Providing Localization using Triangulation Method in Wireless Sensor Networks

Leelavathy S. R, Sophia S

Abstract— ***the applications of sensor networks which are developed require the location of wireless devices, and localization technique has been developed to meet this requirement. The Wireless sensor networks have been proved useful in many applications, like environment monitoring and military surveillance and many more. Triangulation is one such method that will be examined for localization. For the triangulation based localization uses the geometric properties of triangle to estimate locations, which relies on angle measurements.***

Index Terms— ***localization, triangulation, trilateration, time of arrival (toa) time difference of arrival (tdoa.)***

I. INTRODUCTION

The wireless sensor networks components have enabled the development of low-cost, low-power and multifunctional sensor nodes. These devices are small in size and communicate in short distances over a radio frequency channel. These tiny nodes, which consist of sensing, data processing and communicating components, realize the objectives of sensor networks. The infrastructure that is provided by wireless networks ensures a significant impact on the way how the computing is performed. Triangulation servers as the basis for many geometry based algorithm in wireless sensor networks. In this paper we propose the algorithm that produces a triangulation for an arbitrary sensor network, with no constraint on communication model or granularity of triangulation. Already, many techniques have been identified to provide the ability to localize a communicating device [2]. We begin in Section **II** by giving an overview of several techniques used in wireless localization, following the reviewed localization in **III**, we concentrate about discussion on applying mechanisms of localization that is triangulation I**V,** For triangulation based localization, we propose Triangulation Algorithm in section **V**, and finally conclusion in section **V1.**

II. BACKGROUND AND RELATED WOK

Here is the main divisions of localization techniques: one that involve range estimation, and the one that do not [1]. Range based localization algorithms involve measuring physical properties that can be used to calculate the distance between a sensor node and an anchor point whose location is known. Time of Arrival (TOA) is an important property that can be used to measure range, and arises in GPS [5].

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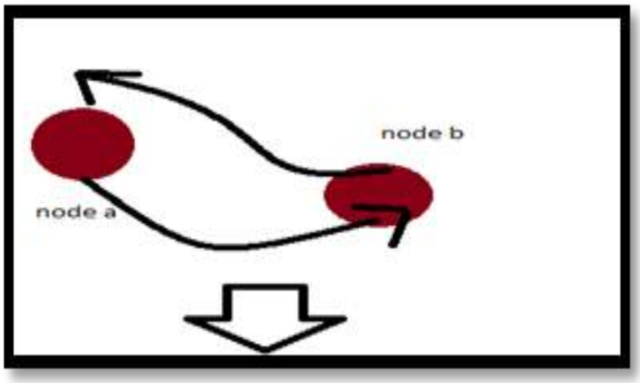
The Time Difference of Arrival (TdOA) is also widely used, and has been used in MIT's Cricket [2], and appeared in APS [3] pointed out that the Angle of Arrival (AOA)[6] can be used to calculate the relative angle between two nodes, which can be further used to calculate the distance. Range free localization algorithms do not require the measurement of physical distance related properties. For example, one can count the number of hops between a sensor node and an anchor point, and further convert the hop counts to physical distances, such as in [7].another example, a sensor node can estimate its location using the Centroid of those anchor nodes that are within its radio range. Compared to range based localization algorithms, these schemes do not require special hardware, and their accuracies are thus lower as well. Secure localization has received attention only recently. One technique that may be used to defend against wormhole attacks is to employ packet leashes [10]. SecRLoc [4] employs a sectored antenna, and presented an algorithm that makes use of the property that two sensor nodes.

III. LOCALIZATION

The basic purpose of any localization algorithm is, given an accurate of measurements, to find the locations of destined node whose positions are unknown. Finding Positioning appears as shown in the following steps: 1.Rangebased provides measurements all distance information amongst the nodes 2.Anglebased – provides Measurements angle information amongst nodes 3.Rangefree –provide only connectivity information. Distance Estimation Ranging :There are four common methods for measuring in distance estimation technique:1.angle of arrival (aoa) [6] 2.time of arrival (toa) 3.time different of arrival (tdoa) 4.the received signal strength indicator (rssi).Ranging between two nodes is found by introducing two nodes in a network and then finding distance between them.



