Based on DV - Hop of wireless sensor network node localization algorithm improvements

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Abstract: **DV-Hop algorithm is a classical range-free localization algorithm used for node locating of wireless sensor network. After analyzing the localization principle and limitation of DV-Hop algorithm， the authors proposed an improved DV-Hop algorithm. The new algorithm used cluster strategy to reduce communication cost and grouping conflict probability in the first stage，and quasi-Newton optimization method was used instead of the least-square method to estimate the position of nodes. Simulation was made by using Matlab7.0，and the results show that the improved DV-Hop algorithm can greatly improve the localization accuracy of the unknown nodes without increasing communications traffic.**

Key words: wireless sensor network; node localization; localization accuracy; DV-Hop

INTRODUCTION

Wireless sensor network composed of a large number of sensor nodes which in the region, the sensor nodes have processing and communication capabilities [1].

Node location is one of the very important technology in wireless sensor networks, the exact coordinates of the location to obtain the node for the purpose of positioning algorithms have been proposed. Manner in accordance with the distance parameters used by the positioning, the positioning algorithm is divided into based ranging algorithm (Range-based) and without Ranging Algorithm (Range-free) [2]. Based on the distance positioning algorithm commonly used ranging techniques TOA [3] or on TDOA [4] ranging, AOA ranging and RSSI [5-6] ranging. Distance independent localization algorithm by estimating the distance between nodes or to determine the possible area that contains the unknown node to determine the location of the unknown node. Representative algorithms include the center of mass algorithm [7], convex programming algorithm [8], the DV-hop[9] algorithm and APIT [10] algorithm. Range-based localization algorithm for the network hardware facilities, high requirements for the Range-based localization algorithm usually requires multiple measurement, these algorithms to obtain relatively accurate positioning results should produce a large amount of computation and communication overhead. Therefore, the Range-free localization algorithm received more and more attention.

At present DV-Hop localization algorithm is the most widely used localization algorithm, the basic idea is the unknown node to the distance between the anchor node with the product of the average per-hop distance and difference between the numbers of hops. For the DV-hop algorithm in the nodes are randomly distributed network environment, there is a big error, we have to correct and improve this. In the literature [11], the unknown node received a number of anchor nodes, the average distance of each jump, the arithmetic average processing; [12] proposed a collinear network local topology-based adaptive threshold to determine the method. Have improved algorithm, the first method to increase the node communication overhead the expense, the last method to increase the computational overhead of the node at the expense of the improvement of the algorithm performance parameters. This paper focuses on the lack of coordinate calculation stage the DV-hop algorithm, specific nodes are randomly distributed, the network topology dynamically changing environment, the DV-hop algorithm corresponding improvement program, improve program performance and simulation, validated by comparison .

I THE DV-HOP ALGORITHM

1.1 The basic idea of the DV-hop algorithm for the positioning process is divided into three stages [13]:

(1) Calculate the minimum number of hops of the unknown node and each anchor node.

The anchor node to neighbor nodes broadcast their own location information packet, including jumping the digital segment, initialized to 0. The receiving node records the minimum number of hops to each anchor node, ignore a larger number of hops the packet from an anchor node. Then the hop count plus one, and forwarded to the neighbor node. Through this method, all nodes in the network be able to record down to the smallest number of hops for each anchor node.

(2) Unknown nodes and anchor nodes, the actual jump distance.

Each anchor node, the other anchor node location information recorded in the first stage and away from the hops, the formula to estimate the average hop distance. Then the anchor node will calculate the per-hop average distance with packet broadcast to the network lifetime of the field, the unknown node records only received a per-hop average distance, and forwarded to the neighbor node. This strategy to ensure that most of the nodes from the nearest anchor node receives the average jump distance value. Unknown node receives an average distance of each jump, according to the record number of hops, calculation of hops to each anchor node distance.

(3) Used the trilateral or multilateral measurements to calculate it’s own position.

When get near to the unknown node after the estimated distance of anchor nodes, usually the trilateral measurement method is adopted for location estimation.

