Research Article

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Data transmission mechanism of vehicle networking based on fuzzy comprehensive evaluation

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Abstract: Because the communication link connection in the Internet of Vehicles is transient and intermittent, the established connection may be disconnected at any time, which cannot meet the requirements of the data transmission of the Internet of Vehicles. Therefore, based on the traditional data transmission mechanism, the fuzzy comprehensive evaluation method is used to achieve the optimal design of the data transmission mechanism of the Internet of Vehicles. First, according to the operation mechanism of the Internet of Vehicles build the Internet of Vehicles model. Then in this model, the fuzzy comprehensive evaluation is used to analyze the data transmission characteristics of the Internet of Vehicles, and the characteristics evaluation results of data transmission are obtained. Finally, set the data transmission protocol of the Internet of Vehicles, select the appropriate data transmission path, allocate the data transmission load, and realize the data transmission of the Internet of Vehicles. The experimental results show that compared with the traditional data transmission mechanism of the Internet of Vehicles, the speed of the designed transmission mechanism is increased by 3.58 MB/s, and the packet loss rate is reduced by 41%.

Keywords: fuzzy comprehensive evaluation method, vehicle networking, data transmission, transmission mechanism, transport protocol, transmission path switching

MSC 2020: 08-XX, 20-XX

1 Introduction

Intelligent transportation includes people, roads, vehicles, data transmission, and management service platform. Among them, vehicle networking technology is one of the key technologies in intelligent transportation system [1]. The Internet of Vehicles refers to connecting cars to form a network. Cars and cars form a car network, which is connected to the Internet. Based on a unified protocol, the three realize the data exchange among people, cars, roads and clouds, and finally realize the functions of intelligent transportation, intelligent car, and intelligent driving. Vehicle networking is a self-organized and distributed data transmission network that is constructed rapidly and dynamically in the road traffic network. Its purpose is to realize the data transmission among the nodes in the intelligent traffic system in real time, accurately and efficiently. The vehicle network is the vehicle terminal equipment, which uses a variety of wireless

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communication technologies to communicate with each other or with the roadside infrastructure, and then connects the data transmission to the Internet [2]. At present, many scholars have done a lot of research in this area. Ren Tiaojuan proposed a data transmission algorithm (DTA) for the Internet of Vehicles based on channel switching. The DTA considers a three-layer network composed of vehicle nodes, relay nodes, and aggregation nodes; classifies nodes according to the driving direction of the vehicle; and proposes different channels. The channel allocation and switching mechanism reduces the interference of data transmission, reduces unnecessary loss, improves the data reception rate of the sink node, reduces the average number of data packet hops, and improves the coverage rate of data transmission [3]. However, this method still lacks in ensuring the reliability and stability of data transmission. Peng Xin proposed a V2R/V2V data transmission scheduling algorithm. The algorithm first generates an initial scheduling operation according to the vehicle's data transmission request and builds an initial scheduling conflict graph and a conflict matrix based on the conflict relationship between the initial scheduling operations. Second, it proves that the conflict matrix is on the basis of semi-definiteness, and a semi-definite planning method is used to allocate channels and improve the scheduling conflict map. Finally, according to the vehicle's detention time in the service area and the amount of data requested for transmission, different service weights are assigned to it, based on the scheduling conflict map, and the V2R/V2V coordinated transmission method completes the scheduling in time sharing [4]. However, this method does not solve the problem of transmission efficiency. In order to ensure the transmission of multimedia data in Internet of Vehicles, DWAB proposes a device-to-device-based car networking similarity secure multimedia data transmission mechanism. By measuring static and dynamic vehicle attributes, back-propagation neural network is used to quickly and accurately calculate vehicle similarity, and an Internet of Vehicles communication group is established based on attribute similarity [5]. The use of vehicle attributes to generate communication keys to protect the privacy of the vehicle can reduce data delay to a certain extent, but there is also the problem of low reliability.

Data transmission in the Internet of Vehicles can be divided into parallel transmission, serial transmission, asynchronous transmission, synchronous transmission, and simplex transmission. Fj et al. [6] proposed the Internet of Vehicles intrusion detection based on logarithmic ratio oversampling, outlier detection, and metric learning. This method improves the effectiveness of intrusion detection in three main ways: first, oversampling a few classes based on a new strategy; second, a new feature based on unbalance ratio is introduced; third, by combining outlier detection and distance metric learning, we can reduce outliers and actively rescale the original samples to make the decision boundary clearer. In addition, genetic algorithm is used to extract the optimal subset of features. Kumar et al. [7] proposed green computing in social networking of vehicles defined by software. Considering the vehicle network structure defined by software, a meta heuristic solution was developed to solve the problem of green traffic data transmission in scalable input/output virtualization, namely bidirectional particle swarm optimization. Compared with the most advanced technology, a large number of simulation experiments have been carried out to evaluate the performance of bidirectional particle swarm optimization. Rathee et al. [8] proposed the block chain-based cognitive radio transmission technology for the Internet of Vehicles, which senses channels through a decision-making technology, so as to provide security for the Internet of Vehicles in the process of spectrum sensing and information transmission using the radio network. Decision-making technology is a technology that arouses the trust of cognitive users by analyzing some predefined attributes. In addition, the block chain is maintained in the network to track every activity that stores information. For the baseline solution in the Internet of Vehicles, the proposed mechanism is strictly verified according to several security metrics using various spectrum sensing and security parameters. However, the above-mentioned traditional vehicle networking data transmission mechanism has problems such as long transmission delay, high transmission interruption rate, and slow transmission speed. Therefore, the fuzzy evaluation method is introduced. The innovation of the research content is to use the fuzzy comprehensive evaluation method, in which the comprehensive evaluation refers to the process of people evaluating and recognizing the relatively complex and abstract evaluation standard system. Using the method of fuzzy comprehensive evaluation, the optimal design of vehicle network data transmission mechanism is realized, so as to improve the reliability and efficiency of vehicle network data transmission.

The main contributions of the research on the data transmission mechanism of the Internet of Vehicles based on the fuzzy comprehensive evaluation method are as follows:

(1) According to the operation mechanism of the Internet of Vehicles, this article constructs the Internet of Vehicles model.
(2) In this model, fuzzy comprehensive evaluation is used to analyze the data transmission characteristics of the Internet of Vehicles, and the evaluation results of data transmission characteristics are obtained.
(3) Set the data transmission protocol of the Internet of Vehicles, select the appropriate data transmission path, distribute the data transmission load, and realize the research on the data transmission mechanism of the Internet of Vehicles based on the fuzzy comprehensive evaluation method.

The results show that the mechanism has good data transmission performance.