(a)

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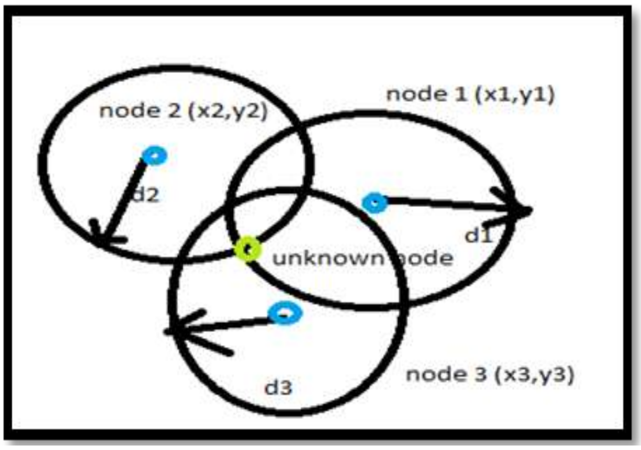

(b)

Figure 1: (a) (b) Distance Estimation

Angle of arrival technique allows each sensor to evaluate the corresponding angles between received signals. Time of arrival will estimate distances between two nodes using time based measures. Time different of arrival is used for determining the distance between a mobile station and a nearby synchronized base station. The Received signal strength indicator rssi is applied to translate signal strength into distance. Ranging between two nodes is the methodology applied between two nodes in the network to determine the actual distance between them: 1.selected measurements are conducted between nodes 2. Measurements are combined to determine the locations. Position estimation techniques classification time based ranging one-way time of arrival (toa).

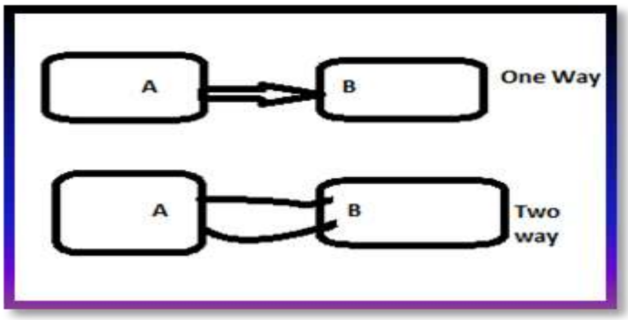

Figure 2: One Way And Two Ways TOA

Ranging based on the time difference. of arrival atomic multilateration: if a node receives 3 beacons, it can determine its location iterative multilateration[9] some nodes not in direct range of beacons, once an unknown node estimates its location, will send out a beacon, multihop approach, errors propagated, collaborative multilateration when more than 2 nodes cannot receive 3 beacons they collaborate.

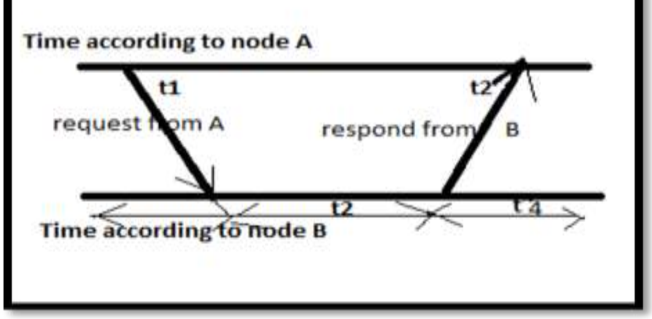

Figure 3: Two Way Ranging

The two way ranging is given by $\mathbf{T_f = (t2-t1) + (t4-t2)/2}$ where t1 is request time from A, t2 is response time from B t2 and t4 are time differences