1.2DV-Hop algorithm detailed process

DV-Hop localization algorithm detailed process description is as follows:

(l)Distance vector exchange phase

Anchor nodes broadcast messages through the use of distance vector routing exchange protocol, each node in the network were obtained with all other anchors between the minimum numbers of hops. Concrete are stored in each node a routing table formats such as: $\{x_i, y_i, top_i\}$, where x_i, y_i is the anchor node coordinates of i, top_i represents this anchor node of the node number of hops. Network initialization phase, the anchor node to flood way to their neighbor nodes send broadcast messages, the message contains the anchor node number, position coordinates and the hop count information, where the default number of hops is 1. Other nodes receiving the broadcast message, save the message, and the value by 1 hop in the same manner continue to forward this message. In this process, a node may receive the anchor node from the same pieces of information, then the node only keep the minimum number of hops of the information, a measure to ensure that each node is recorded with the other between anchors minimum number of hops.

Anchor node hops with other segments of the information acquisition process shown in Figure 1:

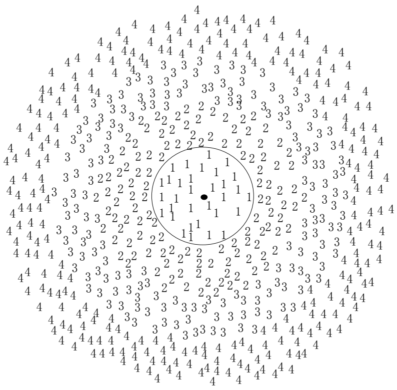

Figure 1: Correct broadcasting stage

(2) Phase correction value computing and broadcasting

After the first stage of flooding broadcast, each node holds one with the smallest among all other anchors.

Hop count routing table, calculated according to this table to get the correction value.

Calculated as follows: $HopAdj_i = \frac{\sum \sqrt{(x_i - x_j)^2 + (y_i + y_j)^2}}{\sum h_{ij}}$

Where, $(x_i, x_i), (x_j, y_j)$ for the two coordinates of the anchor nodes, h_{ij} is the anchor node distance between the numbers of hops.

(3) Coordinate calculation stage

When a plurality of unknown nodes calculate the estimated distance between anchor nodes, the use of the trilateral measurement method or Maximum Likelihood estimation method to calculate the position coordinates of the node itself. Detailed algorithm is follow:

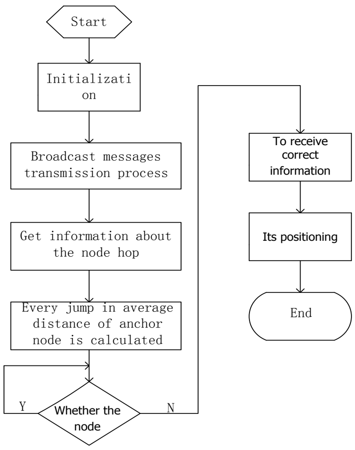

Figure 2: Detailed algorithm process flow diagram

1.3 the lack of DV-hop algorithm is

The DV-hop algorithm, every jump, the average distance between the anchor node as the unknown node to anchor node, the average per jumping distance, expressed as the product of each jumping from the number of hops between the unknown nodes and anchor nodes distance. The DV-Hop localization algorithm more suitable for the anchor nodes evenly distributed, isotropic, intensive wireless sensor networks, because the average hop distance value can be obtained in this case closer to the actual distance value. Shown in Figure 3, when the nodes are densely distributed, multi-hop path distance between nodes in the network closer to the actual distance. When the node sparse, the path between the nodes can’t be tending to straight line, the distance value calculated in this way will have a huge cumulative error.

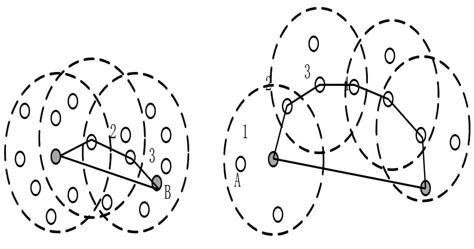

Figure 3: Node distribution of influence on route choice

II IMPROVED DV-HOP LOCALIZATION ALGORITHM

Based the DV-hop algorithm deficiencies the DV-Hop_Boan algorithm. Under the premise of ensuring the DV-Hop thinking, when the network topology is formed, the number of hops between nodes is generally fixed. In order to make the estimated distance obtained with the minimum actual distance error by adjusting the average distance per hop to achieve. It was found that when select all the anchor node as the reference anchor node of the unknown node, the average location error is not the smallest, but select one from the unknown node closer to the part of the node will have a better effect this time every jump multiplied by the average distance and number of hops is also closest to the actual distance. The experiments show that to achieve the lowest average positioning error of the optimal number of anchor nodes and the network environment parameters, different parameters of the network environment, the optimal number of anchor nodes is also different. As a result, propose a new positioning idea.

