Medicon Engineering Themes
Volume 4 Issue 5 May 2023
Article Type: Research Article
ISSN: 2834-7218

On Enhancing Transmission Performance for IoV Based on Improved Greedy Algorithm

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Received: April 07, 2023; **Published:** April 20, 2023

DOI: 10.55162/MCET.04.136

Abstract

With the rapid development of the Internet of Things in human life, Vehicle-to-Vehicle (V2V), Internet of Vehicle (IoV) transmission, a technology is used to make a vehicle can detect the position and movement of other vehicles up to a specified range, which plays a significant role in upcoming cellular networks is expected to reduce the traffic jam and accidents in social life. Based on the idea of Greedy algorithm, a method to find the partial optimal solution to get the global solution, the purpose of improving the system effect can be achieved by using this algorithm into IoV transmission. In this paper, firstly, the development and technical essentials of IoV transmission system as well as the realization principle of greedy algorithm are briefly introduced. Then the rest of paper mainly discusses the performance of four models implementing greedy algorithm in IoV fields based on MATLAB by pairwise comparison of experimental results and analysis.

Keywords: V2V; IoV transmission; Greedy algorithm; Transmission route; MATLAB

Introduction

V2V transmission

Nowadays, with development of economical society and international technology, more and more things are connected in the form of the network to complete the transmission and communication of data, which greatly facilitates our life. Based on the internet of things, a technology enables data to be stored in a cluster of central computers with super-computing power and applied to all walks of life in human society to achieve intelligent management, D2D (Device-to-device, a new paradigm in cellular network, has been developed in various fields. With advantages of allowing User Equipments (UEs) in close proximity to communicate using a direct link rather than having their radio signal travel all the way through the base station (BS) or the core network, D2D connectivity will make operators more flexible in terms of offloading traffic from the core network, increase spectral efficiency and reduce the energy and the cost per bit (Kar and Sanyal, 2018). As a detailed research direction of this technology, vehicle-to-vehicle communications has been developed to decreases the severe traffic congestion as well as accidents. In United States, more than 5.5 billion hours were dissipated due to traffic jams, which is commensurate with 2.9 billion gallons of fuel costing more than 121 billion dollars (Schrank et al., 2012). With growth of population of city areas which leads to generation of more cars, the traditional approach to reduce traffic jams by building more road networks is no longer an efficient way as the capacity have reached the limit in many countries (Wu et al., 2016). V2V communication and IoV technology is based on single carrier frequency division multiple access (SCFDMA) in the PHY layer of computer networks. The transmitting vehicle can decode and sense the dispatching control information sent by the vehicle within a certain range, in which the design senses the resources that will be occupied or collided by other transmitting vehicles to avoid collision(Thota et al., 2020). So V2V communication, as the key technology which enables vehicles to collect previously unobtainable high-fidelity traffic information such as surrounding vehicles' speed, positions, acceleration, destinations, maneuvers and more depending on the protocol design (Hu, 2018). So based on these advantages, it is possible to apply this technology to our reality life to solve traffic problems.

Greedy algorithm

Based on the technical requirements and characteristics of IoV communication, the selection of routes plays an important role in the process of V2V transmission. As a well-known method technique for solving various problems so as to optimize (minimize or maximize) specific objective functions, greedy algorithm is a controlled search strategy that selects the next state to achieve the largest possible improvement in the value of some measure which may or may not be the objective function (2008). When solving the problem, greedy algorithm cannot consider the overall optimal, but decompose the problem into several sub-problems to obtain the step-by-step optimal solution, and then integrate the solution to the problem. Subsequent paragraphs, however, are indented.

Based on the characteristics of the algorithm, in V2V and IoV transmission, considering each vehicle as a sub-problem of the whole problem, it is possible to find the optimal information transmission route of each vehicle and make successive greedy choices in the range from far to near using iterative method, so as to get the optimal transmission route of all vehicles. In real life, the trajectory of traffic is irregular and difficult to predict, so it is unrealistic to analyze the problem from the perspective of considering all vehicles as a whole, in which greedy algorithm is an efficient way to solve this problem. On the other hand, based on the characteristics of fast running speed, simple encoding method and single selection range, the algorithm can effectively reduce the transmission delay and transmission failure rate in IoV transmission, and maintain the information transmission in a controllable hop number, reduce the loss and reduce the cost (Cerrone et al., 2017). The rest of this paper mainly focuses on the performance of greedy algorithm and the advanced methods based on the disadvantages of the original one in Internet of Vehicle transmission.