2 Design of data transmission mechanism of vehicle networking

The structure diagram of the three-layer vehicle networking is shown in Figure 1.

It can be seen from Figure 1 that on the basis of a three-layer network structure composed of vehicle nodes, relay nodes, and sink nodes, the vehicle node is the bottom layer of the three-layer network structure, which is installed in the running vehicle to collect and send vehicle driving data. The information is sent from the vehicle node to the higher level relay node and exchanged with the neighbor vehicle node. As the link between vehicle node and convergence node, relay node is installed on the infrastructure such as streetlamps which can supply power on both sides of the road to realize data forwarding with vehicle node and other relay nodes. As the top layer of the three-layer network structure, the sink node collects the data of all relay nodes in the area and forwards it to the server. The three-layer network structure realizes the data transmission, diffusion, and convergence, which lays the foundation for the rapid data transmission. In this network structure environment, the data transmission of the vehicle networking is completed according to the flow of Figure 2.

In order to ensure the smooth operation of the data transmission mechanism of the vehicle networking, relevant transmission equipment is installed under the network structure, including high-precision Beidou module, STM32 processor module, OBD data acquisition module, wireless module, voice playing module, touch screen, and power module. In the process of vehicle node operation, the OBD data acquisition module is used to obtain vehicle data; the Beidou module is used to obtain the location data of vehicle node; the touch screen is used to interact with the user; the voice broadcast module is used for path

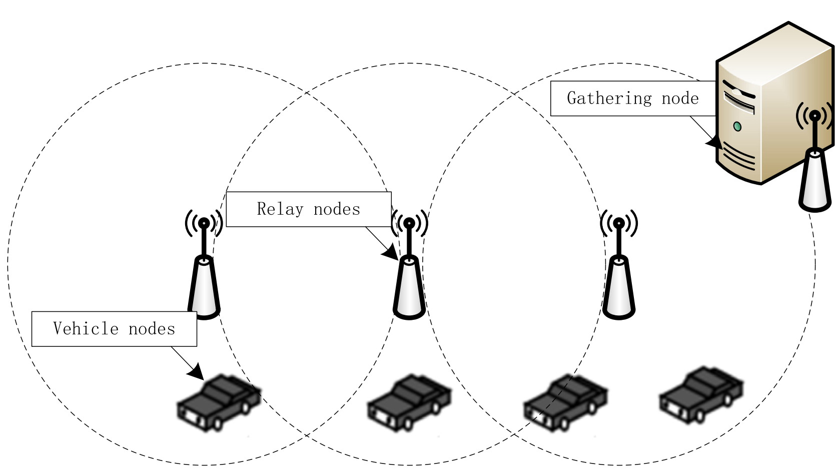

Figure 1: Structure of the three-layer vehicle networking.

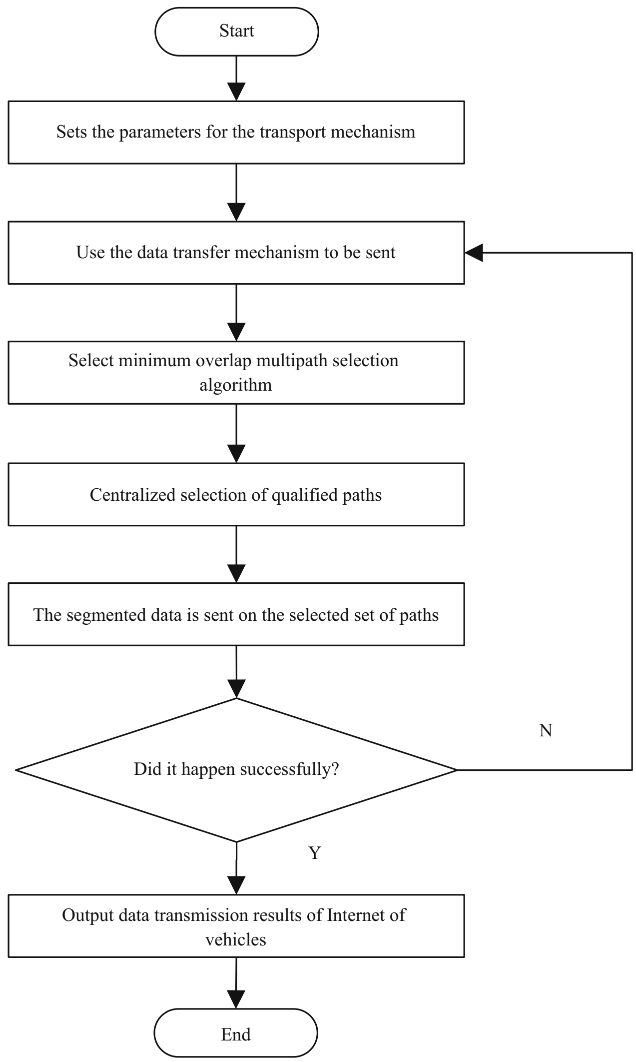

Figure 2: Data transmission flow chart of vehicle networking.

guidance and intelligent alarm; and the wireless module is used to send its own data to other vehicle nodes or relay nodes. The relay node is mainly composed of STM32 processor module, touch screen, wireless module, and power module. During the operation of the relay node, the wireless module is used to obtain the data of other relay nodes or vehicle nodes and report the road status; the touch screen is used to display the road condition data of the current road section; and the STM32 processor is used to analyze the current road congestion, whether there are accident vehicles, etc.

2.1 Building the vehicle networking model

Supposing that the whole vehicle network is divided into several sections, each section has a local controller. The communication range of the local controller can cover the whole section, and the areas responsible by different local controllers do not overlap each other. There are multiple vehicles on each road section, and each vehicle has a certain communication range. The vehicle can only distribute data with other vehicles in the communication range, while the vehicles not in the communication range can only realize data routing through multi-hop forwarding [9]. Each vehicle knows its neighbor's vehicle ID and location. When the vehicle enters the communication range of the local controller, it can find the local controller in its area. The vehicle communicates with the local controller. The vehicle and the local controller can only communicate control information, and the local controller cannot help the vehicle to forward data. $G_R(V, E)$ is defined as the topological structure of the road, where V is the set of road intersections and E is the set of road edges [10]. Choose the optimal path to deliver the data packet. If the fuzzy comprehensive evaluation method fails to receive the data packet successfully after the acceptable time threshold, it will choose the suboptimal path, and so on. For paths belonging to different evaluation grades, the higher the grade, the higher the priority; for paths belonging to the same grade, the higher the evaluation value, the higher the priority, so as to determine the parameter values in the method used. It is assumed that the distance between vehicles follows an exponential distribution, namely:

