

Study on Range-Free Node Localization Algorithm of Internet of Vehicles

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Abstract—Internet of Vehicles (IoV) has been considered to be an important branch which is most likely the first breakthrough in the application of Internet of Things (IoT), and has become the focal point of research. Among them, the localization of vehicles are key technologies of the IoV. This paper focused on range-free nodes location technologies of IoV, and the algorithm and applications in IoV have been discussed. Finally, the localization theories and algorithms appropriate to IoV are comparatively analyzed, and the research direction of positioning technologies of IoV are put forward.

Index Terms—Internet of Vehicles, Localization Method, Range-free

I. INTRODUCTION

Internet of Vehicles (IoV), the vehicle nodes and exchange data must be associated with the position, therefore, must take certain mechanisms and algorithms to achieve real-time positioning and location awareness between nodes on the vehicle node, and the establishment of close ties between the vehicle and the location of the implementation, monitoring, vehicle tracking and positioning, so as to realize the dynamic management and control between the vehicles.

Mentioned vehicle positioning satellite positioning, we first thought (such as GPS or Beidou). However, the source application in vehicle navigation and object tracking, the positioning accuracy, response time and controllability are unable to adapt to the application requirements of vehicle networking. At present, a feasible way is to let the city side of the road traffic. RFID reader, video camera and so on the road side unit (RSU) to obtain accurate location information through satellite positioning, as the anchor nodes in the network to provide location information source, running on the road vehicles with the help of RSU positioning^[1]. At present, there are mainly based on range-based technology and the use of range-free technology in two ways to achieve positioning.

IoV is a special mobile ad Hoc networks (MANET), a wireless sensor networks (WSNs) used in specific environments, or a special purpose Internet of Things (Internet of things, IoT). Therefore, the study of IoV, need to fully consider the network environment, node

movement law, application background and other specialties, and learn from the existing results. Based on the basic theory of positioning technology in MANET and WSNs, this paper compares the range free algorithm suitable for IoV. Combined with the research status and development trend of IoV, the application of each algorithm is given a reference.

II. THE NODE LOCATION TECHNOLOGY PERFORMANCE EVALUATION STANDARD

In the wireless sensor network (WSN) positioning technology, different localization algorithm has different influence on positioning results, usually has the following several indicators to measure^[2]:

Positional Accuracy: position precision is refers to the spatial location information (usually the coordinates) proximity between its true location, it is a leading indicator of measuring sensor network localization, only reach a certain position precision of localization algorithm is real and effective.

Effective Range of Orientation: positioning system can locate Effective range. To satisfy most of the nodes in WSN can be positioning, only covers a wide range of node location to be meaningful.

Node Density: refers to the spread of sensor Node Density in terms of network nodes. In WSN node density had a great influence on the performance of the positioning, usually Node Density high positioning precision will be higher and higher, the opposite will reduce Positional Accuracy. In view of the different localization algorithm in WSN node density is not required for the same, the performance of the sensor nodes and the price also determines the node of the seeding density.

Density of Beacon Node: Density of Beacon Node refers to the Beacon nodes in the proportion in the WSN. Beacon node has its own positioning function, the price is more expensive, could not sow large area, its node determines the positioning precision of the high and low density.

Fault Tolerance and Adaptability: refers to the so-called fault-tolerance of the presence of Fault system will not fail, the characteristics of can still work normally. Fault Tolerance is Fault how should the Fault, to be exact

and not let Error. Adaptability can be thought of as a can adjust itself according to environmental changes can intelligent features of feedback control system, so that the system can work in accordance with the standards of some setting in the optimal state.

Security: Security is refers to the system to legitimate users of response and to resist the illegal request, to protect themselves from the external influence and the ability to attack. WSN usually work in the area of the physical environment is more complicated, positioning system vulnerable to environmental or man-made destruction and attacks, which cannot reach the ideal wireless communication environment to achieve the positioning of the effect, therefore must have a very strong security positioning system and algorithm.

Power Dissipation: refers to the Power loss of Power consumption, Power consumption in the process of WSN design has always been one of the main aspects in its application. Limited due to the energy of the sensor nodes and it is not easy to get, so we need the whole WSN can with less energy consumption and high efficiency of energy utilization to implement security positioning is the first question faced by the current research.

