Distributed Range Based Localization in Wireless Sensor networks

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ABSTRACT: In WSN (Wireless Sensor Network) the task of localization plays an important role regarding a location dependent information like in military applications, forest fire detection etc. This dissertation work focuses on designing a highly efficient and accurate protocol for localization of wireless sensor networks with an addition of a little bit extra hardware to the basic node. The protocol basically lies in the range based localization category and thus provides extra accuracy and reliability. The heart of the localization hardware added is the servo based parabolic antenna which senses the nearby nodes and based upon the RSS (Received signal strength) value of signal distance and angle of arrival is estimated and processed. By using these two parameters the location of bare node with respect to the anchor node is calculated. The accuracy of the protocol depends on various factor and parameters like ease of deployment, radius of transmission, speed of servo, probability of broadcasting as anchor node etc. These factors are simulated to find out the best tradeoff between accuracy with other factors.

I. INTRODUCTION

In Micro electro mechanical system (MEMS) computing and communication technology massively emerged distributed wireless sensor networks with high number of nodes. Each node is able to sense the environment, perform simple computations and communicate with its other sensors or to the central unit. One way of deploying the sensor networks is to scatter the nodes throughout some region of interest. This makes the network topology random. Since there is no a prior communication protocol, the network is ad hoc. These networks are being implemented to perform a number of tasks, ranging from environmental and natural habitat monitoring to home networking, medical applications and smart battlefields. Sensor can give signal when there is any fault to the control center in a factory or it can warn about fire on a remote forest hill indicating that a forest fire is about to start. On the other hand WSN (wireless sensor nodes) can be designed to detect the earth vibrations generated by silent footsteps of a burglar and trigger an alarm.

As most of the applications depend on a successful localization, i.e. to find out their positions in some fixed coordinate system, it is very necessary to design efficient localization algorithms. Localization can be used in large scale ad hoc networks. There are some uses of localization i.e. in the smart kids school node localization can be used to monitor the progress of the children by tracking their all activities with toys and also with other things. It can also be used in hospital environments to keep track of all kind of records and people.

Issues and challenges in Wireless Sensor Networks

There are mainly 2 type of issues like:

1) Design issues

a) **Fault tolerance**: It happens in WSNs when any sensor node is deployed in harsh environments.
b) **Scalability**: When the capacity of any system is increased by adding extra hardware is called scalable system. Hence when number of sensor nodes are added in sensing area then it becomes scalability.
c) Transmission media: In WSNs nodes are connected through wireless network hence there may be any traditional problem in the network cause of uncontrolled media.
d) Coverage problem: Because of wide range area network there is a problem of cover all the nodes efficiently which makes the issue of quality of network.

2) Topology issues

a) **Geographic routing:** It is a routing principle which is used to send messages from source to destination without using network address. It gives the geographic position information and mainly used in wireless networks.
b) **Sensor holes:** It consist any node whether it is in use or not participating in the network or it is not in use. To find out this kind of nodes is very complex because WSNs have low capability nodes with poor localization problem.
c) **Coverage topology**: It is a common problem in sensor networks and also more considerable now a days. The goal of a well simulated network is all nodes are covered equally at every point in the service area. Hence there are issues of connectivity problem.

*3) **Other issues :***

a) Hardware and O.S problem
b) Energy saving
c) Time Synchronization
d) OSI layers
e) Localization
f) Design and architecture problem
g) Database problem
h) Security problem
i) Power management

II. Localization in WSN

Localization is defined with the help of localized and unlocalized nodes after finding out their geographic position.

1. Wireless sensors have huge security parameters such as radio communication, power nodes etc. and report all of these to the sink node i.e. back end security system. A prompt action by security personnel is possible only if location information is provided with the sensed information [14].
2. Because of some faults, few nodes may expired due to the battery drainage or by physical forces. In such cases, new nodes to be removed and battery can be replaced efficiently can be achieved efficiently by adopting geographic routing rather than physical routing schemes [14]. Geographic routing made the task of locating a node easy as compared to physical routing.
3. WSNs works on the basis of wireless distributed systems as each node is routed far away from each other which makes their location much more important to get fine area network in harsh environments with quality information.
4. Location based routing saves efficient energy by eliminating the need for route discovery and improves the behavior for applications where requests are location dependent [15].
5. Coverage of all sensor nodes is determined by using geographic location of each node.

III. PROPOSED WORK

In case of range based localization the location of any sensor node is calculated using the range and signal strength of the system. With the help of signal strength the estimation of distance is done and by using different models the estimation is further corrected. Another method to correct the distance estimation is to use the different nodes to calculate the distance and based on the average value the exact distance is find out.