$$f(x) = \begin{cases} \dfrac{1}{\rho_{ij}} e^{-\frac{1}{\rho_{ij}}x}, & x > 0 \\ 0, & x \leq 0, \end{cases} \tag{1}$$

where ρ_{ij} represents the average density of vehicles on path r_{ij}, then the average delay of packet transmission on path r_{ij} is as follows:

$$t_{ij} = \left(e^{-\frac{R}{\rho_{ij}}}\right)^{d_{ij}\rho_{ij}-1} \frac{d_{ij}}{R} + \left(e^{-\frac{R}{\rho_{ij}}}\right)^{d_{ij}\rho_{ij}-1} \frac{d_{ij}}{2v_{ij}}, \tag{2}$$

where $\left(e^{-\frac{R}{\rho_{ij}}}\right)^{d_{ij}\rho_{ij}-1}$ indicates that the vehicle density on the path r_{ij} is large, and when the spacing is less than the vehicle communication radius R, the probability of data packet transmission by multi-hop is shown; $\left(e^{-\frac{R}{\rho_{ij}}}\right)^{d_{ij}\rho_{ij}-1}$ indicates the probability that the spacing between at least one vehicle on the path r_{ij} and the adjacent vehicle is greater than R, d_{ij} represents the distance coefficient between vehicles, and v_{ij} represents the data value transmitted by nodes between vehicles. At this time, due to the inability to communicate with the adjacent vehicle, the data packet can only be transmitted by carrying [11]. The final results of the vehicle networking model are shown in Figure 3.

2.2 Fuzzy comprehensive evaluation and analysis of data transmission characteristics

Supposing there are n evaluation units in the evaluation system, $(a + b)$ evaluation indexes in total, including a quantitative index (m inputs, s outputs) and b non-quantitative indexes [12]. Data envelopment analysis is used to calculate the relative efficiency of quantitative index. Then the characteristics of the data to be transmitted are analyzed according to the comprehensive evaluation process shown in Figure 4.

Let the input and output vectors corresponding to the jth decision-making unit be X_j, respectively, and its expression is as follows:

$$\begin{cases} X_j = (x_{1j}, x_{2j}, \cdots, x_{mj})^T > 0 \\ Y_j = (y_{1j}, y_{2j}, \cdots, y_{sj})^T > 0. \end{cases} \tag{3}$$

That is to say, each decision-making unit has m types of "input" and s types of "output." Where x_{mj} is the input of the jth decision unit to the ith input and y_{sj} is the output of the jth decision unit to the rth output [13]. Let the weight vectors of input and output be v and u, respectively. Efficiency index refers to the ratio of output to input when input is $v^T X_{j0}$ and output is $u^T Y_{j0}$ under the weight coefficients v and u. The higher the efficiency index is, the more output the data can get with less input. When optimizing the efficiency index of a single decision-making unit, the efficiency evaluation index of the decision-making unit is used:

$$h_{j0} = \frac{u^T Y_{j0}}{v^T X_{j0}}. \tag{4}$$

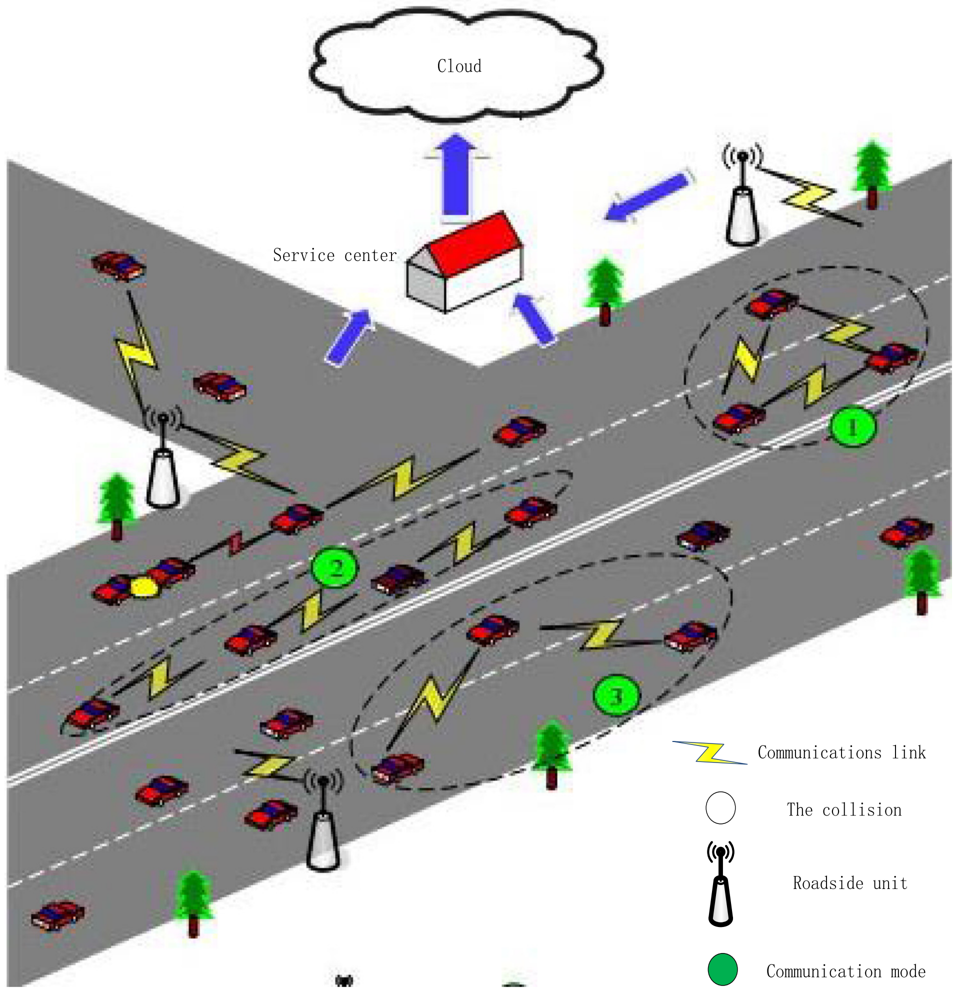

Figure 3: Schematic diagram of vehicle networking model.

The maximum is the optimization objective, with the efficiency index of all decision-making units as the constraint, to form the following linear evaluation expression:

$$(P) = \begin{cases} \max \_Y_{j0} \\ s.\ t.\ (vu)^T X_j - Y_j \geq 0 \\ (vu)^T X_{j0} = 1 \\ vu = 0, \end{cases} \tag{5}$$

where $s.\ t.\ (vu)^T$ represents the number of conditions of the decision-making unit, X_j represents the weight coefficient, and Y_j represents the constraint coefficient. The input and output data of n decision-making units to be evaluated are substituted into the above-mentioned linear programming P to solve their optimal solutions, respectively, and then the efficiency evaluation indexes of each evaluation unit are obtained [14,15]. Then, the isosceles triangle membership function of Figure 5 is used for fuzzy processing.