Each unknown node initially set a threshold closure value of N, after the exchange of information, has been estimated distance from the anchor node. Select the first receiver to the N anchor node, the application of maximum likelihood estimation method to seek the unknown node coordinates. Select only the short distance part of the anchor node as a reference anchor node, the new positioning algorithm not only reduces the amount of computation in the positioning process, improve efficiency, and by choosing the optimal reference number of anchor nodes to achieve better average the purpose of positioning errors.

The main difference improved algorithm to calculate the error correction value of the node coordinates and the third step of the unknown node coordinates further amended in the second step in the positioning process.

2.1 coordinate error correction values

Calculate the number of hops between any two anchor nodes, the DV-hop and other anchor nodes in order to distance divided by the number of hops, and as the average jump distance, each anchor node to calculate the estimated jump distance and sent tone work. Improved algorithm using similar steps to estimate the per-hop distance, the difference is that each node by the actual distance and estimated distance to minimize the squared error to calculate the coordinates of the nodes, error correction value.

2.2 node coordinate calculation and correction

In the third stage of the DV-hop algorithm, if we can estimate the distance of the unknown node with three anchor nodes, the coordinates of the unknown node can be estimated by the trilateral positioning or multilateral positioning method [14]. Multilateral orientation ranging error sensitive, when ranging error, there is a large deviation between the estimated multilateral positioning coordinates and real coordinates. For this defect is proposed to improve the multilateral location in the idea of positioning accuracy using two-dimensional hyperbolic. Two-dimensional hyperbolic positioning algorithm is applied to specific wireless sensor network node position calculation.

DV-hop algorithm, triangular positioning to get the final position of the unknown node. In the improved algorithm, we will not use the traditional triangular positioning, instead of using the two-dimensional hyperbolic positioning algorithm.

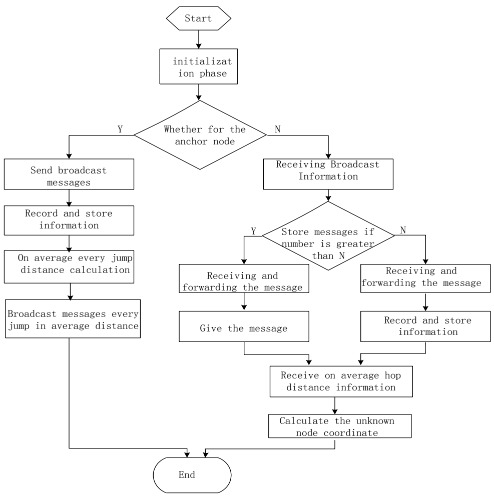

Figure 4:Dv-Hop_Boan specific flowchart：

III ALGORITHM SIMULATION

In order to test performance of the algorithm, the traditional DV-Hop localization algorithm and improved algorithm on the platform of MATLAB simulation comparative analysis. Network model [15] [16] to do the following assumptions Dispenser sensor nodes randomly in a 100m x 100m area, the coordinates of unknown nodes and anchor nodes is randomly generated. Discussed below the anchor node density, number of nodes in the traditional DV-Hop localization algorithm and improve the algorithms of ranging error and the impact of the positioning accuracy. Each performance of the simulation are randomly 100 times income.