Cost and Consideration: the cost of location algorithm includes time cost, capital cost and space cost. Under the premise of ensuring the accuracy of positioning, the positioning system should be the minimum cost, such as the amount of computation required, the amount of communication, storage space, etc.

III. THE MAIN RANGE-FREE LOCALIZATION ALGORITHM ANALYSIS

Although positioning algorithm based on distance measurement can realize accurate positioning, but also often higher requirements for hardware, hardware cost increasing, is not conducive to the use of large area, in various fields, wide Angle. Without ranging localization algorithm is simple to use, only need to use the unknown node to estimate the distance between the reference node or other location information, and then use Trilateration or Maximum Likelihood Method to calculate the unknown node coordinate information. The existing positioning algorithm based on without range mainly include: DV - HOP algorithm, Centroid algorithm, Amorphous algorithm, Convex Optimization algorithm and MDS-MAP algorithm, AHLos localization algorithm and Cricket system, etc.

A. DV-HOP algorithm.

DVHOP algorithm^[3,9,10] does not require network nodes have distance function, which USES the average of the jump distance to represent the distance between the adjacent nodes, to calculate the actual distance, the coordinates are calculated by the trilateral measurement method. Algorithm of faults is to use the jump distance between the two nodes represent the actual linear distance will cause the error, the accuracy of positioning. Therefore, DVHOP algorithm in the high density of nodes in the network can achieve high precision positioning, positioning accuracy is not ideal in sparse network.

B. Centroid.

Centroid^[4,8] refers to the physical system is considered to focus on the quality of an imaginary point. In sensor networks, the center of mass is to point to the center of the polygon, the polygons each vertex coordinates of the geometric average is the bar centric coordinates. Centroid algorithm is the University of Southern California's Nirupama Bulusu etc, the algorithm is suitable for outdoor positioning under the circumstance of high node density, it is based on the network connectivity (Connectedness) implementation of node localization. Its basic idea is: the unknown nodes according to their own set of threshold method to receive the beacon nodes around the contains the node ID and position information to determine its area, according to its beacon node ID and position information received by the calculation area in the center of mass, and the area of the center of mass as its own positioning results. This algorithm is simple, the hardware requirements is low, don't need any additional hardware devices, but in the process of positioning requires more beacon nodes, and the algorithm are assumed in the process of locating nodes with wireless signal transmission model of the ideal, this also has the very big difference with the actual situation, thus affecting the positioning precision of the Centroid. The basic principle of centroid is shown in Fig.1.

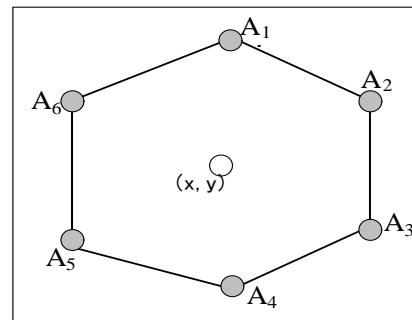


Figure 1. diagram centroid algorithm

In this algorithm, $A_1, A_2, A_3 \dots A_6$ Six vertex coordinates are $(x_1, y_1), (x_2, y_2), (x_3, y_3), (x_4, y_4), (x_5, y_5), (x_6, y_6)$ the area of the center of mass as follows:

$$(x, y) = \left(\frac{x_1 + x_2 + x_3 + x_4 + x_5 + x_6}{6}, \frac{y_1 + y_2 + y_3 + y_4 + y_5 + y_6}{6} \right)$$

C. Amorphous

Amorphous^[5] is based on the connectivity of the localization algorithm, it needs to know in advance the connectivity of the network. Algorithm implementation process, the unknown node first calculated with the minimum hop count between each beacon node; And then calculate the unknown node to jump distance of each beacon node, which assumes that the network node communication radius is the same; Finally re-use Trilateration or MLE algorithm for position calculation. Amorphous is easier to implement, but the positioning precision is not high, there are two significant drawbacks:

one is the need to know in advance the network connectivity, the other is to be higher in the process of positioning the node density^[6].