Algorithm system model performance

As one of the classical algorithms to solve the problem of point coverage, the core idea of greedy algorithm is to solve the node with the largest degree and iteratively approach the global optimal result with the local optimal result (Shang et al., 2021). The rest of this mainly shows four models to demonstrate different aspects of greedy algorithm application in the fields of IoV transmission. The program design and experiment part of this paper is mainly based on MATLAB, the following conditions are set as shown in the table below.

Vehicle position remains unchanged during transmission.
The transmission Angle is 90 degrees.
The presence of dead-end in the transmission relay assumes transmission through another path.
Relay assumes that the target vehicle sends information to the optimal (farthest) vehicle.
The congestion delay is 2 msec/per.
Vehicles at both ends of the map relay information through other vehicles.
Map size: The number of long and wide lanes is 11, and the spacing of lanes is 19.

Table 1: The conditions specified in the algorithm.

Model1 and model2 illustrate the effect of the traditional algorithm in IoV transmission, and take the transmission range as the variable to further research the transmission effect.

Model1

According to the idea of finding the partial optimal solution at each step, when realizing greedy algorithm in IoV transmission, it is significant to find the most optimal route to the target vehicle for every starting point. Assume that the location of the vehicle in the map is placed randomly, and the transmission range is determined. The main idea of the program design is as follows Firstly, in the main program of building the cellular network, the map is determined, including the length and the width of the image and the number of lanes. Map drawing and random placement of vehicles are performed by two concrete functions and a variable called PLAZA, is used to record the image. In addition, the main program initializes the parameters that reflect the results of the system for subsequent recording of experimental results.

After that, the function named relay is designed to calculate the number of hops, failures and time of delay. In this function, the nested Transmit function plays a major role in the implementation of IoV information transmission using greedy algorithm.

In the transmit function, when the first target vehicle is selected, a function named Numofcars is used to calculate the number of vehicles in specified range with the target as the center. What is more, the positions of these vehicles are sorted by the distance from far to near. The information of the coordinates is stored in an array called POS which is used to find the optimal route and next node transmitted the data. When the number of vehicles in the target range is not zero, according to the POS array obtained by running the above function, the information is transmitted to the farthest vehicle in the range to achieve the optimal path. In the next transmission, the receiving vehicle is taken as the starting point, and the routing table is updated and the optimal path is selected through the above steps. When the last destination vehicle reaches the edge of the map, it is recorded as the end of a V2V transmission. In a transmission, the number of nodes passing through is denoted as hop and the transmission delay is determined randomly by the number of vehicles within the range when the transmission is completed, which is more universal.

Finally, in order to ensure a better fit between the program and the actual situation, 50 iterations of each transmission simulation were carried out to calculate the total data through cellular network, and the data are presented more clearly by drawing charts in MATLAB.

According to the conditions set above, the Fig.1 shows that the flow of original algorithm based on a single range value.

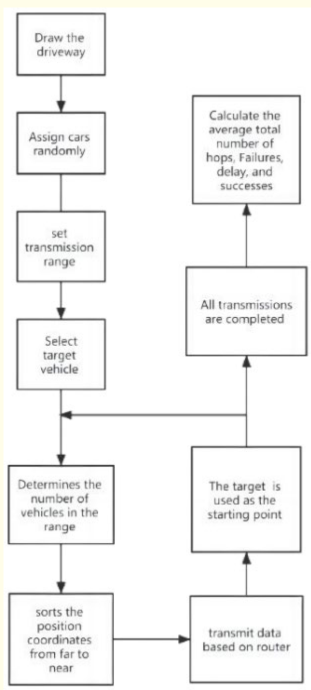

Figure 1: Original algorithm process.

Model2

Model1 can fulfill the basic purpose of IoV transmission, but it may cause excessive transmission loss or more time of delay in a single range. Based on this consideration, model2 proposes a way to mix two or more ranges into the final transmission range, which solves the above problem well.