The final comprehensive evaluation can be carried out with the fuzzy unified and non-quantitative FCA results of data envelopment analysis. By calculating the fuzzy index weight, the characteristic evaluation results of data transmission are obtained.

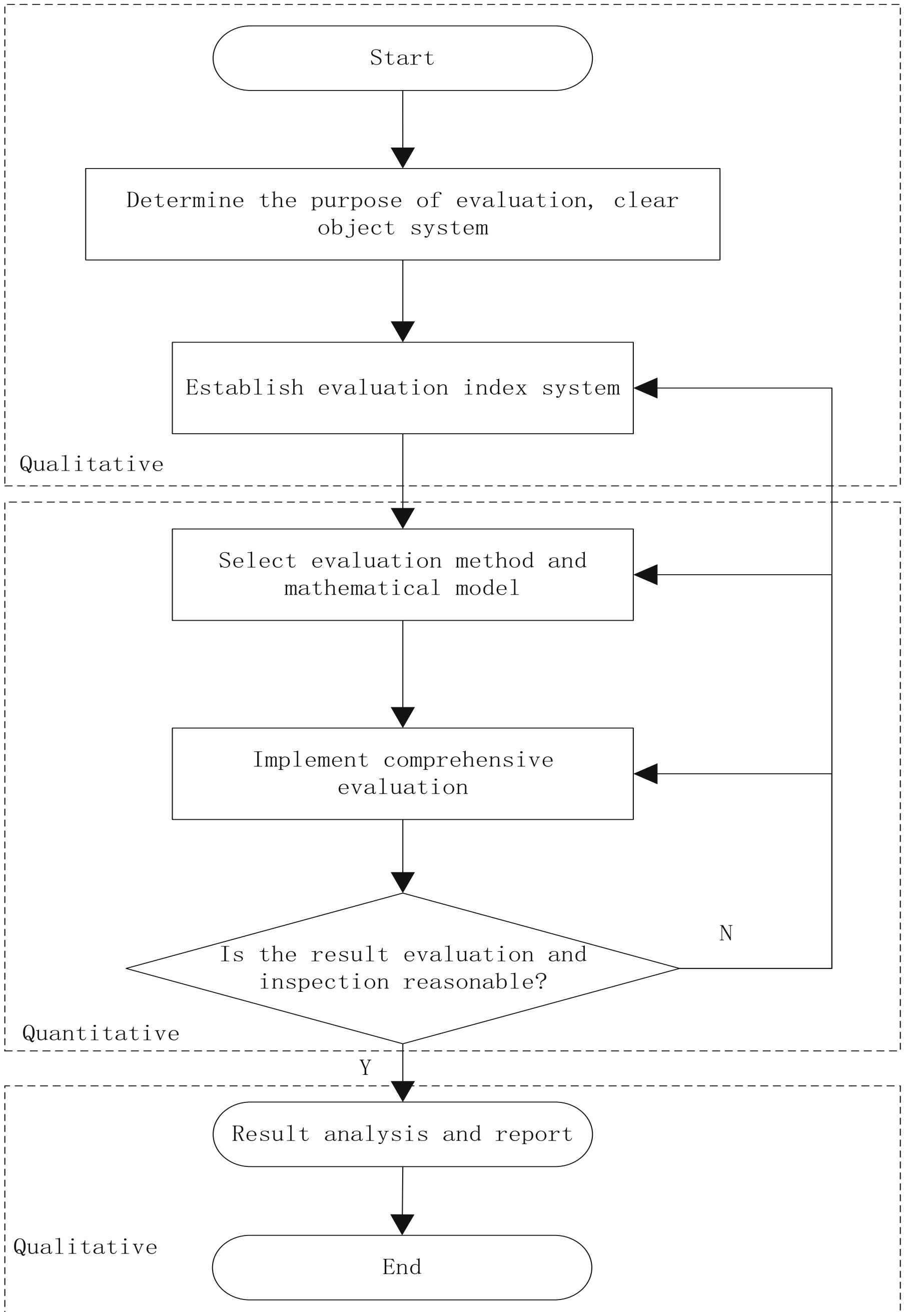

Figure 4: Flow chart of comprehensive evaluation.

2.3 Setting the data transmission protocol of the vehicle networking

The behavior of data transmission protocol in the vehicle networking is embodied in four core mechanisms: encoding and decoding, Media access control, Frame and signature processing, and Clock synchronization. In addition, the controller host interface can be used as the core mechanism of the host, so that it can cooperate with each other in a systematic way and can also be used to provide feedback to the host for the core mechanism. There are eight basic protocol operation control states in the nodes on the bus, and the nodes complete different functions in each protocol operation state. All nodes in the communication system follow the protocol given in the figure for state transition, and then complete the normal communication of

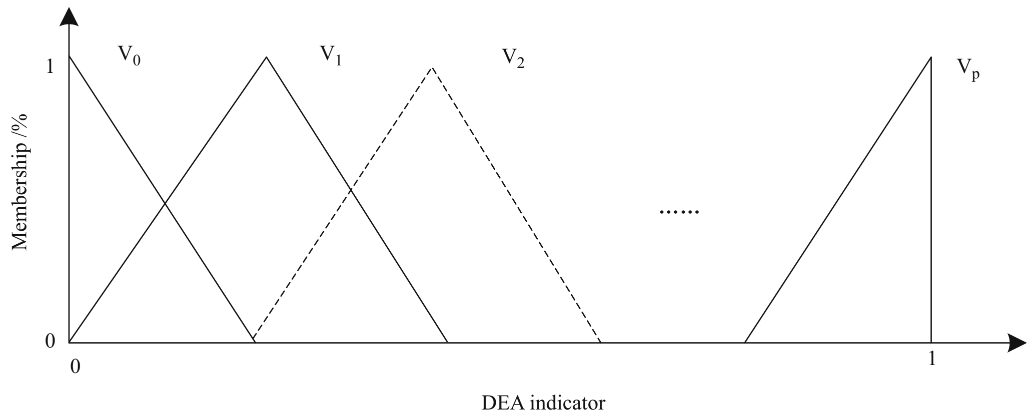

Figure 5: Membership function under fuzzy comprehensive evaluation.

nodes [16]. The specific eight states include default configuration state, parameter configuration state, ready state, wake-up state, start state, normal active state, normal passive state, and stop state. Code is to process the source data frame to be sent, such as adding signature and check bit. The decoding process is the reverse process of encoding, which is used to analyze the received data frame and extract the effective data according to the specification. Protocol coding can be divided into data frame coding and signature coding. The basic format of the protocol frame is shown in Figure 6.