D. Convex Optimization localization algorithm.

Convex Optimization^[7] is a kind of centralized positioning algorithm, the so-called centralized localization algorithm is relative to the case of a distributed localization algorithm, centralized positioning algorithm using concentrated thought, after collected all the sensor nodes effectively information unified positioning calculation, the extensibility of centralized localization algorithm is bad, signal transmission and processing more troublesome, will not be able to use flexible. Convex programming algorithm is shown in Fig.2:

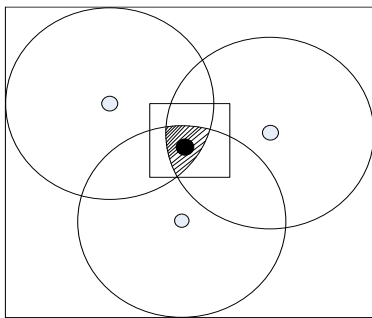


Figure 2. Diagram of Convex Optimization Principle

The basic principle of unknown nodes according to the first communication radius and can communicate with the beacon node to establish its possible location area, when the exhaustion after these areas are filtered according to certain standards in these areas and position classification, finally determine a rectangle (as shown in Fig.3 of the rectangular area of the shaded area), to calculate the mass center of the rectangle and place it as the coordinates of the unknown node, so as to realize the node localization.

E. MDS-MAP localization algorithm.

MDS-MAP^[7] belongs to the centralized positioning algorithm, it is to use the node connectivity information between nodes generated by Dijkstra or Floyd algorithm distance matrix, then using Shortest Path Algorithm to get the location information between nodes. MDS to MAP the realization of the localization algorithm mainly divides into the following three steps:

- (1) first of all, from the global perspective, according to the given node connectivity information between network topology connected graph is generated, and then through Shortest Path Algorithm to roughly estimate the distance between each pair of nodes, node distance matrix.
- (2) the classic multidimensional scaling analysis technology was applied to the node distance matrix, calculated the entire network of 2 d or 3 d relative coordinate system, the coordinates of the relative coordinates.
- (3) according to the position of the beacon node and beacon node of the node from the density of (2) the

relative coordinate transformation, make it become the absolute coordinate system.

MDS-MAP algorithms assume that are connected between each pair of nodes, when the nodes density is small^[7], not only the node positioning error is very big, the outside also can lead to many nodes can't locate. Only the network connectivity to a certain extent, all of the unknown node can realize positioning. Generally adopts the algorithm for node coordinates for the relative position coordinates, transformed into absolute coordinates to matrix operation, the relative coordinates of unknown nodes in the two-dimensional space into absolute coordinates generally requires at least three beacon node for auxiliary operation, in the three-dimensional space requires at least four beacon nodes, so the algorithm calculation and energy consumption are generally bigger.

F. AHLos localization algorithm

AHLos^[11] is a distributed localization algorithm based on TDOA ranging technology. The working process of the algorithm is: when the neighbor nodes of the unknown nodes in the anchor nodes is greater than or equal to 3, estimated by the maximum likelihood method to calculate its position, and upgrade to the anchor node, while the new level of anchor node information broadcast to the network; with the increasing number of anchor nodes, is not part of the original estimation method gradually with the conditions of the unknown node's position using the maximum likelihood. The process is repeated until all the unknown nodes as anchors. AHLos algorithm by atomic multilateration(AM) algorithm, iterative multilateration(IM) algorithm and collaboration multiaturation(CM) algorithm consisting of a total of 3 sub algorithms.

When the number of anchor nodes in the network is small, the AHLos algorithm can achieve the location of the unknown node, its location advantage. In the networked car, when the road information infrastructure is not perfect or poor network connectivity caused by signal interference and other reasons, the AHLos algorithm can make up for the lack of network environment. However, the iterative process at the same time to the accumulation of errors, namely the cumulative error, reduce the overall positioning accuracy. Based on the AHLos algorithm, the author proposes the algorithm of n-hop multilateration primitive^[12-13], not only gives a decision whether the node can participate in the condition of the CM algorithm, and using the Calman filter technology to reduce the cycle of positioning cumulative error and improve the positioning accuracy.

G. Cricket system:

Cricket^[14] was used to determine the spatial positioning system of mobile or stationary nodes in specific locations inside the building, is a typical symbol positioning system. In Cricket system, the anchor node periodically transmits RF signals and ultrasonic signals at the same time, including the anchor node in the RF signal the position information and the unknown node by node ID, TDOA measurement to the anchor node distance. When

the unknown node at the same time were 3 and above to different anchor nodes in the distance, you can determine their position by three edge measuring method.

