Node Localization Using Time Stamp Based Approach in Wireless Sensor Network

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Abstract: **Localization is a very crucial issue and challenge in WSN. Wireless sensor networks are used in many different application domains such as military intelligence and surveillance, disaster relief, environmental monitoring, inventory tracking, home and agricultural monitoring and many more. It is important to know the position of each sensor node in network for outlining the solution to various problems in its application area. Hence node localization is an important system parameter for applications related to wireless sensor network. In this paper, an overview of other techniques for node localization is discussed and we propose a node localization algorithm using time-stamp based approach for finding location of unknown nodes.**

Index Terms - WSN, Node localization, Time stamp, Hyperbolic trilateration.

I. INTRODUCTION

Wireless sensor network consists of thousands of low cost, small and energy efficient sensor nodes spread over a topographical region to observe and to report of an event. These sensor nodes have a set of algorithms by use of which they communicate to their neighbour nodes and base station. Sensor nodes perform two operations in network. First, they sense the data from the environment and secondly forward packets from one node to another node with equipped wireless technology. Sensors in WSN cooperatively monitor physical and environmental conditions such as pressure, sound, temperature, vibration or pollutants [1].

Wireless sensor networks have a wide range of application domains such as military intelligence and surveillance for monitoring the cordial armed force or to get the location of enemy, home monitoring, agricultural monitoring, commercial and industrial inventory tracking, and disaster relief [1] [2]. In wireless sensor network, communication is achieved by employing the multi-hop transmission [5]. In this, transmission between source node and destination node occurs by help of multiple intermediate nodes by forwarding number of messages.

Awareness of network topology is very important in many application areas such as routing of packets and traffic management. In many applications, we need node location and co-relate it with data collected from that node to give solution to the problem if any arises. For example, if a fire alarm is triggered in building, then to get control over the fire we should know the floor number and area of the floor. So the need indicates that the node location should be known by some way. GPS and manual entry are the ways but the problem with GPS is its high cost and with manual entry is the scalability [5]. Hence, techniques for self-calculating the location are known as localization protocols. These protocols are needed for workable implementation of large scale sensor networks.

Localization means to find the location of a node in network. The main goal of localization is to get as accurate as possible information of node by help of data collected by other nodes in the network. With the support of infrastructure, a node can find its location by extracting the information received by the infrastructure or by making a node send signals periodically; the infrastructure can calculate the location of nodes.

In this paper, we present a new localization method that provides the accurate position of a node by using three anchor nodes. We are using hyperbolic trilateration method for position computation and time stamp based approach for distance estimation.

II. LITERATURE SURVEY

In WSNs, co-ordination occurs among nodes located in a certain locale. In localization algorithm, sensor nodes (nonanchornodes) and anchor nodes co-ordinate with each other to calculate the position of other nodes by observing a few aspects such as number of nodes in network, presence of any obstacle and energy resources.
For determining the location of a node in 2D, 3 Anchor nodes are required whereas in 3D, four anchor nodes are required. Consider the following terms that can be used to nominate the state of a node:
Unknown nodes: These are the nodes in the network that are not aware of their location information. These nodes are also known as dumb nodes.
Settled nodes: Initially unknown nodes that managed to determine their positions using localization technique.
Beacon nodes: Nodes in WSN that know their location earlier known as Anchor or Beacon node.
Base Station: This node is a special anchor node that acts routing WSN information from the network to the PC.

In Localization, there are numbers of algorithms pointing various approaches to deal with the localization problem. Localization algorithms are classified into categories based on various aspects. These aspects are centralized vs. distributed, anchor based vs. anchor less and range based and free [5].

Centralized vs. Distributed Localization: In centralized localization, a central base station is responsible for computation of positions. The information like connectivity and pair wise distance measurement etc is sent to the central base station and calculated results of positions are sent back to the network. For example, MDS-MAP is a centralized algorithm for determining the co-ordinates of non-anchor nodes [11].

In distributed localization, sensor nodes perform all the computation. The nodes communicate with each other to find their location in the network. Distributed localization is flexible to implement for large scale network.

Anchor Based Vs. Anchor Less Localization: Anchor based localization algorithms help to find the co-ordinates of unknown nodes in the network by providing as a starting point as the location of these nodes are already known.

In anchor less localization, a local map is constructed with exact node positions where each node known distance measurements.

Range Based Vs. Range Free Localization: Range based methods are employed for estimating distance or angle between sensor nodes to determine the location of unknown nodes. Range based methods include angle of arrival (AOA), time of arrival(TOA) [13], time difference of arrival (TDOA)
[14], and received signal strength indicator (RSSI) [15].

Range free scheme obtains the position of unknown nodes by using connectivity information between unknown nodes and anchor nodes. DV-Hop is an example of range free localization algorithm.

III. METHODOLOGY

For estimating the location of an unknown node in a 2-D space, first we will calculate the distance d between the nodes using timestamp based approach and then an algorithm will localize the unknown nodes with help of three anchor nodes.

Time stamp based approach for distance calculation:

In time stamp based approach, there are sensor nodes and anchor nodes in the network. The sensor node has request P_{req} of the following format:

R_ID	N_ID

Figure1. Packet request

Where R_ID is Request Id and N_ID= Node Id.

Sensor node also has a table T_{record} of the following format:

R_ID	N_ID	X	Y	T_1	T_2	T_3	T_4	P_d	S	d

Figure2. Table T_{record}

Where X= X coordinate of node, Y= Y coordinate of node, T_1= Timestamp of sending the request packet from requesting node, T_2= Timestamp of receiving the request packet on reply node, T_3= Timestamp of sending the reply packet on reply node, T_4= Timestamp of receiving the reply packet on requesting, P_d= Propagation delay, S= Speed of the communication channel and d = Distance between the requesting node and replying node.