Compared to the last one, this model basically retains the structure of the previous algorithm. The difference is that when the range turns to be a hybrid value, the new function called Hybrid-NumofCars is used to calculate each number of vehicles in different ranges and integrates the position sorted from far to near under each range (the range is sorted by small to large). Therefore, when performing the function of transmission named Hybrid-Transmitfun, it is more efficient to select the next transmission node which can achieve the purpose of transmitting by the optimal path in a small range and making it lower time of delay.

In order to improve the transmission efficiency and reduce the cost, the updated greedy algorithm changes the single transmission range (250m, 350m, 450m and 550m) into a hybrid range. The specific process is shown in the figure below.

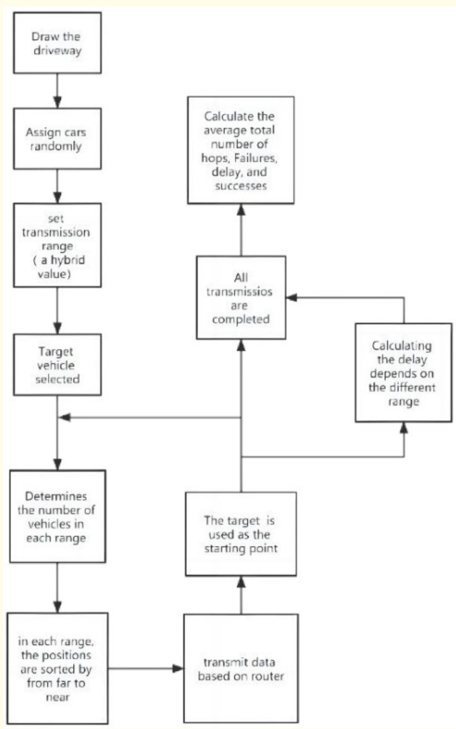

Figure 2: Greedy algorithm based on hybrid transmission range.

Through model 1 and 2, this paper explores the implementation process of general greedy algorithm in IoV transmission and illustrates its application effect in the third part. Based on above two, it is possible to find that the application conditions of the above two models are relatively simple as well as the transmission routes, so they are not completely applicable to the real traffic situation. Therefore, the following model3 and 4 introduces volume which is a variable used to determine the transmission route. The rest of this part mainly shows two models based on above idea update the traditional algorithm to achieve better effect in IoV transmission.

Mode3

Compared to the previous algorithm, in the algorithm of model3, the same functions are used to draw the map and place the vehicles randomly. In main program called cellular used to form the network, the same arrays storing some data which reflect the performance of the algorithm system are initialized. Then the iteration is ready to run. The difference is that model3 adds a new variation named volume playing an important role in updating the optimal path and selecting the nodes.

In each iteration, as the vehicle density changes continuously, the vehicle position is updated every time a IoV transmission is performed.

In each IoV transmission, the function of relay is used to implement greedy algorithm. Its main idea is as following. Firstly, according to the scale of volume, the vehicle location coordinates on the map are randomly assigned to the source vehicle and the destination vehicle. It is worth noting that for each pair of source and destination vehicles, the vehicle coordinates cannot be the same. Then, the function introduces queue, a four-dimensional array that records the coordinates of the source vehicles, the traffic of the source, and the location of the next node. After that, when transmitting a data from source to destination, a function named NumofCars is also used to calculate the number of vehicles in the specific range between the source and the destination, and the positions of the vehicles are sorted by distance from small to large, which are all stored in an array, POS. If the destination vehicle is the closest vehicle to the source vehicle, the transmission is successful; Otherwise, the nearest vehicle is used as the source, and the coordinates of the destination are loaded into the volume of the vehicle, so as to complete an update of the routing table. In the process of continuously updating the route according to the traffic volume, the information is transmitted in a cycle of optimal route until all the information reaches the destination or the transmission fails. In the communication process of every two vehicles, the information can get the optimal path to be transmitted every time so as to realize the greedy algorithm. Finally, after each transmission, the relay function calculates the delay according to the traffic volume, and calculates the number of hops based on the number of nodes between the source and destination.

