

The research and optimization of AD-Hoc network localization algorithm based on the distance-assisted

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Abstract—In order to enhance the accuracy of AD-Hoc network localization and the autonomy of the range-free localization algorithm, the sensing distance-accumulated value, as a scale, is used to modify accumulated distance and estimate node location information by the way of curve fitting, instead of calculating the coordinate value by the way of maximum likelihood estimation. By means of the mathematical deduction and simulation analysis, this localization algorithm, based on the distance-assisted, could realize the quantitative analysis of DV-Hop algorithm, reduce the physical localization difference of the AD-Hoc network due to the multi-hop communication mechanism, modify the accumulated distance in the hop segment, improve the localization accuracy in a network of nodes that are unevenly distributed. In dense or sparse networks, this new improved algorithm could achieve a better localization data of the nodes than the traditional algorithm, and realize the nodes autonomous localization in the AD-Hoc network.

Keywords—AD-Hoc network; Range-free localization; DV-Hop algorithm ; Distance-assited ; Hop count quantitative analysis

I. INTRODUCTION

AD-Hoc network is a distributed, multi-hop forwarding, node power constrained self-organized network[1,2]. There is an important branch of the localization technology in this network, which is based on the topological relationship of the whole network. The localization process is realized by the multi-hop localization information. At present, it is still in the research stage for the localization algorithm of AD-Hoc network. The proposed algorithm has the precondition of their own application. After the investigation, at present, the common problems of AD-Hoc network localization algorithm are as follows[3,4]: a. localization error accumulation in large scale AD-Hoc networks; b. the complexity of the localization algorithm and the problem of the amount of the communication information of the algorithm itself; c. the problem of autonomous analysis and adaptation to the topology of AD-Hoc network; d. the problem of the optimization to the localization algorithm based on actual network scene.

II. THE STUDY ON THE PRINCIPLE OF THE LOCALIZATION ALGORITHM BASED ON THE DISTANCE-ASSISTED

For the shortcomings of the traditional algorithm in the localization accuracy[5], the main research of the localization algorithm based on the distance-assisted(LDA)is how to reduce the difference of the physical position of the AD-Hoc network

with the multi-hop mechanism in the case of not fully relying on the range accuracy.

In order to improve the localization accuracy of traditional algorithm for the nodes in the uneven and sparse distribution network, it focuses on three aspects: hop count quantization, curve fitting, and beacon information selection.

A. Hop count quantization

In the AD-Hoc network, the nodes' communication and distance measurement are realized by multi-hops between nodes. Hop count generation mechanism of the DV-Hop algorithm is shown in Figure1. A is an anchor node whose position is known. U_{n1} , U_{n2} and U_{n3} are the nodes whose position is unknown. It's assumed that initial hop values of unknown nodes are zero. U_{n1} , U_{n2} are in the communication range of A, so $hn(\text{hop count}) = 1$; U_{n3} isn't in the communication range of A, so hn is unknown. When calculating the distance between the unknown node and the anchor node, the distance results are the same for the U_{n1} and U_{n2} , $d_{\text{hop}_A} * hn = d_{\text{hop}_A}$ (d_{hop_A} represents the average hop distance of A). From the Figure1, there exists a considerable difference between the position by calculating and the actual position of the unknown node.

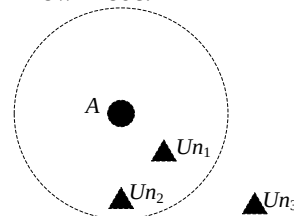


Figure 1 Hop count generating mechanism

In the view of the above problems, the idea of the hop count quantization is introduced, and the number of hops is quantized, which is segmented in the distance of the 1 hop range[6,7].

In the process of the hop count quantization, every node needs to make a round of communication to obtain the distance signal from its adjacent nodes. The distance and the hop number are two independent physical quantities. After obtaining the distance signal, the hop count is quantized by the following two steps.

- 1) **Distance signal sorting:** It's assumed that A is an anchor node in the AD-Hoc network, and there is a group of adjacent nodes which the distance is a one hop to A. $D(A, n)$ is used to represent the distance

signal between A and N, $n \in N$. If n belongs to N , $D(A, n)$ could be selected. And, all nodes, which belong to N , could be rearranged according to certain order. With this step, the nodes are sorted and formed the node list In accordance with the order of increasing distance.

