An Improved Node Localization Algorithm for Wireless Sensor

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*Abstract:-***This paper introduces an improved localization algorithm that bases on distance and local coordinate system which is built up by beacon nodes. This algorithm evaluates the differences of several independent localization information to determine whether upgrade this node as beacon nodes according to the size of the difference whether beyond the prescribed or not. It can effectively prevent and reduce the accumulated and spread error in localization process by the audit of beacon nodes, and improve the positioning accuracy of nodes in the network.**

Keywords: wireless sensor networks, node localization, localization algorithm

I. INTRODUCTION

The location technology of wireless sensor network (WSN) is utilized in solving the localization of events and nodes in WSN, so as to offer effective location information for applications .The data collected by sensors would be significant only if it contained coordinate information in WSN. Since the significance of location information, we must ascertain the geographic location of sensor node for most, then deepen event detection, and adopt measures, and make the decision in the end. The relative localization of node can be dented as followed: locating one node as datum, and establishing one coordinate system on the basis of one criterion, ascertaining relative distance and direction between other nodes and this one, so as to count coordinates of other nodes in the same coordinate system. In the mobile net, however, node cannot acquire localization neighbor nodes directly, but measure the distance between each modes and itself. In this instance, each node could ascertain its relative distance between others by interchange distance information of their adjacent nodes.

At present, there are a large number of systems and algorithms that could work out localization of WSN node itself. However, different localization systems and algorithms are utilized to solve certain issues. The functions are different in network compose, energy demand infrastructures and spatio-temporal complexity .

II. THE IMPLEMENTATION PROCEDURE OF LOCALIZATION ALGORITHM

The sensor node is divided into beacon node and unknown node in WSN. Beacon node is a reference point of unknown node. All the sensor nodes are unknown nodes except the beacon node, they ascertain their localization information based on the beacon node. As Figure 1 shown, in WSN, M is beacon node, S is unknown node, node S communicates between the close M-mode or S-node which is already acquire its localization, then s-Node could calculate its localization with certain algorithms, which is based on what it obtains in communication[1].

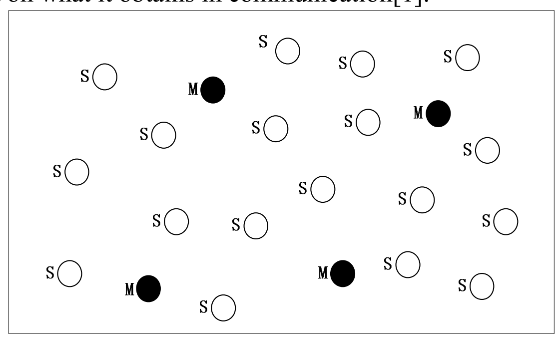

Figure 1. Beacon nodes of wireless sensor network and unknown nodes

A. The Classification of Localization Algorithm

In sensor nets, localization algorithm usually is classified as following [2]:

1) Localization Algorithm based on distance and Distance-independent Localization Algorithm.

Localization Algorithm based on distance requires absolutely distance and direction between nodes, so as to calculate distance of unknown depending on actual distance between nodes. The localization based on non-distance calculates node localization depending on estimative distance between nodes but absolutely distance and direction.

Incremental Location Algorithm and Concurrent Location Algorithm

The beacon node is the basis of Incremental Type Localization Algorithm. It locates the nearby nodes of beacon node at first, and then locates extensive nodes gradually. The disadvantage of this category algorithm is that the measurement error probably accumulates and spreads in the process. Concurrent location algorithm refers to the calculation of the position of all the nodes at the same time.

2) Localization Algorithm Based on Beacon node and Non-beacon Node

Beacon node localization algorithms refers to beacon nodes work as a reference point location, and each node localization produces the absolute coordinate system as a whole in the course of localization,; Non-beacon node localization algorithm only concerns about the relative position of the node positioning algorithm in location without participation of the beacon nodes. Each node itself

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as a reference point can be put into their neighboring nodes in the coordinate system defined, and then the adjacent coordinate system in order to be merged, the final overall relative coordinate system is generated.

Being discussed in this paper is a distance-based , incremental, beacon node localization algorithm.

B. Geometrical bases of localization algorithm

There are large numbers of methods that can be used to fix/ascertain localization of spatial point in Algorithm Geometry. As long as the formations proved by sensor are given enough, all the geometry principles could utilized to fix one localization can be serves as algorithm. In the process of localization, those unknown nodes which are already acquired the distances of closer beacon node usually calculate their localization with Trilateration [3].