The main function of the transmission protocol frame format shown in Figure 6 is to provide a reference for analyzing the transmission mode of the received and extracted data frames, the frame header consists of 5 bytes (40 bits), the first bit is reserved bit, and the next 4 bits are index bits, indicating payload, empty frame, synchronous frame, and start frame in turn, followed by 11 bit frame ID, 7-bit payload length, 11 bit frame header CRC, and 6-bit cycle counting digit [17]. Frame ID is used to prompt the time slot during transmission. In each communication cycle, a frame ID can only be used once, with an effective range of 1–2,047. In the static segment, the data segment length of all frames is fixed and equal, while in the dynamic segment, the load length of different frames can be different. The head cycle check CRC is calculated by logical polynomials according to the agreed indication bits and is available in the system. The data can only be received when the CRC of the frame header sent by the transmitting node and

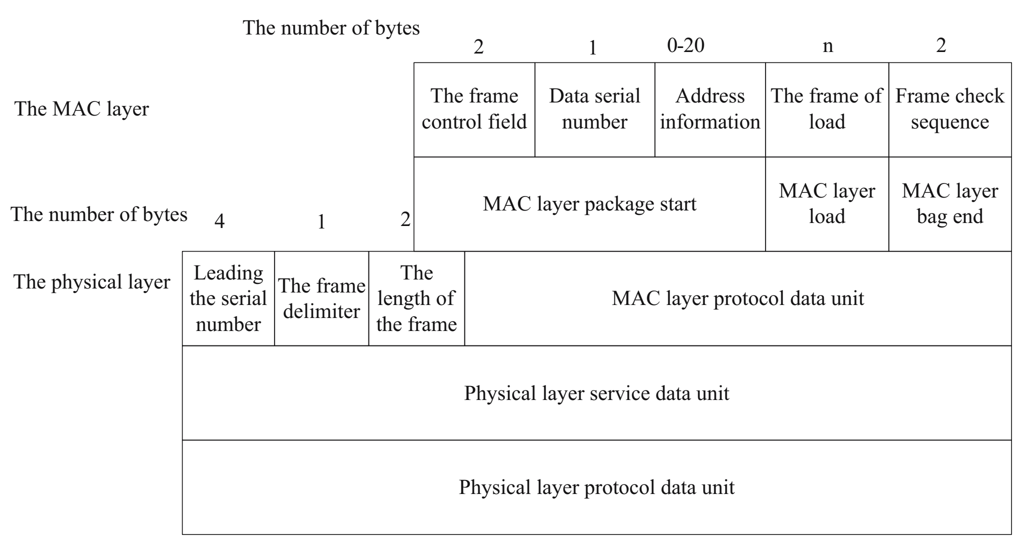

Figure 6: Format of transmission protocol frame.

calculated by the receiving node is equal. The period count records the number of cycles of the data frame when the data are sent, and the range is 0–63.

2.4 Selecting and switching transmission path

2.4.1 Path selection

There are many wireless connections in the environment of the vehicle networking, but the situation of each line is various and the difference is huge, so it should choose the link with good quality for transmission [18–20]. Therefore, a path selection method is designed: First, the bandwidth, delay, and packet loss rate of the link are estimated, and the better link is selected for data transmission considering these path parameters. Packet loss rate and delay are very important, so it is necessary to select the appropriate data transmission path. The specific selection process is shown in Figure 7.

At the beginning of connecting to the network, all paths are selected for data transmission. However, the nature of multiple paths is different at this time, and the transmission capacity of the network is different. Therefore, the link is evaluated to calculate the packet loss rate, delay, and other parameters of each path. Then, considering the packet loss rate of the path, all paths are traversed, and the path with

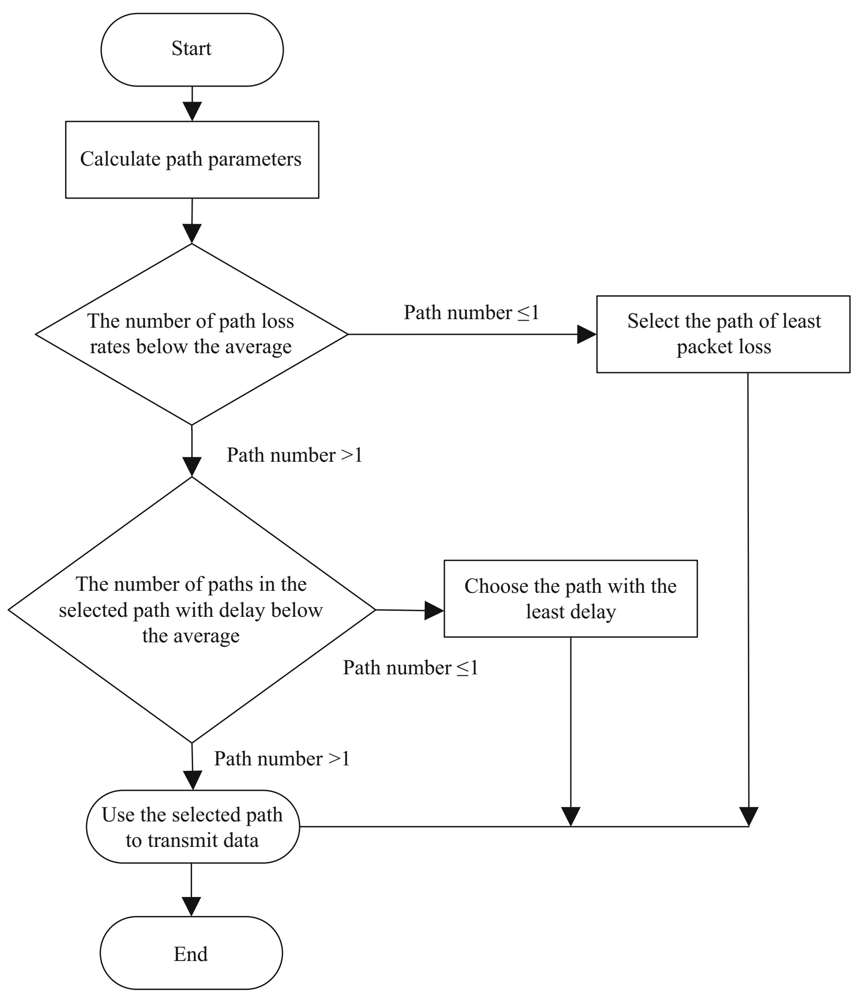

Figure 7: Flow chart of path selection.

the packet loss rate below the average value is selected. Paths above the average are not discarded and need to be evaluated at all times, unless they are disconnected before they are removed from the path list [21,22]. If there is more than one path at this time, then all the selected paths are traversed, to select the path with the delay below the average value, if any, these paths are used to transmit data; if not, the path with the minimum delay is selected. At this time, the whole association becomes a single path transmission, and the selected path is the link for data transmission.