- 2) **Quantization:** In LDA each hop could be specified up to a distance interval, which is called r . And the extent of the hop quantization is r . To quantify the hop count, the one hop is divided into s parts, and the corresponding node is assigned the suitable hop interval. If the Quantization level of the hop is r , the level of the specified distance is r .

B. Curve fitting

The concept of the range resolution was introduced, which is used to explain the problem of hop count quantization. The hop relationship of any two nodes is as shown in Figure 2.

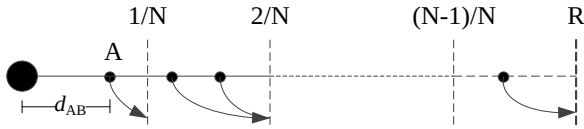


Figure 2 Hop count quantization of distance-assisted

The hop relationship is expressed as the following formula,

$$hop_{AB} = \frac{1}{N} \left[N \frac{d_{AB}}{R} \right] \quad (1)$$

where N represents Quantization levels.

In the equation (1), the hop count is quantified. When N tends to infinity,

$$hop_{AB} \approx \frac{d_{AB}}{R} \quad (2)$$

So, the average distance per hop can be rewritten as follows,

$$hopSize_i = \frac{\sum_{j \neq i} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum_{j \neq i} \frac{d_{ij}}{R}} \quad (3)$$

where d_{ij} represents the accumulated value of the shortest path from the anchor node i to the beacon nodes j .

The estimated distance could be expressed as follows, which is from the unknown node to the anchor node.

$$\begin{aligned} D_{ik} &= hopSize_i \times hop_{ik} \\ &= \frac{\sum_{j \neq i} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum_{j \neq i} \frac{d_{ij}}{R}} \times \frac{d_{ij}}{R} \\ &= \frac{\sum_{j \neq i} \sqrt{(x_i - x_j)^2 + (y_i - y_j)^2}}{\sum_{j \neq i} d_{ij}} \times d_{ij} \end{aligned} \quad (4)$$

By these calculation, the distance accumulated is used as the scale to fix the straight-line distance between the nodes. Although the range error still exists, it, which is compared to the DV-Hop algorithm, completely eliminates localization errors caused by the low resolution of hops[8,9].

C. Beacon information selection

- 1) **Localization correction value options:** In LDA, the localization correction value matches the corresponding anchor node. When any anchor node receives other anchor location information and the shortest path information of the cumulative distance, the anchor node will calculate localization correction value, and broadcast with its own ID. In this process, the unknown node will receive anchor node information which contains the localization correction value, position data and cumulative distance. Localization effective distance equals that the same anchor nodes Localization correction value multiplies by the cumulative distance data in this anchor node.
- 2) **Localization method :** In LDA, Maximum Likelihood Estimate is adopted. All anchor nodes received information is used to locate the unknown nodes. In the joint action of the whole anchor nodes, the localization error which is caused by the anchor nodes in the uneven distribution is reduced. The express mode is shown in the Figure 3.

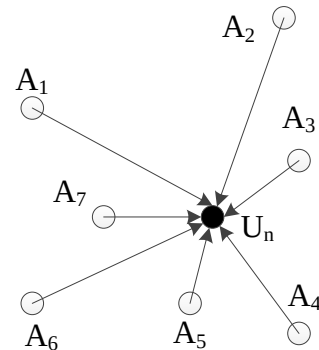


Figure 3 The localization selection mode of the anchor modes

III. THE PROCESS DESIGN OF LDA

The detailed process design is shown in Figure4, and the implementation strategy of the LDA process is described as follows.

A. Anchor nodes information initialization

Self-localization information is broadcasted, which contains anchor node ID, coordinate value and initial cumulative distance. Typical distance vector routing and switching protocol is adopted, the beacon node to its neighboring node broadcasts the anchor nodes message is broadcasted to their neighbor nodes, which contains localization information and initialization distance sense information.

B. The information that unknown nodes receive

After the unknown nodes with the adjacent anchor nodes receive the localization information, the anchor nodes localization information is corresponding to the cumulative distance information through the identification of the anchor node ID[10].