The next task is to find orientation of the node from the particular node in respect with the node whose location is known to us. This is basically done here using the angle of arrival technique for which a particular directional and steerable antenna is used. By the help of this hardware we can easily find the location of the particular node and by combining the both i.e. distance and AOA we can calculate the exact location of particular node.

The assumptions and environment regarding the simulation and working of the algorithm are:

1. The whole network is time synchronized.
2. There is different hardware for the communication and for localization.
3. The surrounding environment is noise free in the working frequency range of the network.
4. The network is connected graph with one node connected to at least a single node in the graph.
5. At least one node is installed with GPS so that bare nodes' location can be calculated with respect to the anchor node.

Hardware Proposed

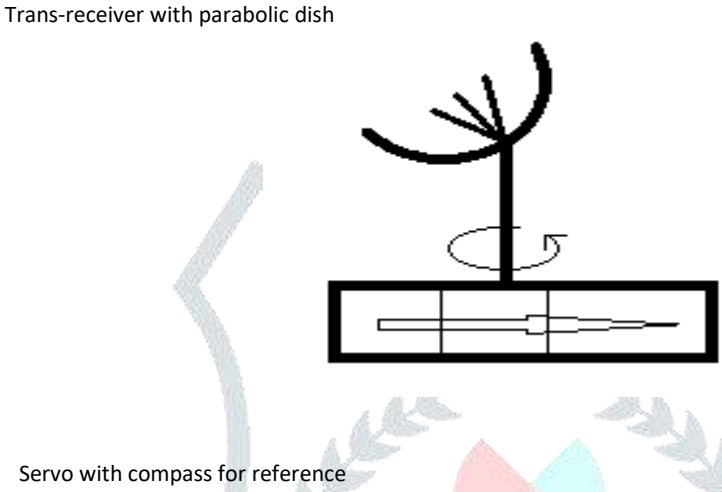

Figure: Steerable beam antenna

As shown in figure two hardware added to the base node i.e. parabolic unidirectional antenna and another one is the servo with compass. The working of both these equipment is as:

Parabolic dish: This dish is basically a directional antenna which acts as trans-receiver to find out the received signal strength in a particular direction from the other nodes which are transmitting their location with the particular signal strength. This measured signal strength will be further converted to the distance from the transmitting node, and the next task is to communicate with the node for further sampling of exact estimation of angle of arrival and signal strength.

Servo with compass: This is the main heart of the localizing device used in the technique. Servo provides the exact rotation to the antenna mounted on it by the help of potentiometer. This potentiometer is a resistance based device whose resistance is directly proportional to the angle of rotation of the device. So by using a probe we can exactly find out the angle of antenna with respect to the reference compass. For exact estimation the sampling accuracy of the servo should be good in order to calculate the exact angle of arrival from the transmitter node.

Proposed Algorithm

The range free techniques are unable to provide the exact location of the sensor node so that are not usable for scenarios where exact location is needed. So for these kinds of scenarios we use the range based methods which require some special hardware. So in the system of several nodes we can use some nodes with GPS and most of the other nodes are without GPS. Nodes with GPS are location known and they are equipped with more powerful resources like battery with more Ampere hours, more computation and communication capabilities. These nodes are called as anchor nodes and will work as reference for the other nodes for localization.

Two types of algorithms that will be used are anchor node initiated and bare node initiated. Anchor node initiated algorithm. Has been designed for the scenarios where location of nodes need to be updated frequently or nodes' mobility is more. On the other hand simple node initiated algorithm has been designed

for the nodes which are stationary. So for better performance the combination of both i.e. during the initialization phase of network we will use the anchor initiated algorithm and for later on purposes the bare node initiated algorithm is used for localization purpose.

Localization is achieved as shown in figure 4.2. Location of node with unknown coordinates (a, b) is find out using another node with known location co-ordinates (x, y) as given in equation (4.3). This is done by calculating the value of Θ and h.

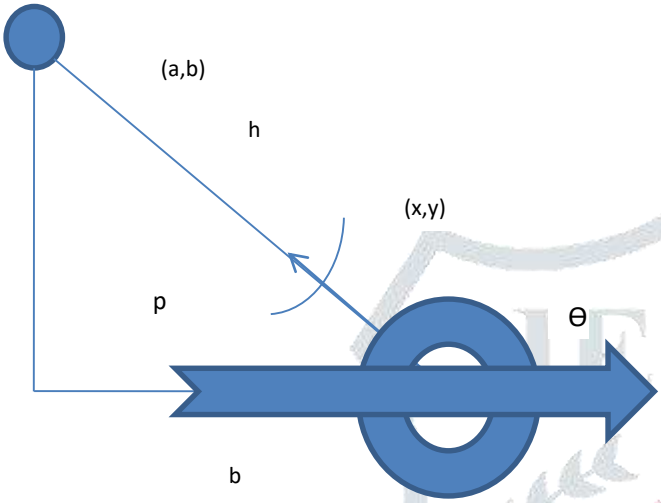

Figure: location calculation using anchor node

Let p be the perpendicular, h be the hypotenuse and b be the base as shown in figure 4.2.