The location of three reference nodes A1(x_1,y_1)、A2 (x_2,y_2)、A3(x_3,y_3) which shows in figure 2(a) are known. The distances between node and reference node are r_1、r_2 、r_3. Ideal situation is that according to (x_i,y_j) reference point and distance r_i determination of Three Circles intersect on a point, which is the estimated position of the node (1)

$$\begin{cases}(x-x_1)^2+(y-y_1)^2=r_1^2\\(x-x_2)^2+(y-y_2)^2=r_2^2\\(x-x_3)^2+(y-y_3)^2=r_3^2\end{cases} \quad (1)$$

can calculate the location of node(x , y) is (2)

$$\begin{bmatrix}x\\y\end{bmatrix}=\begin{bmatrix}2(x_1-x_3) & 2(y_1-y_3)\\2(x_2-x_3) & 2(y_2-y_3)\end{bmatrix}^{-1}\begin{bmatrix}x_1^2-x_3^2+y_1^2-y_3^2-r_1^2+r_3^2\\x_2^2-x_3^2+y_2^2-y_3^2-r_2^2+r_3^2\end{bmatrix} \quad (2)$$

C. Establishment of Coordinate System

By measuring the electromagnetic signal intensity, one of the wireless sensor network nodes can determine the collection of its one-hope neighbor nodes K_i. Through DTOA or TOA measurement of the distance d_{ij} this nodes and J in-between is a node of K_i. The distance forms a distance table D_i. The distance table D_i of each node will exchange with their one-hope neighbor nodes table D_i, then Node i can get the distance between any two nodes in K_i[4].

Construction of the following coordinates: The point i is the origin of coordinates. Select one point p from the one-hop neighbor node set K_i of the point i . The ip is the x-axis direction. Select one point q from the K_i and set q in first quadrant, then the y-axis is determined . As Figure 3 shown:

The coordinate values of the point i ,p , q:

i: $x_i=0 \quad y_i=0$

p: $x_p=d_{ip} \quad y_p=0$

q: $x_q=d_{iq}\cos\gamma \quad y_q=d_{iq}\sin\gamma$

Among them, γ is the angle between the linear iq and the linear ip, and

$$\gamma = arc\cos\frac{d_{ip}^2+d_{iq}^2-d_{pq}^2}{2d_{ip}d_{iq}},$$

$$x_q=\frac{d_{ip}^2+d_{iq}^2-d_{pq}^2}{2d_{ip}} \quad y_q=\sqrt{d_{iq}^2-x_q^2}$$

。

After the establishment of coordinate system, the known three points in coordinate are set beacon nodes and then other coordinate values of unknown nodes in the network x can be calculated by trilateral. Finally, the localization of the nodes achieves in this coordinate system [5].

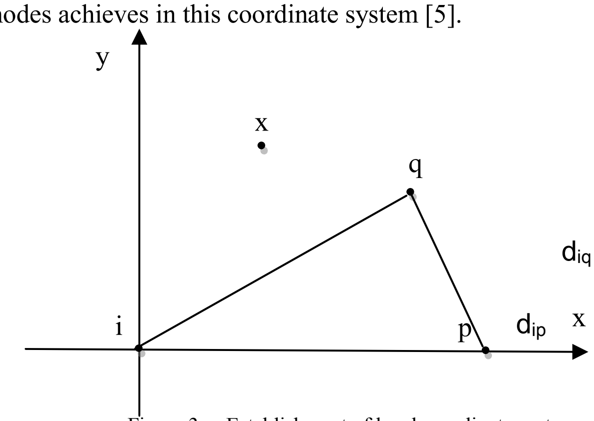

Figure 3. Establishment of local coordinate system

D. Incremental Localization Algorithm

Beacon nodes i , p , q are the basis of this algorithm. It locates the nearby nodes of beacon node at first, and then locates extensive nodes gradually [6]. But with range error between nodes, Incremental Localization Algorithm may accumulate and spread measurement error. The positioning accuracy of the nodes are those away from the beacon node. Peripheral and location later will greatly reduce. Even the node would be located in the wrong place. So it is necessary to improve this algorithm. Such as controlling error propagation and spreading , reducing positioning distortion caused by accumulation of error. The steps are as follows:

Step One : The unplaced node will make a topological relation matrix by topological relations vector which belong to itself or one-hop neighbor nodes, and then it will be located by range that is in the matrix

Step Two: If the point i, p, q are one-hop neighbor nodes of an unplaced node, we can determine the unplaced node position by Trilateration and let it as a beacon node.

Step Three: We can determine an unplaced node position by Trilateration if the unplaced node can communicate with three beacon nodes directly.

Step Four: If an unplaced node can communicate with n beacon nodes (n>3) , then the unplaced node can be located by three nodes. Find the C_n^3 values of location (x_i, y_i) , Of these $i=1,2,3\cdots,C_n^3$, find the average $(\overline{x},\overline{y})$, variance σ :

$$\bar{x} = \frac{1}{C_n^3}\sum_{i=1}^{C_n^3} x_i$$

$$\bar{y} = \frac{1}{C_n^3}\sum_{i=1}^{C_n^3} y_i \quad (3)$$

$$\sigma x = \frac{1}{C_n^3}\sum_{i=1}^{C_n^3}(x_i - \bar{x})^2 \quad (4)$$

$$\sigma y = \frac{1}{C_n^3}\sum_{i=1}^{C_n^3}(y_i - \bar{y})^2$$

$$\sigma = \sigma x + \sigma y \quad (5)$$

We can get the location information of node by（3） and get the deviation of the location information σ by (5) . Making the $(\bar{x}, \bar{y})$ as the location information of an unplaced node, and set a threshold σa. If $\sigma < \sigma a$, set the node as a beacon node ,or set the node only as a located node.