The anchor node has reply packet P_{rep} of following format:

D N ID	**S N ID**	**X**	**Y**	**T_2**	**T_3**	**S**	**R ID**

Figure3. Packet P_{rep}

Where, D_N_ID= Destination node id , S_N_ID= Source node id , X= X coordinate of source node, Y= Y coordinate of source node, T_2= Timestamp of receiving the packet Preq, T_3=Timestamp of sending the packet Prep, S= Speed of the communication channel, R_ID= Request Id of destination node.

The anchor node also have table T_{queue}. This has following format:

RN_ID	T_2	R_ID

Figure4. Table T_{queue}

Where, RN_ID= Node Id requesting node, T_2= Timestamp of receiving the packet P_{req}, R_ID= Request Id.

The anchor node has this table T_{queue} because at certain time it may be loaded with lot request. So as to reply efficiently it has to maintain this table.

By following the below given steps, distance is calculated between the nodes.

Step 1.A node Ni broadcast a packet P_{req} in the network and requests for its coordinate. Ni makes entry in the table T_{record} with R_ID= Request_ID and T_2 with timestamp of sending the packet P_{req}.

Step 2. On receiving the request packet P_{req}, anchor node N_A checks the table T_{queue}.

If table T_{queue} is empty then the anchor node immediately reply the request with reply packet P_{rep} with timestamp T_3 equals to timestamp of sending the corresponding packet P_{rep}.

Else it makes an entry in its table Tqueue with RN_ID= N_ID and T_2 with timestamp of receiving the packet P_{req} and corresponding R_Id. When this request comes on top, the anchor node sends the required data to the corresponding node and deletes it from the table T_{queue}.

Step 3. On receiving the packet P_{rep}, the sensor node matches R_ID in the table T_{record} and place the value in corresponding column. Makes an entry for T_4= timestamp of receiving the packet P_{rep}.

Step 4. Calculate the

$$P_d \text{ as } P_d = (T_2-T_1) + (T_4-T_3)/2 \quad (1)$$

And an entry is done in corresponding cell.

Step 5. Calculate the distance d as

$$d = S * P_d \quad (2)$$

Finding the intersection of two circles

Let us assume two circles are intersecting at a point. The concept of finding intersection point of two circles will be used in locating the unknown node whose co-ordinates will be find by

$$x= (1/2)\ (x_B + x_A)+(1/2)(x_B-x_A)(r_A^2-r_B^2)/d^2+\_\ 2(yB-yA)K/d^2 \quad (3)$$

$$y= (1/2)\ (y_B+y_A)+(1/2)(y_B-y_A)(r_A^2-r_B^2)/d^2+\_-2(x_B-x_A)K/d^2 \quad (4)$$

Algorithm for Localization using three anchor nodes

To show our approach, we take an example. In this example there are three anchor nodes namely N_{A1}, N_{A2} and N_{A3}. We have a sensor node Ns in the field.

The algorithm for localization using three anchor nodes has following steps:

Step1. Node N_S will ask for coordinate by broadcasting the packet Preq.

Step2. Anchor nodes N_{A1}, N_{A2} and N_{A3} will receive the packet P_{req}.

Step3.On receiving the packet Prep node Ns will update its table as with the help of equation (1) and (2).

R_ID	N_ID	X	Y	T_1	T_2	T_3	T_4	P_d	S	d

N001	N_{A1}	X_1	Y_1	T_{11}	T_{21}	T_{31}	T_{41}	P_{d1}	S_i	**d1**
N002	N_{A2}	X_2	Y_2	T_{12}	T_{22}	T_{32}	T_{42}	P_{d2}	S_i	**d2**
N003	N_{A2}	X_3	Y_3	T_{13}	T_{23}	T_{33}	T_{43}	P_{d3}	S_i	**d3**

Step4. As soon as node Ns gets the information of three nodes whether they are anchor or ordinary node it will stop receiving the new packets Prep from any other node. And broadcast stop. Nodes receiving stop message from the particular node Ns, they will delete it from their table T_{queue}.

Step5. Now with the help of equation (2) and (3) and using the coordinate of first two node from the table T_{record} it will calculate two sets of coordinate (x_{s1},y_{s1}) and (x_{s2},y_{s2}).

Step6. With the help of given equation it will check which two coordinate satisfy it. This equation is for node N_{A3}. This equation only satisfy those coordinate which will be lying on the circumference of the circle having centre at (x_3, y_3) and radius equal to d_3.

$$(x-x_3)^2+(y-y_3)^2-d_3^2=0$$

This can achieve by replacing the variable x and y first with (x_{s1}, y_{s1}) and then with (x_{s2}, y_{s2}). If replacing of variable x and y results 0 then that it is the required coordinate.

Now the new node will act as another anchor node if required. It can serve as anchor node when any node can't get three nodes with coordinates.

IV. CONCLUSION

In this work, we propose a position estimation algorithm for localizing the unknown nodes in wireless sensor network. This algorithm is based on time stamping approach and hyperbolic trilateration. Time stamping method for finding distance gives accurate results and does not need any additional hardware which is not achieved in previously discussed algorithms other than RSSI. Hyperbolic trilateration is the basic method to find exact location of node is WSN. The proposed algorithm uses only three anchor nodes and localizes the nodes in 2-D space in WSN.

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