After all iterations, the total time of delay, the number of hops and failures are computed by the main program and reflected as figures.

The algorithm flow of Model3 is shown in the Fig.3 below.

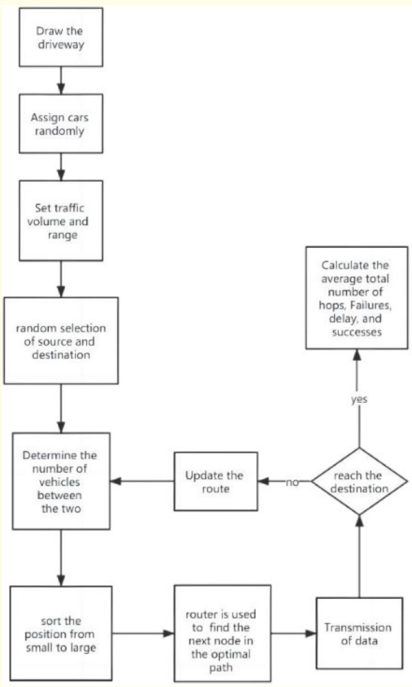

Figure 3: Greedy algorithm flow based on volume update.

Model4

The algorithm process of Model4 is basically consistent with model3, but the only difference is that after sorting the position distance between the source vehicle and the destination vehicle, this function will further sort the position coordinates according to the traffic volume of each vehicle from small to large, which can be used to get the more better transmission path in order to reduce the delay and transmission loss.

The flow chart of model4 is shown as following.

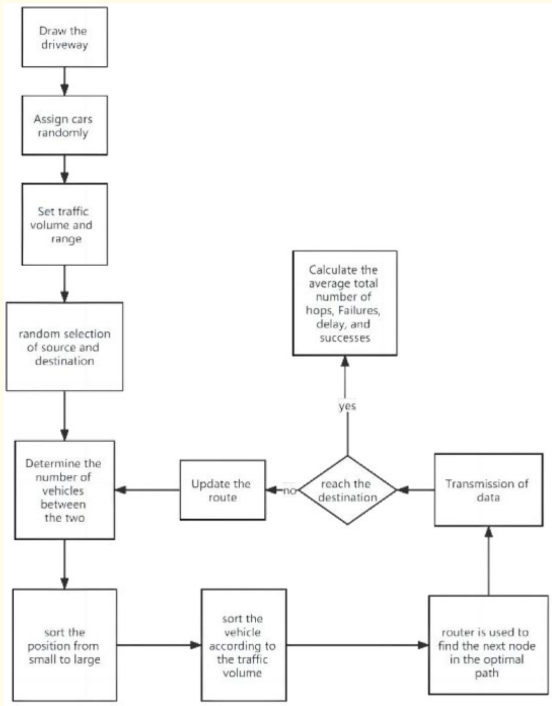

Figure 4: Greedy algorithm flow based on volume update-new.

Result and Discussion

Single range and mixed range

As mentioned above this paper demonstrated the improvement of the transmission range of the original greedy algorithm in IoV, so as to improve the transmission efficiency and reduce the transmission delay and failure rate. In order to fit the actual traffic situation, based on MATLAB codes, this paper tested the single range of transmission range of 250m, 350m, 450m, 550m, and the mixed range of 250m&550m, 250m& 450m, 350m&550m, and 250m&350m & 450m &550m, which are all based on the condition that the number of changes in traffic density is 40, and the change interval is 0.02.

In the traditional wireless communication network analysis, the increase of node density, the small transmission distance, and the increase of signal strength will improve the communication quality and connectivity probability, but this will also lead to the enhancement of interference received by the node, which will reduce the communication quality and network connectivity probability (Jing, 2019). When a vehicle forwards a message to the next vehicle, the wireless channel is affected by a combination of path loss and small-scale fading. When the transmission mode with fewer hops is adopted in the area, the transmission channel condition is poor and the receiving success rate is low. When hops are large, the transmission distance each time decreases, and the average accepted SNR (Signal-to-Noise Ratio) increases, while multi-hop propagation may cause a long delay and higher cost due to more complex network structure (Hu, 2016). The number of hops in each cycle of transmission is calculated by the function of relay, which completes the computation by counting the number of nodes in each cycle. With the increase of car density, the number of hops obtained from each loop is added to the array, and a common value is obtained after several iterations. The data obtained from the final results are drawn in the form of line graph in the coordinate system with den-change as the X-axis and the number of hops as the Y-axis, and the changes under each range are distinguished by color. When the transmission range of vehicles is small and single, it can be predicted that the number of hops has been maintained in a relatively high range due to the dependence of transmission on each node. However, if the range is large then the number of forwarding nodes required in a specific range is small, the number of hops is small. The result is expected to be seen that the performance of hybrid-range can make the hops of system balance between the two.