2.4.2 Switching transmission channel

In order to further improve the low throughput and fairness of the system caused by vehicle competition and resource shortage, the channel scheduling scheme of the system is designed. At present, there are three kinds of road conditions: two-way road, intersection, and T-junction. Therefore, the channel switching methods of the above three road conditions are mainly analyzed [23], as shown in Figure 8.

In the two-way road, the vehicle only need to consider the driving information of the front vehicle, so the vehicle node only need to obtain the front vehicle node information from the relay node or the front vehicle node. The simulation of two-way traffic condition communication is shown in Figure 8(a). The relay nodes B1, B2, and B3 and vehicle nodes V3 and V4 adopt channel B communication. Relay nodes A1, A2, and A3 and vehicle nodes V1 and V2 use channel A communication. Vehicle node V4 broadcasts data in channel B, relay node B2 receives data and sends data packets to relay node B3, and vehicle node V3 receives data packets from vehicle node V4 and front relay node B2 for path planning and anti-collision analysis; Vehicle node V1 and vehicle node V2 communicate in channel A without interference with channel B. According to the traffic simulation diagram of T-junction shown in Figure 8(b), the traffic situation of T-road is analyzed. Vehicle V1 travels along Road B, only need to broadcast data in channel B in the process of driving; Vehicle V2 turns left from Road D to enter Road B, broadcasts vehicle data in channels B, C, and D in the process of turning left; Vehicle V3 travels on Road D, only broadcasts on channel D; Vehicle V4 passes through T-junction along road C, broadcasts channel C; and Vehicle V5 turns right from Road D into Road C and broadcasts in channels C and D. From the above analysis, it can be concluded that: at the T-junction, vehicles turning left broadcast all channels; at the junction, vehicles going straight broadcast channels on both sides and current channels; and at the junction, vehicles turning right broadcast current channels and channels to be entered, and other vehicles broadcast only in current channels. The intersection traffic simulation is shown in Figure 8(c). Vehicle V1 drives on Road D and only communicates data with vehicle nodes and relay nodes on the channel; Vehicle V2 turns left from Road D and enters road A, and then turns to pass other roads, so during the turning process, data are broadcast in the whole channel; Vehicle V3 enters road A and only communicates data on channel A; Vehicle V4 passes the intersection on road A and broadcasts data in channel C; Vehicle V5 turns right from Road D to enter Road C, which only affects channels C and D, so only broadcast data in channels C and D. From the above analysis, if the vehicle arriving at the intersection turns left, it will broadcast all channels at the intersection; if it goes straight, it will broadcast data only in the channel; and if it turns right, it will broadcast data in the current channel and the channel to be entered.

2.5 Distributing data transmission loads

In order to verify the effect of selecting and switching transmission paths, it is necessary to allocate data transmission load. Because high voltage (HV) relay transmission works in time division duplex mode, sample value (SV) has the same transmission time as SV transmission and HVs transmission. In case I, the source SV must select HV to transmit information to the destination SV. The density of active SVs or HVs is $\frac{1}{2}\lambda_1 P_h$. The transmission capacity is defined as the product of user density and transmission success probability. The transmission success probability of SV and HV, HV and SV communication is respectively:

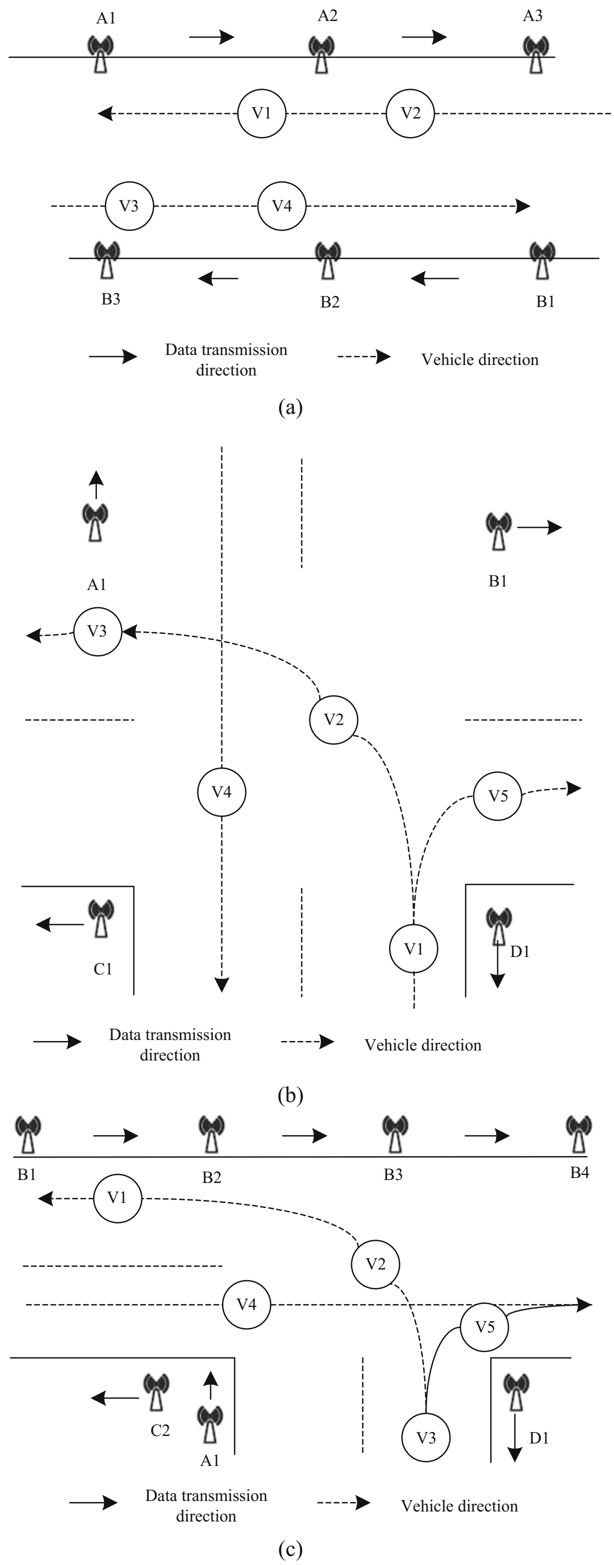

Figure 8: Traffic connection diagram of different intersections.