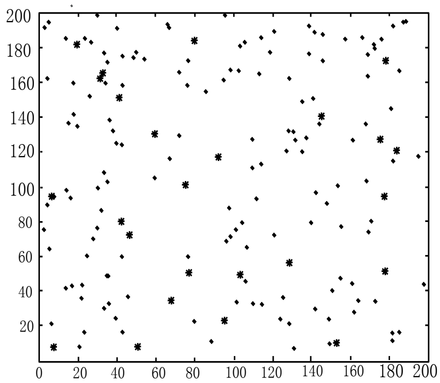

Figure 5: 100 nodes randomly distributed

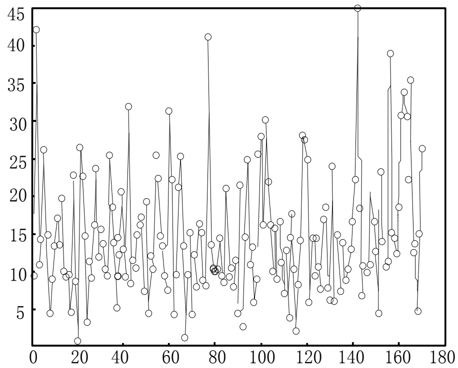

Figure 6: The error of the unknown sensor network diagram error

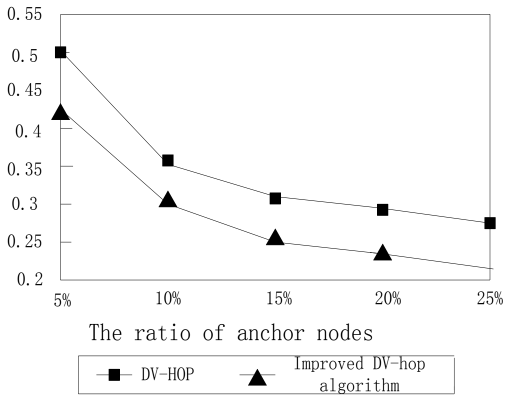

Figure 7: The average location error under different percentage of anchor nodes

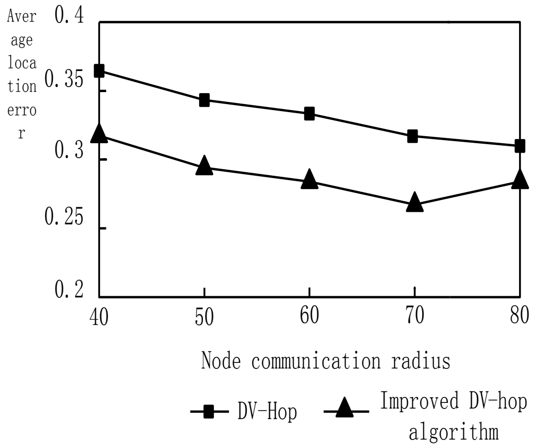

Figure 8: The average location error under different communication radius

3.1The analysis of simulation results

In the experimental area to maintain anchor node for 20 percent of the total number of nodes changes from 20 to 100, more traditional DV-Hop algorithm and the improvement of the DV-hop algorithm of ranging error. It can be seen from the figure, with the increase of the number of nodes, the average location error of the two algorithms show a decreasing trend. Improve the error correction algorithm to the coordinates of the nodes, under the same conditions, the improved algorithm ranging error was significantly less than the tradition of the DV-hop algorithm. Improved DV-Hop algorithm than conventional DV-hop algorithm the average ranging error reduces 12.5%.

100 nodes randomly deployed in the simulation area, the ratio of anchor nodes is 5%, respectively, 10% ... 25%. The tradition of the DV-hop algorithm and improve the comparison of the average location error of the DV-hop algorithm when the proportion of different anchor node. The horizontal axis is the ratio of anchor nodes, the longitudinal axis of average positioning error. With the increase in the proportion of anchor nodes, the average location error of the two algorithms show a decreasing trend. Under the same conditions, the average positioning error of the improved algorithm is significantly less than the tradition of the DV-hop algorithm. For example, in the anchor node ratio of 20%, improving the DV-hop algorithm is about 11.3% lower than the average error of the traditional algorithm.

Maintain parameters anchor proportion of 20% in the experimental area, the total number of nodes changes from 20 to 100, more traditional DV-Hop algorithm and the improvement of the DV-Hop algorithm, the average positioning error. It can be seen, with the increase of the number of nodes, the average location error of the two algorithms show a decreasing trend. Under the same conditions, the improved algorithm the average location error was significantly less than the tradition of the DV-hop algorithm. For example, in the number of nodes to 50, improve the average error is decreased by about 17.1% of the DV-hop algorithm than conventional DV-hop algorithm.

IV CONCLUSION

This paper presents an improved DV-Hop localization algorithm. Proposed new node coordinate calculation method, the application of the new node coordinate location model. Error correction value of the node coordinates to fix the initial positioning coordinates, to get results closer to the actual coordinates. The theoretical analysis and algorithm simulation shows that compared with the traditional algorithm, the improved algorithm significantly improves the positioning accuracy of the node under the premise that does not require additional hardware and software overhead.

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