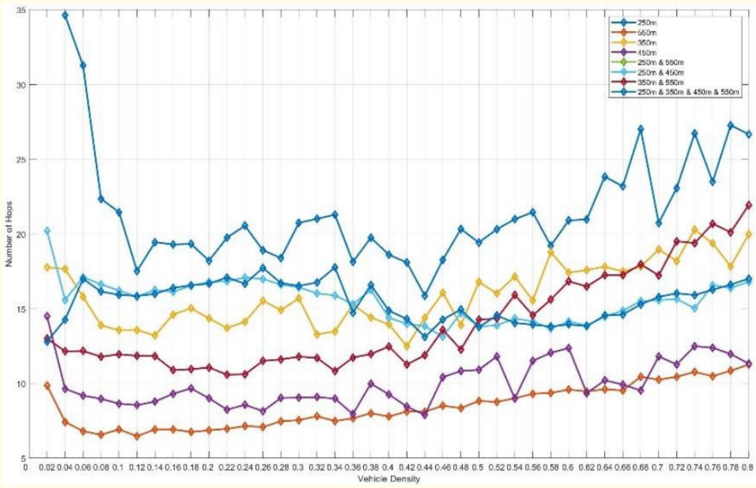

Figure 5: Number of Hops.

As shown in Fig.5, within a given traffic range, the number of hops in a single transmission range is always maintained at a high (250m) or low (550) level, which may lead to unstable transmission or excessive transmission energy consumption.

However, the number of hops in a mixed range is moderate, which meets above expectation.

In this experiment, when there is no communication vehicle within the set range in the process of cyclic transmission of information, it is marked as a failure. The number of failures in a transmission is also executed by the relay function, and the main program, cellular, calculates the average number of failures and the change of delivery ratio with the increase of vehicle density through cyclic iteration.

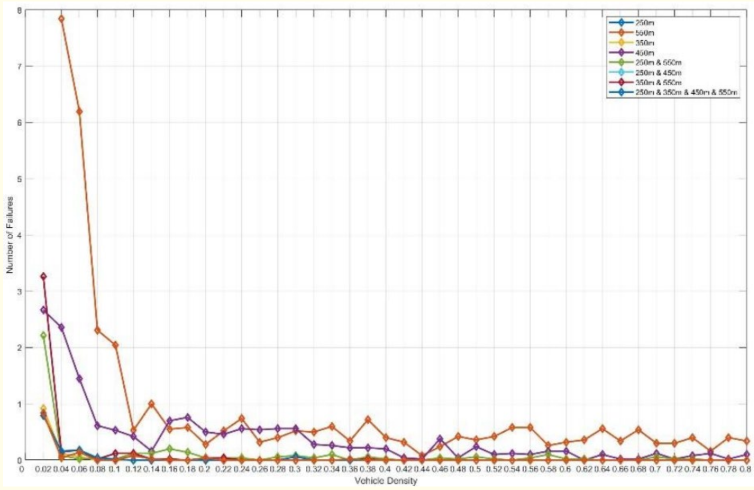

Figure 6: Number of Failures.