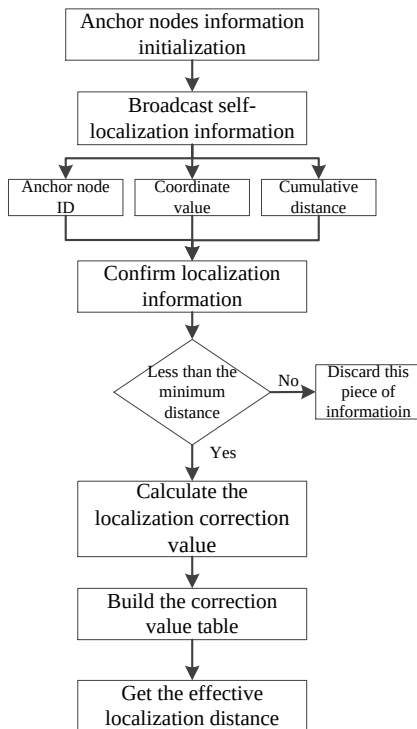


Figure 4 The process design of LDA

C. The data transmitted to the whole AD-Hoc network

The distance cumulative value of the shortest path is sensed between the anchor nodes. The next level neighbor nodes continue to receive information from the upper level nodes. To reduce network traffic, the nodes can discard the invalid information on beacon nodes. If the information of an anchor node has been received and its corresponding cumulative distance value is not less than the minimum record value, the information is considered invalid.

D. Correction value calculation

When all anchor nodes receive their own accumulated distance and position information from other anchor nodes, anchor nodes uses the cumulative distance value to modify the linear distance between the anchor nodes of the network, and get the network correction value table.

E. Effective localization distance

The unknown nodes receive the localization correction value of every anchor node, and get effective localization distance information.

IV. SIMULATION ENVIRONMENT AND SIMULATION RESULTS

A. Simulation environment description

The performance of LDA is evaluated via computer simulations. In Table1,100 nodes are placed in the specific field (100m×100m) randomly, and there are 10% anchor nodes among them. The communication radius of every node is $R=25m$. Initial rang error is 5%R. The parameters variation section are demonstrated as table1.

TABLE 1. PARAMETERS VARIATION SECTION

Parameters	Variation section	Step-by-step
Total nodes	50-400	50
Anchor nodes proportion	5%-40%	5%
Communication radius	20-50m	5m
Rang error	10%R-40%R	10%R

B. Simulation results analysis

By comparison among LDA, 3 DV-Hop and DV-Hop, the advantage of LDA are obvious in Figure5.

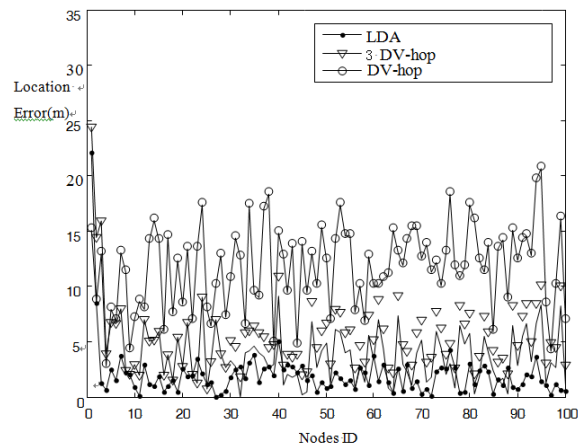


Figure 5 The comparison of unknown nodes localization error

Because of using the sensing distance as the information-assisted and modifying the accumulated distance in multi-hop, the curve effect caused by the low resolution of hops is improved, and the localization error is decreased obviously, and the layer structure is clear.

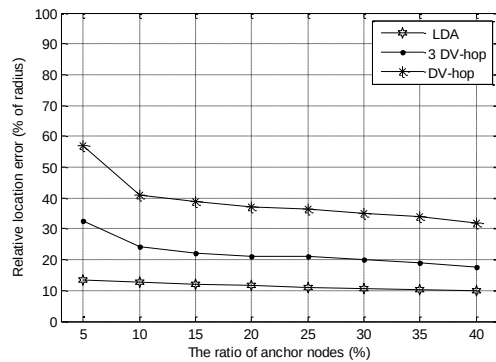


Figure 6 The influence of the ratio of anchor nodes on the localization error

The influence of different parameters on the localization error is shown in the Figure6, Figure7 and Figure8.

