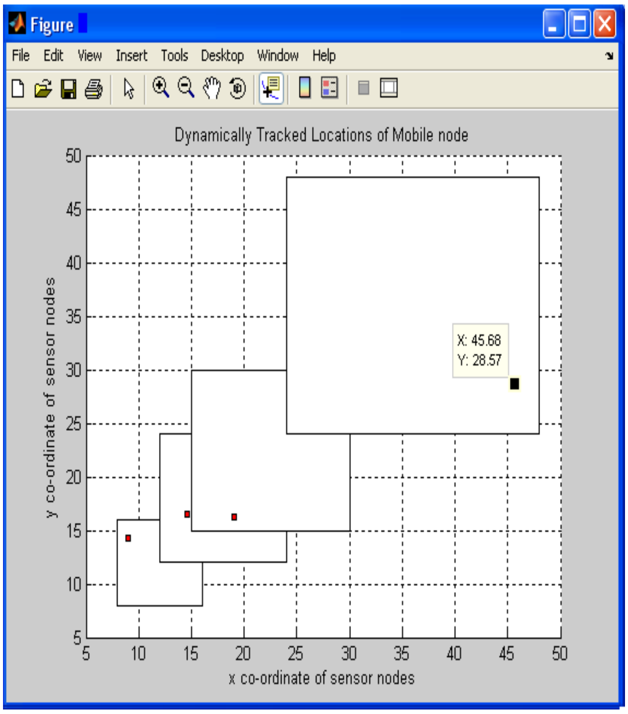

Fig. 4 Dynamically Tracked Locations of Mobile node

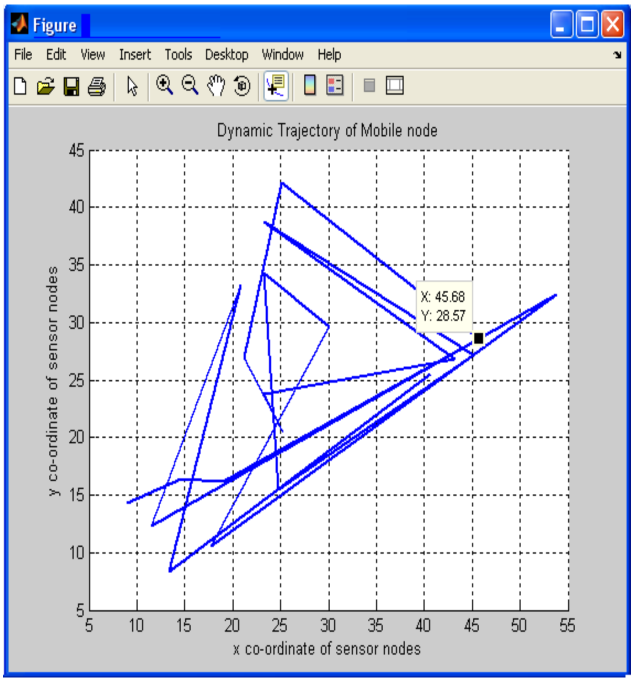

Fig. 5 Dynamic Trajectory of Mobile node

IV. CONCLUSION

Tracking the location of mobile node in wireless sensor networks is an important issue. The metrics for the performance of any localization scheme such as hardware cost, computational cost, accuracy etc are considered. Measurement selection type depends upon the type of application and deployment scenario.

For two dimensional scenarios, computation and communication cost is less compared to three dimension localization. While using RSSI, limitations such as it provides less accurate initial estimate for distance but still it has been favoured by researchers because of its low cost as compared to any other measurement technique. Here, we have tracked the location of mobile node that uses a RSSI approach in a wireless sensor network. We conclude that for the proposed system to work there must be the availability of anchor nodes at the vertices of a square and whenever anchor nodes broadcast packets containing their locations and other sensed parameters, the mobile node within the broadcast range can always estimate its distance to the anchor nodes and localize its position.

In this paper, we proposed a localization technique of node based on RSSI. Many good techniques of localization are already present but the advantage of this method is that it has low-overhead in terms of hardware costs. This method works better than other schemes in terms of localization error. It has less storage and communication overhead also. The computation overhead is slightly greater compared to other schemes. In future, we would like to decrease the computation overhead of the proposed method further.

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