$$\begin{cases} P_s(S_{\mathrm{INR}} \geq \gamma_2) = e^{\frac{1}{2}\lambda_1 T_\gamma R^2} \\ P_s(S_{\mathrm{INR}} \geq \gamma) = e^{\frac{1}{2}\lambda_1 T_\gamma R^2\left[\left(\frac{P_1}{P_2}\right)^2+1\right]}, \end{cases} \tag{6}$$

where S_{INR} represents the error penalty item of the Internet of Vehicles data transmission, γ represents the amount of forwarding control data, P_1 represents the node balanced configuration value, and P_2 represents the node balanced transmission value. The transmission capacity of communication between SV and SV working in orthogonal mode is marked as $C_{H,1}$, which can be expressed as follows:

$$C_{H,1} = \frac{1}{2}\lambda_1 P_h P_s(S_{\mathrm{INR}} \geq \gamma_2) \times P_s(S_{\mathrm{INR}} \geq \gamma), \tag{7}$$

where λ_1 represents the input value of the multimode channel and P_h represents the output value of the multimode channel. The data transmission capacity is shown in Figure 9.

Before each data transmission, the capacity between the data to be transmitted and the selected transmission channel shall be compared. If the data to be transmitted are greater than 80% of the channel capacity, the data shall be allocated into multiple parts for transmission, otherwise, a single channel can be used for direct transmission.

2.6 Realizing the multi-path transmission of the vehicle networking

In the normal driving process, the data transmitted in the channel include the information of vehicle nodes, the communication information between vehicle nodes and relay nodes, and the information between relay nodes. In order to reduce the delay of communication, the single hop communication mode is adopted between vehicle nodes and between vehicle nodes and relay nodes. According to the information of the vehicle node and other relay nodes, the relay node judges the congestion, accident, and other states of the road section, and needs to transmit the road condition state information to the rear relay node and the vehicle node, so it needs to consider the fast communication between the relay nodes. In order to quickly transmit the road condition information in front to the rear and let the vehicle node quickly acquire and update the road condition information in front, it is considered that all the relay nodes on the same side should be built into the aggregation tree with the aggregation node as the root node. The vehicle node, as the leaf node of the aggregation tree, should access the aggregation tree at any time and send its vehicle driving information to the relay node of the corresponding access point. After the relay node is started, the relay node needs to establish its own routing table. The specific methods are as follows: broadcast routing packets to other relay nodes within the scope of communication and receive routing packets from other

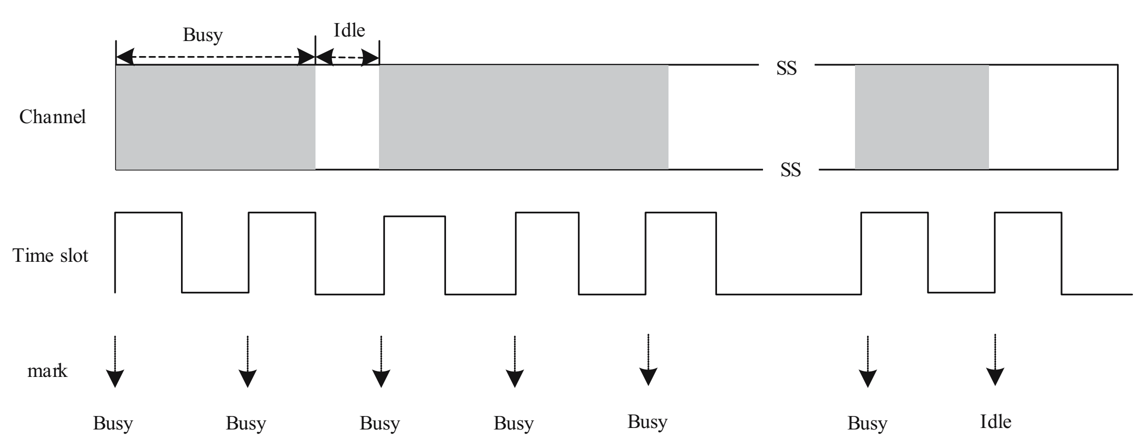

Figure 9: Statistics of channel load.

relay nodes to determine whether the relay node address is greater than its own node address. If it is greater, return information including its own address. After receiving the return messages from other relay nodes, the relay node establishes a routing table. In the routing table, by using the numbering rules of relay nodes, it can judge the current relay node and the relay node with the farthest physical location in the routing table, and select the relay node as its next hop forwarding node. To sum up, through the collaborative work of the aforementioned steps, under the vehicle networking model, the communication transmission of multiple vehicle data is realized, and the problems existing in the traditional communication mechanism are solved.

3 Performance test and analysis

3.1 Building data transmission test platform

Generally, the verification methods of theoretical research results under the environment of vehicle networking are divided into two categories: field test in the real traffic environment and simulation experiment in the network simulation environment. Due to the large cost of field test, the difficulty of deploying communication equipment in a large range, the difficulty of experiment execution, and certain risks, etc., the main verification method in the academic research in the field of vehicle networking is to build a simulation verification platform through some simulation simulators to verify and analyze the proposed design scheme. Therefore, the network simulation software NS3 is used to simulate and verify the proposed data delivery scheme. The performance evaluation indexes such as data transmission rate, transmission delay, and data packet loss are analyzed and compared to verify whether the proposed method can ensure the accurate and effective transmission of data packets. The simulation and verification platform in the vehicle networking generally include two parts: One is traffic simulation, which is mainly completed by some commonly used traffic simulators, while the network protocol simulation is mainly realized by some commonly used network simulators. When building the architecture of dynamic simulation experiment, the traffic simulator simulation of urban mobility is first used to configure the traffic scene needed in the simulation experiment, simulate the vehicle's moving track and road topology, generate and record the Trace file generated in the process of vehicle driving, then import the Trace file into the NS network simulator (version 3.0). In the network simulator, the transmission protocol is designed, the simulation parameters are configured, and the dynamic vehicle network is simulated.

3.2 Preparing the transmission data of vehicle networking

In order to ensure the authenticity of the experimental results, the actual vehicle generated data are collected in the actual vehicle networking system as the preparation data to be transmitted in the test experiment. The communication management client of UA535 data acquisition card is installed in the PC. The client can directly set parameters such as the number of sampling channels, total sampling frequency, and total length. The collected signals can be displayed on the display in real time, or the user-defined file name collection disk can be stored in the computer hard disk for later viewing. The working mode of wireless AP is set as infrastructure wireless roaming mode, and the IP address of PC is set as 192.168.0.5, so that PC can be connected with UA535 data acquisition card. The experimental equipment, the signal generator, acceleration sensor, UA535 data acquisition card, and PC are, respectively, connected with the power supply, and the acquisition card collects the signal through the acceleration sensor and connects the data acquisition card with the PC with the network cable. The collected data will be stored in different files according to different types, as the data to be transmitted in the vehicle networking environment. Prepare the data transmission of vehicle networking to pave the way for setting data transmission test indicators.