The Cticket system provides functions for the spatial location of the symbol location through distributed positioning method, the system of the building within a specific spatial location (such as room number) the positioning is more efficient and accurate, and can be applied to the three-dimensional parking lot management, can also be applied to road traffic environment specific.

IV COMPREHENSIVE ANALYSIS AND PROSPECT

Although the car networking in the vast majority of positioning technology and algorithm come from WSNs, but due to special application environment and function, some in the WSNs have mature application protocol does not comply with the vehicle networking applications. For example: APIT (approximation point-in-triangulation test)[15]. APIT algorithm is the detection of triangle area with the fusion, the positioning accuracy depends largely on the fusion area size, but by the city road traffic and environmental constraints, the formation of regional integration is difficult, so the application of APIT algorithm in vehicle networking is limited. This kind of algorithm is more, no longer list.

Although there are many localization algorithm based on WSNs now, but a considerable part is improved based typical localization algorithms in this paper have been introduced on. For example: SHARP (simple hybrid absolute relative positioning) [16]. The algorithm combines the advantages of MDS-MAP and DV-distance algorithm, it uses a MDS-MAP with high accuracy in determining the reference when the relative coordinates of nodes, and avoid computing the distance matrix of all nodes, and with reference to the efficiency of DV-distance algorithm. So, under the same conditions, the SHARP algorithm has higher accuracy than MDS-MAP and DV-distance; moreover, MBAL (mobile beacon assisted localization)[17], the algorithm is the use of an installation the location of the unknown nodes in the network GPS receiver of the mobile anchor node. The mobile anchor node continuous flooding on behalf of their ID and position The information, when the unknown node detects 3 or above and the mobile anchor node in different locations of the distance information, they can determine the location of the. MBAL algorithm itself can be used for positioning the vehicle in an open area or some emergency environment using three sided measurement, play to its advantages.

In addition, RFID, GSM, CDMA positioning technology is based on the specific application of the basic positioning principle and algorithm introduced in this paper. This paper analyzed the localization algorithm basically is for planar systems, but in complex traffic environment especially three-dimensional traffic system currently appear, must study the three-dimensional positioning method in application the car networking environment. At present, in the field of WSNs research for the three-dimensional localization algorithm is also very active, but also made some achievements, such as

Landscape-3D[18], Constrained 3D[19], SBL [20]. However, in the present research, the vast majority of three-dimensional positioning only in two-dimensional positioning base the improved algorithm, completely original algorithm is less. For example: in the Landscape-3D algorithm, as the node location assistant(LA) device periodically broadcasts its own The unknown nodes in the network can calculate the distance between the and the LA by receiving the position information and RSSI, and then determine the position of the node by using the basic positioning principle of the method of the two sides

The car network positioning technology in MANET (mobile Ad Hoc networks) and WSNs, but the long-term constraints of energy consumption, MANET and WSNs application of computing ability, communication ability, storage capacity and other issues in car networking has become a major problem for the non, car networking positioning technology research and application to remove some restrictions but the car networking. Research on positioning technology not only solve the problem of vehicle positioning itself, but on the basis of people and vehicles, cars and trucks, coordinate the communication between vehicle and road, and then realize the safe driving of the vehicle and other substantive issues. Therefore, in car networking in the need to strengthen the absolute and relative positioning technology study on data fusion and positioning and dynamic analysis.

V. CONCLUSION

WSNs is a research hotspot in recent years and focus on positioning technology and a large number of algorithms are constantly emerging, however a large number of existing localization algorithms are improved for typical localization algorithm basic positioning principle. Those methods based on range-free technology, although the positioning accuracy is relatively low, but it can meet some of the requirements of IoV location, so, it is widely applied and studied. Although the IoV is a new concept and application, but the theoretical research and technology application related to you can have a However, at present, the research on WSNs and MANET is still at the initial stage, so there are a lot of problems to be solved and unknown problems to study.

ACKNOWLEDGMENT

The project was supported by the Scientific Fund Project of Huanggang Normal University (Grant No. 201616103). the project of excellent ICT engineer training program in Huanggang Normal University (Grant No. 2014zy04), and the project of zxfz2016A014 in Huanggang Normal University.

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