IV. TRIANGULATION METHOD

Triangulation methods constitute a large class of localization algorithms that exploit some measurement to estimate distances to anchors, and from these distances and optimization procedure is used to deter mine the optimal position. The robust methods that we describe can be easily extended to other localization techniques, such as the Centroid method. Triangulation methods involve gathering a collection of {(x, y, d)} values, where d represents an estimated distance from the wireless device to an anchor at (x, y). These distances d may be stem from different types of measurements, such as hop counts in multi hop net works as in the case of DVhop [8], time of flight as in the case of CRICKET, or signal strength. For example, in a hop based scheme like DVhop, following the flooding of beacons by anchor nodes, hop counts are measured between anchor points and the wireless device, which are then transformed into distance estimates. In the ideal case, where the distances are not subjected to any measurement noise, these **{(x, y, d)}** values map out a parabolic surface given as

$$d^2(x, y) = (x-x0)^2 + (y-y0)^2 \text{-------- (i)}$$

Whose minimum value **(x0, y0)** is the wireless device location. Gathering several **{(xj, yj, dj)}** values and solving for **(x0, y0)** is a simple least squares problem that accounts for over determination of the system and the presence of measurement noise.

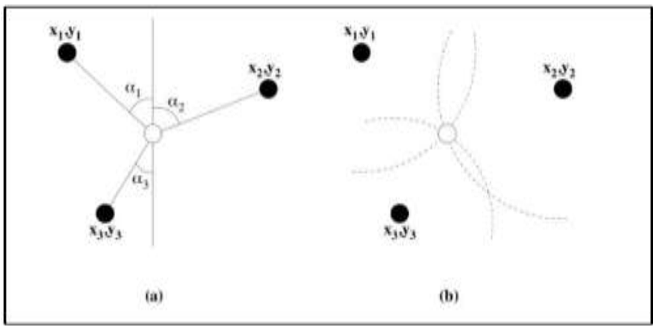

Figure 4: a) Unknown location is found using three angle measurements (AoA) [6] b) Unknown location found using the intersection of the radial measure from three known nodes (ToA)

The above figure depicts the traditional triangulation method by which the location of the sensor node is found using Angle of Arrival method and Time of Arrival method. Triangulation uses geometric properties of triangle to estimate locations, relies on angle measurements. A minimum of two angular lines are needed for 2 dimensional space the pseudo code is given as follows.

Unknown receiver location $\mathbf{x_r = [x_r, y_r]^T}$

Angle measurements from N anchor points

$\boldsymbol{\alpha = [\alpha_1 \ldots\ldots \alpha_N]^T}$

Known anchor location x_1= [xi, yi]^T

Actual angles $\theta(x) = [\theta_1(x)\ldots\ldots\theta_N(x)^T]$

Relationship between actual and measured angles is

$\alpha = \theta(x_r)+\delta\theta$ with $\delta\theta = [\delta\theta_1 \ldots \delta\theta_N]^T$

Relation between angles of N anchors and their location

$\tan\theta_i(x) = \frac{y_i - y_r}{x_i - x_r}$

V TRIANGULATION ALGORITHM

Location measurement techniques can be categorized into 3 main groups as follows.