3.3 Setting the test indexes of data transmission

Based on the above preparation of vehicle network transmission data, set the test index of data transmission. The purpose of this test experiment is to test the application performance of the designed data transmission mechanism of the vehicle networking and verify its transmission performance from the data transmission speed and reliability. The test indexes that determine the transmission speed are the actual transmission rate and the transmission delay of data. The experimental results can be obtained through the data transmission monitoring software. The security of data can count and calculate the packet loss rate of data to get the test results. The value of packet loss can be determined by comparing the data size before data transmission and the received data size.

3.4 Experimental process

In the experiment, the designed data transmission mechanism based on fuzzy comprehensive evaluation method and the traditional data transmission mechanism of the vehicle networking are set as the test methods, among which the designed transmission mechanism is the experimental method and the traditional transmission mechanism is the comparative method. The two data transmission methods are carried out in the same experimental environment, and the data type and data size are the same. According to the application sequence of data transmission method, the prepared data to be transmitted are input into the vehicle networking environment, to determine the data transmission vehicle and data receiving vehicle in the vehicle networking, and install the data receiving interface on the two experimental objects, which can directly count the data amount and data transmission speed. In addition, a certain degree of interference factors should be introduced into the experimental environment to simulate other vehicle interference in the real vehicle networking environment.

3.5 Analysis of experimental results

According to the set experimental process, the data transmission performance of the data transmission mechanism based on the fuzzy comprehensive evaluation method is analyzed from the data transmission rate and packet loss rate.

3.6 Data transmission rate

Through the third-party software connected to the vehicle networking, the real-time data transmission rate is directly output, as shown in Figure 10.

After statistics and comparison, it is found that the average transmission rate of the traditional data transmission mechanism is 1.86 Mb/s, while the average transmission rate of the designed data transmission mechanism based on the fuzzy comprehensive evaluation method is 5.44 MB/s, which is 3.58 MB/s higher than that of the traditional data transmission mechanism.

3.7 Packet loss performance

The statistics and calculation results of packet loss performance of the same data are shown in Table 1.

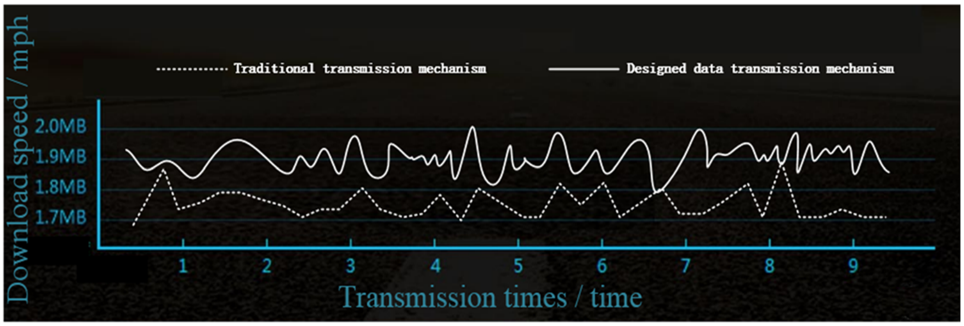

Figure 10: The detection interface of data transmission rate.

According to the calculation, the total packet loss of the traditional data transmission mechanism is 87.2 MB, while the data loss of the designed data transmission mechanism based on the fuzzy comprehensive evaluation method is 5.3 MB, and the corresponding packet loss rate is 43.6 and 2.6%, respectively, which saves 41% compared with the traditional one. The reason for the low packet loss rate of the studied method is that when the method is first connected to the network, all paths are selected for data transmission. At the same time, the link is evaluated, and the packet loss rate, delay, and other parameters of each path are calculated. Then, considering the packet loss rate of the path, traverse all paths and select the path with the packet loss rate below the average value. The path above the average value is not discarded and has been evaluated all the time, which is conducive to reducing the packet loss rate to a certain extent.

4 Conclusions

Considering the three-layer network composed of vehicle nodes, relay nodes, and sink nodes, the driving conditions of vehicles in three different road scenarios are analyzed: straight roads, T-junctions, and intersections. The nodes are classified and different channels are allocated according to the driving direction of the vehicle. Vehicle node and relay node only communicate in the allocated channel to reduce the interference of data transmission. On this basis, the fast diffusion method of relay node information and the priority transmission method of emergency traffic information are proposed. Compared with the traditional data transmission mechanism of Internet of Vehicles, the following conclusions are drawn:

(1) The method designed in this article not only ensures the reliability of data transmission but also improves the efficiency of data transmission.
(2) The data transmission rate of the vehicle network under the data transmission mechanism of the Internet of Vehicles based on the fuzzy comprehensive evaluation method is increased by 3.58 MB/s, and the packet loss rate is reduced by 41%.

Table 1: Experimental results of packet loss rate

Number of data transfers	Data transfer size (MB)	Data reception under traditional data transmission mechanism (MB)	Data reception under the design of data transmission mechanism (MB)
1	200	183.3	200
2	200	192.2	200
3	200	187.6	198.4
4	200	174.9	200
5	200	198.6	200
6	200	193.3	197.2
7	200	200	200
8	200	182.9	199.1

The data transmission method designed in this article can be used to design a message-type recognition algorithm in subsequent research, classify the messages to be transmitted according to their importance, determine the transmission order, and prioritize more urgent messages such as security messages. Massive traffic data of the Internet of Vehicles are constantly generated. These data have important reference value for analyzing and solving current traffic problems. It believes that in the near future, when the data transmission technology of the Internet of Vehicles is perfect, the development of the Internet of Things will reach a certain level. In the initial stage, this method can be widely used in practice to reflect the actual value.

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Author contributions: In this paper, based on the traditional data transmission mechanism, the fuzzy comprehensive evaluation method is used to achieve the optimal design of the data transmission mechanism of the Internet of Vehicles. Hongtao Zhang according to the operation mechanism of the Internet of Vehicles, build the Internet of Vehicles model. Yi Guo, and Zhenxing Wang using this model, the fuzzy comprehensive evaluation is used to analyze the data transmission characteristics of the Internet of Vehicles, and the characteristics evaluation results of data transmission are obtained. Liancheng Zhang set the data transmission protocol of the Internet of Vehicles, select the appropriate data transmission path, allocate the data transmission load, and realize the data transmission of the Internet of Vehicles. Hongtao Zhang, Liancheng Zhang, Yi Guo, and Zhenxing Wang made a great contribution to the preparation of the manuscript.

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