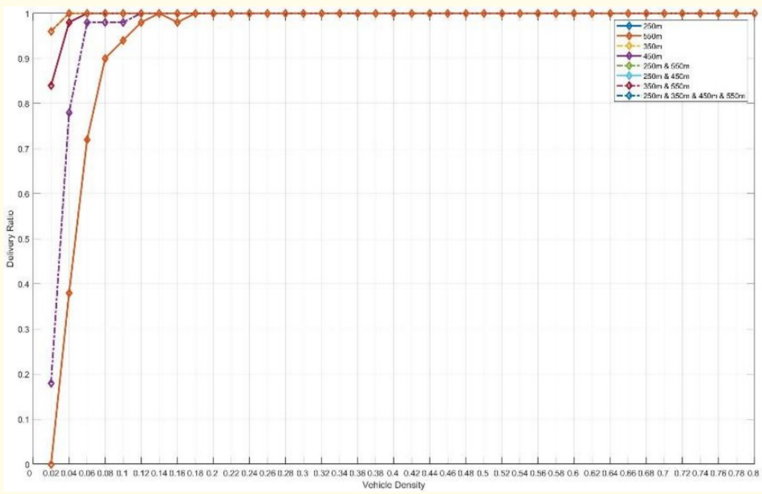

Figure 7: Delivery Ratio.

In Fig.6, at a low vehicle density, the number of failures is lower and lower as increasement of range, which means a high failure rate in the condition of small transmission range in IoV communication. According to Fig.7, when the vehicle is maintained at a lower density level, the success rate of information transmission in a single lower range is lower. In the actual traffic conditions, when the car keeps driving at a high speed, such a situation is easy to cause a high accident rate.

Therefore, it is very important to increase the transmission success rate by improving the transmission range when the vehicle density is low.

In the communication process of a specific network, the energy of the communication node of wireless network sensor technology is relatively limited, which easily causes the delay of data transmission and thus the loss of data, which affects the overall performance of the communication network application system (Lei et al., 2013). As mentioned above, the node efficiency of the system plays an important role in the transmission of information. Due to the limitation of hardware cost, the data storage space of sensor nodes is limited, and the data transmission delay should not be too large (Yang and Ma, 2022). Otherwise, a large amount of data will be lost. Considering the limitation of data transmission delay and the number of hops in the actual sensor network system, the waiting time of each data transmission is set during the running of the function, relay, and some vehicles in each transmission range are randomly selected to cause delay to simulate the actual traffic situation.

Finally, the main program iteratively shows the total time of delay and the mean of delay by drawing the line diagram to reflect the experimental results.

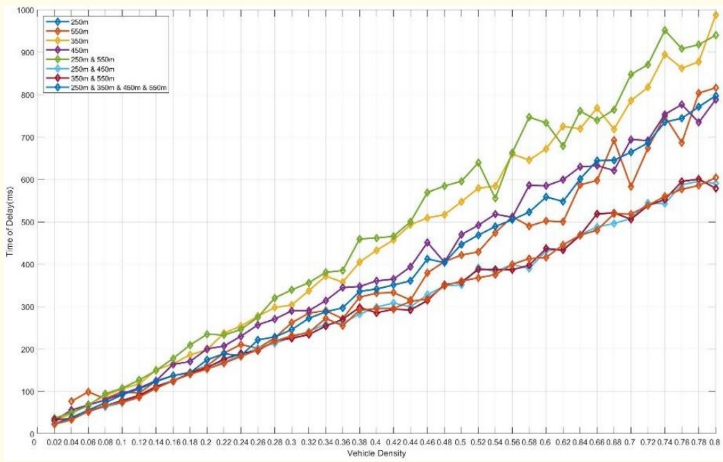

Figure 8: Time of Delay(ms).

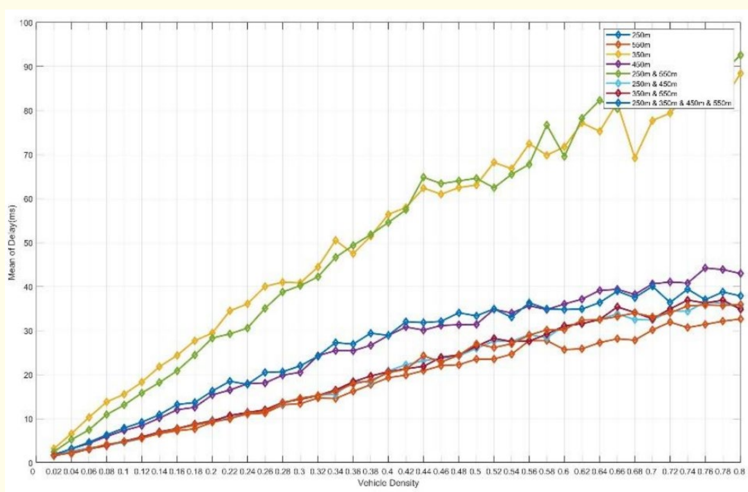

Figure 9: Mean of Delay(ms).