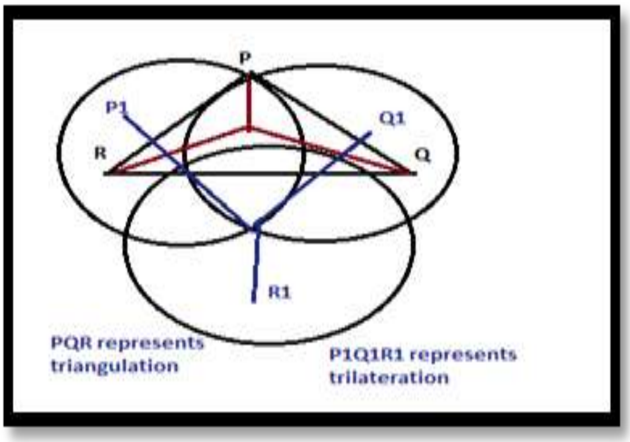

Figure 5: Triangulation Trilateration & Multilateration

In triangulation initially AoA measurements are gathered at the sensor node from at least three anchor nodes and to localize the node geometric operations and properties are applied on the measurements. Trilateration uses distance measurements of three anchor nodes to the unknown node in its near vicinity receive tuples in the form (x, y, d). In this tuple, (x, y) are the coordinates of that anchor node and d is the distance to the anchor node. Then simple geometric operations are applied to find the location of the node where all the three anchor nodes intersect each other. Triangulation mechanism is an example for range based localization technique. It uses geometric properties of triangles i.e. trigonometric laws, laws of sine and cosine to estimate the location. In this method, at least two angles of an unlocalized node from two localized nodes are measured to estimate its location.

Sine Rule: A/sine a+B/sine b + C/sine c=2R

Cosine Rule: $A^2=B^2+C^2+2BC\cos(a)$

$B^2=A^2+C^2+2BC\cos(b)$

$C^2=A^2+B^2+2AB\cos(c)$

The Sine Rule in the triangle ABC with radius 2R gives the distance estimation. The Cosine Rule gives the distance of each point with respect to their respective angles. We can depicts this using the projection formula

a=b cos C+ c cos B

b= c cos A+a cos C

c=a cos B+ b cos A

Description of Triangulation Algorithm: Aim of the proposed algorithm for localization reduces the estimation error in finding the location and also the time complexity in computation is reduces as the mapping of strongest signals is taken into consideration. The proposed algorithm is consists of the following steps.

Step 1: Assumption: Assume a sensor node say 'N' wants to calculate its location L.

Step 2: Random Deployment of Sensor Nodes: The transmitted Sensor Nodes are randomly deployed and their corresponding coordinates are found

Step 3: Collection of RSSI: Received Signal Strength from all the sensor nodes collected at unknown node 'S'.

Step 4: Mapping of Signals: The Strongest signals from the collected signals are found and circles are mapped.

Step 5: Location computing: From step 4 only 3 values are taken to compute the location of the sensor 'S'

Step 6: Estimation of node position: Finally the Euclidean distance from the reported location vector of the mobile device is generally regarded as being the correct estimate of the position of the sensor node.

Distance formulae is given as

$$\sqrt{(X-x_1)^2+(Y-y_1}=d_1 \quad \text{--------------------- (1)}$$

$$\sqrt{(X-x_2)^2+(Y-y_2}=d_2 \quad \text{--------------------- (2)}$$

$$\sqrt{(X-x_3)^2+(Y-y_3}=d_3 \quad \text{--------------------- (3)}$$

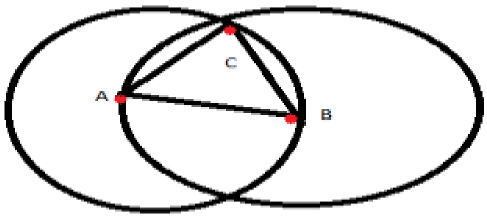

Figure 6: Multilateration

$distance[(x,y)(a,b)] = \sqrt{(x-a)^2+(y-b)^2}=d_1$------- **(4)**

$distance[(x,y)(b,c)] = \sqrt{(x-b)^2+(y-c)^2}=d_2$-------- **(5)**

$distance[(x,y)(c,a)] = \sqrt{(x-c)^2+(y-a)^2}=d_3$-------- **(6)**

Our proposed algorithm can tolerate distance measurements errors and thus work well under practical sensor network settings and effectively promote the performance range of application that depends upon triangulation

VI. CONCLUSION

In this paper we presented localization using trigonometric concepts of triangulation, The node localization is still the most substantial topic in wireless sensor networks and also it is vital because of effecting in monitoring, data processing power consumption and etc. we proposed triangulation method and an algorithm to find localization has different phases and techniques to estimate the location of unknown nodes, also reduces the estimation error in finding location with time complexity in computation is reduces as the mapping of strongest signals is taken into consideration.

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