Step Five: If an unplaced node can communicate with only two beacon node, we can calculate two possibilities of the unplaced node's position, then choose the position which the third beacon node is further than maximum communication distance as the estimated position of the unknown location node .The third beacon node is one node that can communicate with the two beacon nodes.

Step Six: If an unplaced node can communicate with only one beacon node, we can position on the part of the unknown location node which can be approximated to locate. If the number of one or two –hop beacon node is more than three, we can calculate the distance to these beacon nodes by the method of accumulated distance and then locate by step four.

Step seven: Repeat until all nodes already position.

III. Conclusion

There are many location algorithms for WSN, such as DV-Hop, Amorphous, and APIT and so on. They all belong to the location algorithm without distance. Although the hardware requirements of theirs are low, the larger location error and low accuracy do exist. When using Localization Algorithm based on distance, measurement of the distance between nodes vulnerable to obstacles and other environmental factors, therefore, has distance measurement error. Basic principle of Incremental Localization Algorithm is to set the node which is constructed coordinate system as beacon nodes, and position the node in the network gradually spreads. So it is easy to accumulate and disseminate error and the positioning accuracy of the later locating node is low[7].

This improved location algorithm is not only be able to avoid the error location information of the located node is transmitted to the unplaced nodes, but also improve the positioning accuracy of the nodes and reduce the error accumulation. Due to the complexity of the algorithm of increasing orientation of convergence rate will be reduced, so that the time required for the entire network nodes localization increase.

References:

[1] Liming Sun,Jianzhong Li,Yu Chen and Hongsong Zhu, Wireless Sensor Network, tsinghua university press 2005.

[2] Xiaowei Li,Yongjun Xu and Fengyuan Ren, Wireless sensor network technology, Beijing University of Technology Press. 2007.

[3] Fubao Wang,Long Shi,Feng yuan Ren, Self -Localization Systems and Algorithms for Wireless Sensor Network,Journal of Software 2005,16(5):857-868

[4] Zuchang Ma, Yining Sun,Wireless Sensor Network Node Localization Algorithm. Computer Engineering, 30（7）:13-14, 2004..

[5] HU L, EVANS D. Location form mobile sensor network s. 10th Intern at ion al Conference on Mobile Computer and Networking [C] .Philadelphia: ACM Press, 2004: 45 - 57.

[6] RUDAFSHAN IM, DATTA S. Location in w ireless ad hoc sensor networks. International Conference on In formation Processing in Sensor Networks[C] . Cambridge: ACM Press, 2007: 51- 60.

[7] Zheng Zhang ,Sha Hong,Tianjuan Ren,Analysis of Wireless Sensor Network Node Localization Algorithm,Journal of Guizhou University (Natural Science Edition) 2010,27 (1) 99-102

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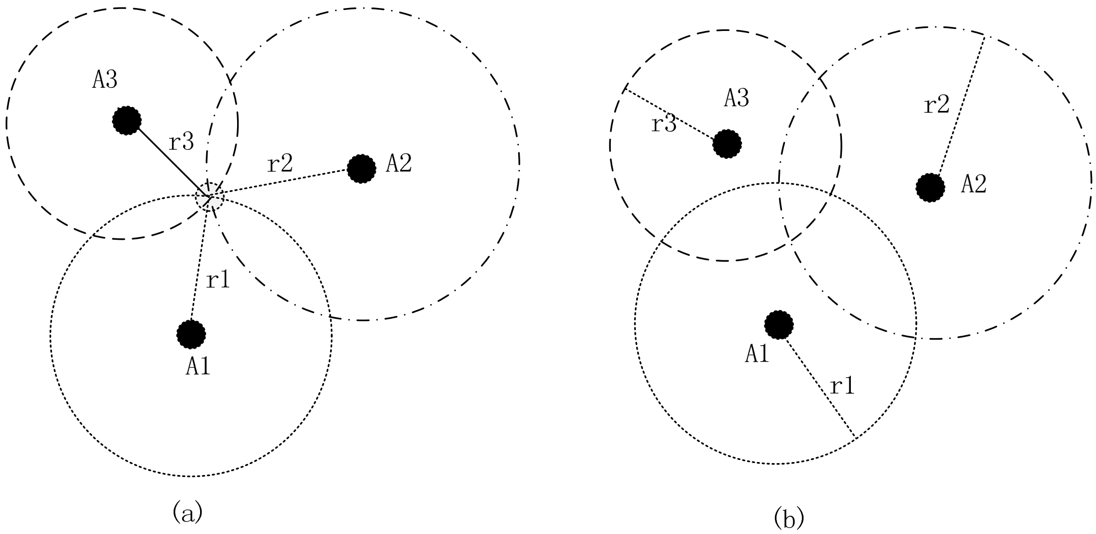

Figure 2. Trilateration（a）The ideal situation;（b）The actual situation