Fig.8 and Fig.9 both demonstrate the variation of delay with vehicle density in different ranges. In a single range, when the transmission range is large, with the increase of vehicle density, the number of vehicles involved in relay increases, which directly causes the increase of delay. However, the hybrid range solves this problem well. The updated greedy algorithm optimizes the transmission route and calculates the transmission process separately for different transmission ranges, thus greatly reducing the transmission delay.

By analyzing the above results, it is possible to find that the in the field of IoV transmission, especially in the traffic with low vehicle density, the greedy algorithm in the hybrid transmission range can achieve a good balance between reducing the delay and improving the transmission success rate, and maintain the transmission loss and stability at a moderate level.

New algorithm based on volume

As mentioned in description in model 3 and 4, the new algorithm is a proposed greedy algorithm adding a new variation named volume to update the optimal path and selected the next communication nodes. The data processing and calculation methods of the new algorithm are basically similar to those of model1 and 2. Based on the volume variable, the two algorithms in this experiment also calculate the number of nodes that pass through a cycle through the relay function to get hops and calculate the delay based on the time transmission interval of each message of traffic. Finally, the main program reflects the experimental results by drawing line charts.

According to the algorithm structure mentioned above, the result can be expected that because the vehicle location coordinates are sorted according to the traffic volume, the new routing table can make the time of delay of each transmission process lower, which achieves the purpose of optimizing system performance.

According to the conditions in table1, in this experiment, the vehicle transmission range is set as 550m, the traffic volume is set as 100, the vehicle density is changed 40 times with 0.02 interval, and the overall iteration is 10 times to obtain a general result.

The following four figures show the result of performance two model in IoV transmission.

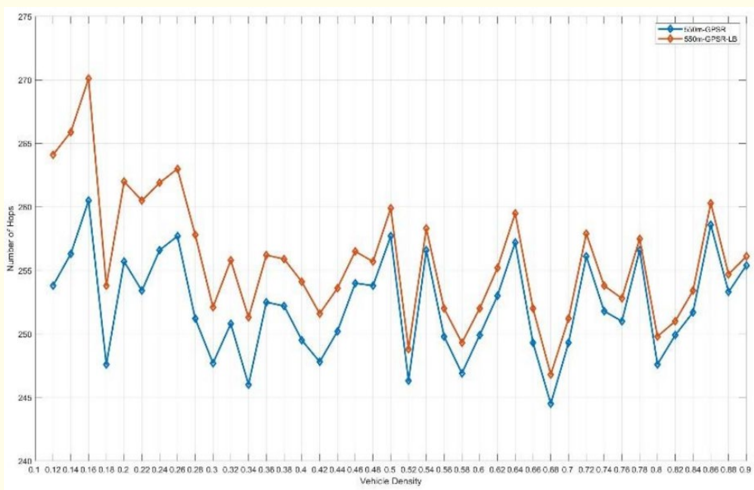

Figure 10: Number of hops in new algorithm.

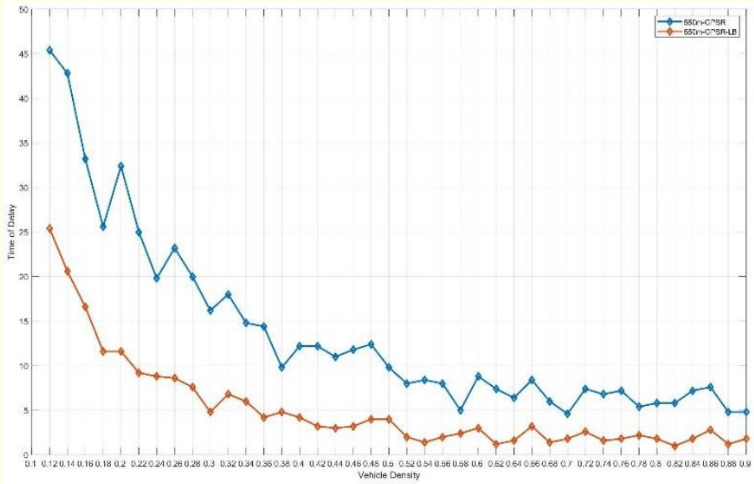

Figure 11: Time of delay in new algorithm.