Judging from Figure6, Figure7 and Figure8, the localization error can be reduced to a certain extent, but not be completely eliminated. The simulation results also proves that the results of the mathematical derivation of the localization algorithm. When the node density becomes small, the localization error, which happens in the DV-Hop position process, sharply increases from dense network into sparse network. When nodes total number equals 50, anchor nodes ratio equals 10%, and communication radius equals 25m, DV-Hop algorithm localization error even is higher than the 80% range of the wireless node, and 26% higher than LDA error.

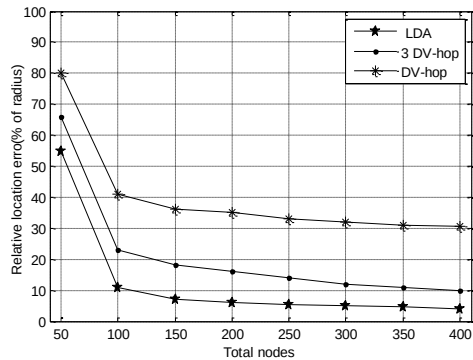


Figure 7 The influence of the total number of nodes on the localization error

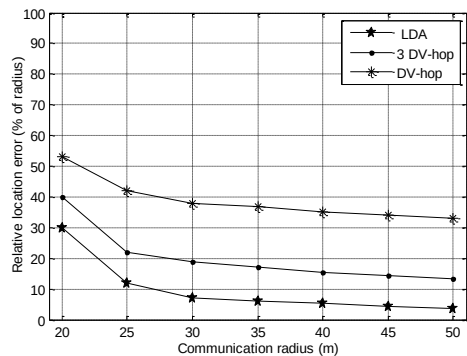


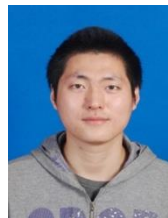
Figure 8 The influence of the communication radius of anchor nodes on the localization error

V. CONCLUSION

The LDA could reduce the physical localization error of the AD-Hoc network with multi-hop mechanism. By fitting the difference between the linear and curve, the LDA's localization accuracy is improved than the traditional localization algorithm in uneven or sparse AD-Hoc network distribution.

REFERENCES

- [1] Liu J, Wan J, Wang Q, et al. A survey on position-based routing for vehicular ad hoc networks[J]. Telecommunication Systems, 2015:1-16.
- [2] Patel M. Study of Localization Techniques in Vehicular Ad-hoc Networks[J]. International Journal of Computer Aided Engineering & Technology, 2013, 4(4):194-202.
- [3] Del P P J, Soomro A, Nandagopalan S S, et al. Beaconing protocol for ad-hoc networks: CA, CA2556039 C[P]. 2014.
- [4] Sahu P. Multi-Parametrized Optimized Ad-Hoc On Demand Distance Vector Routing[J]. International Journal of Computer Science & Information Technolo, 2014.
- [5] Park J W, Park D H, Lee C. Angle and ranging based localization method for ad hoc network[J]. Journal of Supercomputing, 2013, 64(2):507-521.
- [6] Hu Y, Li X. An improvement of DV-Hop localization algorithm for wireless sensor networks[J]. Telecommunication Systems, 2013, 53(1):13-18.
- [7] Gui L, Val T, Wei A, et al. Improvement of range-free localization technology by a novel DV-hop protocol in wireless sensor networks[J]. Ad Hoc Networks, 2015, 24:55-73.
- [8] Kulaib A R, Shubair R M, Al-Qutayri M A, et al. Improved DV-hop localization using node repositioning and clustering[C]// Communications, Signal Processing, and their Applications (ICCSPA), 2015 International Conference on. IEEE, 2015:1-6.
- [9] Cao Y, Yan K, Jinbao X U. A Kind of Double Particle Swarm Optimization DV-Hop Localization Algorithm Based on Best Anchor Nodes Set[J]. Chinese Journal of Sensors & Actuators, 2015.
- [10] Miles J, Kamath G, Muknahallipatna S, et al. Optimal trajectory determination of a single moving beacon for efficient localization in a mobile ad-hoc network[J]. Ad Hoc Networks, 2013, 11(1):238-256.



Jiawei Wu was born in 1994. He is presently a student at School of Information Engineering, Tianjin University of Commerce. His major is in Communication Engineering. He has numerous scholarship and awards. His research experience contains Wireless communication optimization technology in phones, Design of radio frequency communication module based on Galileo chip, and Fuzzy recognition method of vehicle license plate number based on Internet of things.