$p/h = sin\theta$

$p = h.sin\theta$ *Eqn (4.1)*

And similarly

$B = h.cos\theta$ *Eqn (4.2)*

So,

$N(x, y) = N(x + B, y + p)$ *Eqn (4.3)*

Proposed Protocol –DRBL

The proposed protocol is divided in to three main algorithms which execute according to the localization requirement. The first algorithm presented as Algorithm 4.4.1. Initiates with broadcasting of invitation message which is received by neighboring nodes. If the neighboring node wants to be localized then it sends a query message to the broadcasting node. Anchor node again broadcasts its location with time T & T', after which bare node waits for time T' and then initiates servo rotation. Afterwards a table is created with angle to RSS strength. The angle with maximum value of RSS is selected and sampling algorithm starts execution. Afterwards the distance and angle of arrival from the anchor node is calculated using enhanced RSSI based accuracy algorithm [14]. Then location is calculated and the node again broadcast as anchor node with a probability p. Value of p depends on the deployment density of the nodes in the field.

Algorithm: Anchor node localization algorithm

1. Anchor node initiates localization by broadcasting invitation message.
2. Bare nodes with unknown location reply with location query message.

3. Anchor node broadcasts its location with time spam T & T' if any query is received.
4. Nodes B receive this message and wait for time T'.
5. Start to rotate its steerable antenna to make one complete rotation.
6. Nodes B make a table of RSS with respect to angle.
7. AOA is calculated with respect to max RSS in table by the help of servo and compass by setting it to its best sampling mode.
8. RSS value is used to estimate the distance bet. The node B and node A using enhanced RSSI based accuracy algorithm [14].
9. Location of bare nodes is calculated and they again repeat the same process with a probability p.

In bare node initialization algorithm the basic difference is that in this algorithm the localization is initiated by the bare node while in case of anchor node localization algorithm the localization process is anchor initiated. The second difference is that in this algorithm if no node with known location is found then it also creates another table of nodes with unknown location and selects the node with minimum RSS value and task of localization is handed over to that node. Afterwards, with the help of this node the original bare node's location is calculated. This explained algorithm is presented as Algorithm BNL algorithm.

Algorithm. Bare node localization algorithm:

1. Bare node initiates by broadcasting a location query with time T, T'& Id.
2. After time T' it initiates its servo rotation.
3. Node with known location if receives this message broadcast its location & id for time T after waiting for time T'.
4. Nodes with unknown location also reply in same manner but with id only.
5. Bare node makes a table of RSS with respect to angle both for location known nodes and location unknown nodes.
6. After getting max RSS servo is set to best sampling mode & AOA is calculated.
7. By the help of RSS value the distance is estimated using enhanced RSSI based accuracy algorithm [14].
8. Using AOA and RSS location is calculated.
9. In case no node replies with known location bare node looks for next table.
10. Node with min. RSS is selected and follows the algorithm from 1st step again.

This Algorithm BSM, controls the accuracy, time and energy consumption by controlling the sampling rate of servo. For good accuracy it takes more samples per degree of rotation while in case of lower accuracy requisition it works with less no of samples per degree of rotation.

Algorithm. Best Sampling Mode Algorithm

1. Bare node initiates the algorithm by sending the sampling request to the node with maximum RSS directionally using the directional antenna.
2. Node receiving this request, reply with the acknowledgment and piggybacks the stream of sampling packets with definite predefined transmitting strength.
3. The bare node receives the stream which is sampled at a particular rate value. This value is set according to desired accuracy, time and remaining energy.

IV. CONCLUSION

Localization of sensor nodes is defined with the help of various kind of applications. Here in this paper different kind of algorithms are used to determine the more accurate and feasible solution of the location of sensor nodes. Here four algorithms are used based on anchor or without anchor angel, distributed area network, sampling mode and bare node localization etc. These algorithms provides the mathematical result of nodes location with accurate angels. These accurate node positions made the sensing networks area easy to find geographic location and conduct each node in harsh environments also with efficient battery life and geographic position.

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