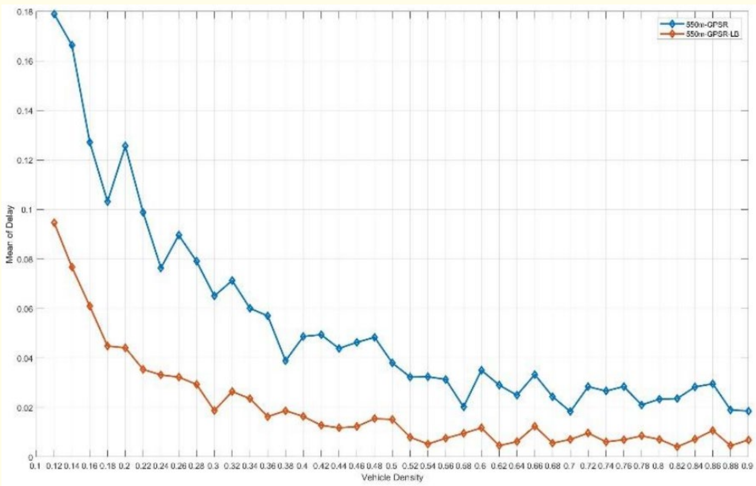

Figure 12: Mean of delay in new algorithm.

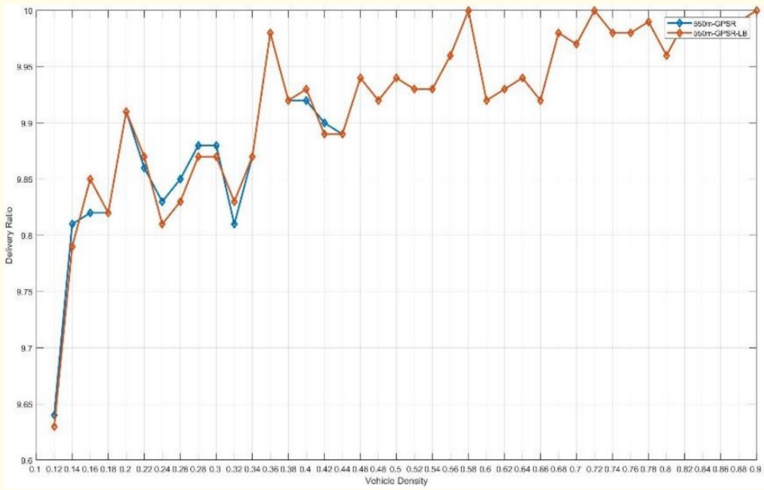

Figure 13: Delivery Ratio in new algorithm.

According to the above results, since sorting vehicle position coordinates using the volume to update the routing table in order to get the optimal path, compared with model3 in Fig.11 and Fig.12, the new algorithm greatly reduces the time of delay as well as them mean of delay, in which way it improves the efficiency of system while maintaining similar the number hops and higher success ratio, as shown in Fig.10 and Fig.13.

Conclusion

As a novel routing protocol for datagram networks, Greedy Perimeter Stateless Routing (GPSR) uses the positions of routers and a packet's destination to make packet forwarding decisions (Karp and Kung, 2000). This paper applies this idea to the field of IoV transmission, and uses MATLAB to establish four kinds of system models based on greedy algorithm to simulate the real traffic situation for experimental testing. The experimental results verify the superiority of greedy algorithm in mixed transmission range and the superiority of the new algorithm which introduces volume to update transmission routes. Both algorithms can reduce system delay and improve system efficiency to a certain extent. In the future development, we also got inspiration on heterogeneous networks and the social relationship inference model, that gives out new perspective for privacy preservation in mobility data, we can further develop advance greedy algorithm that achieve better performance and provide more positive social impact (Jiang et al., 2020) (Li et al., 2020).

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