Research Article

Research on Distributed In-Vehicle Wireless Self-Organized Routing Protocol Distribution Mechanism

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In recent years, the application of intelligent transportation systems has gradually made the transportation industry safe, efficient, and environmentally friendly and has led to a broader research prospect of vehicle wireless communication technology. Distributed vehicular self-organizing networks are mobile self-organizing networks in realistic traffic situations. Data interaction and transmission between nodes are achieved through the establishment of a vehicular self-organizing network. In this paper, a multipath routing protocol considering path stability and load balancing is proposed to address the shortcomings of existing distributed vehicular wireless self-organizing routing protocols. This protocol establishes three loop-free paths in the route discovery phase and uses the path stability parameter and load level parameter together to measure the total transmission cost. The one with the lowest total transmission cost is selected as the highest priority path for data transmission in the route selection phase, and the other two are used as alternate paths, and when the primary path breaks, the higher priority of the remaining path will continue to transmit data as the primary route. In this paper, to improve the content distribution performance of target vehicles in scenarios where communication blind zones exist between adjacent roadside units, an assisted download distribution mechanism for video-like large file content is designed in the V2V and V2I cooperative communication regime. That is, considering a two-way lane scenario, we use the same direction driving vehicles to build clusters, reverse driving vehicles to carry prefetched data, and build clusters to forward prefetched data to improve the data download volume of target vehicles in nonhot scenarios such as highways with the sparse deployment of roadside units, to meet the data volume download demand of in-vehicle users for large files and give guidance for efficient distribution of large file content in highway scenarios.

1. Introduction

In recent years, with the rapid development of wireless communication technology, the Internet of Vehicles (IoV), as an important branch of the Internet of Things (IoT), has received more and more attention from governments, research institutions, and enterprise manufacturers. Incorporating sensor, image processing, vehicle positioning, and other sensing technologies, wireless communication, heterogeneous network fusion, and other network technologies, as well as cloud computing, mobile edge computing, big data, and other application technologies, IoV can realize the network communication between each module inside the vehicle [1], vehicle and vehicle occupants, vehicle and vehicle,

vehicle and pedestrian, and vehicle and roadside facilities, which can be used for urban network interconnection, intelligent traffic management, intelligent city construction, vehicle autonomous driving, and other industry fields to provide active assistance and effective support and provide a variety of technical solutions to the abovementioned urban traffic management problems [2]. VANET (vehicular ad hoc network) is the name of vehicle-to-vehicle communication in the networking form category, which mainly uses vehicles as the basic network nodes and can build networks, self-configuration, and self-management in the form of self-organization without fixed infrastructure, providing each vehicle driving on each road in the city with access to network communication, data exchange, and resource sharing

services. It also provides a shared, free, metropolitan network communication resource platform for urban areas with high population and traffic density because of its advantages such as a large number of nodes, flexible organization, and no three-way communication costs [3].

Depending on the application scenario, current industry applications based on vehicle self-organizing networks fall into the following three main categories.

(1) *Driving Safety Class*. This class of applications mainly targets the user's interaction with the surrounding environment during the vehicle driving process, such as distance, speed, driving status, ground friction, and nearby vehicles, to avoid serious accidents such as collisions when the vehicle is out of control. The driving safety application requires fast, accurate, and reliable forwarding of emergency alarm information, which has the highest priority in network communication and is divided into separate transmission channels in such vehicle networking communication protocol standards as IEEE802.11p [4]. In addition, the application is mostly broadcast-based, to ensure the dissemination coverage of safety information, so the design and development need to consider solving the broadcast storms and other collateral problems; propagation distance, because it is mainly communication between adjacent vehicles, the number of forwarding hops is small, and most of them are single-hop, that is, direct communication is the main

(2) *Traffic Management Category*. This class of applications is mainly aimed at solving road traffic management-related problems; on the one hand, with the vehicle self-organizing network and roadside units to collect real-time information on vehicles and roads, intelligent traffic control center can centralize statistical processing and trend prediction of road network information within the whole city, to release traffic information to relevant vehicles and traffic flow, and carry out real-time scheduling such as signal adjustment, road dynamic speed limit, and path induction operations, to ensure the smooth operation of urban road traffic flow, effectively respond to unexpected accidents, and reduce congestion [5]. By another way, vehicles can make corresponding dynamic planning adjustments to their paths through the received real-time traffic information to avoid congested sections and save travel time. Such applications have a strong focus on information dissemination, so they are mainly multicast and unicast, and with the road and location information of each vehicle, the propagation distance is controlled accordingly; in addition, from the perspective of macroscopic scheduling, there is no need to ensure that each vehicle can receive each piece of traffic information, so compared with security applications, the requirements in network transmission in real-time and reliability are lower

(3) *User Interaction Category*. This kind of application mainly refers to different kinds of users, through the vehicle self-organizing network such as audio and video communication, mobile joint office, entertainment games, resource sharing, instant chat, and other forms of interaction. In addition, enterprise manufacturers can also use this to complete such as service information push, multimedia resources on-demand, and other related service activities. It is worth noting that, for such applications, vehicle self-organizing network is not a fixed application crowd; that is, the end-user is not only the car driver, but it is also more to provide a shared, free of charge city network communication resources, roadside pedestrians, and even indoor personnel can communicate with each other with the help of heterogeneous network convergence and other related technologies, through the vehicle self-organizing network for data relay, to achieve network communication channels diversified choice and combination, effectively reduce network communication costs, reduce the instability of a single network channel, and enhance the user experience. The data communication of such applications is mostly unicast, and the transmission form is multihop transmission between vehicles, and the delay requirements vary according to the nature of specific types; for example, video and audio conferencing have high delay requirements, while information pushing has lower requirements

2. Related Work

In recent years, domestic and foreign scholars have conducted a lot of research on routing protocols applicable to VANETs, among which literature [6] conducted a comparative study of six earlier single-path protocols such as AODV, DSR, OLSR, and DSDV in a vehicular network environment, and the results show that in most scenarios, with the increase in the number of nodes, AODV shows better performance than other routing protocols. The literature [7] proposes an on-demand multipath distance vector protocol, AOMDV, based on AODV, which finds multiple acyclic disjoint paths simultaneously. The performance of the protocol is compared with that of AODV, and the results show that AOMDV achieves significant improvement in end-to-end delay and can reduce routing overhead. The literature [8] proposes a load balancing routing protocol based on the location-aware protocol GPSR to accommodate the dynamic nature of vehicular self-organizing networks. In this protocol, node traffic information during data transmission is used as a routing criterion, and node location updates are also requested periodically during the routing process. Specifically, this load balancing protocol not only considers the movement of network nodes but also analyzes the cache queues of neighboring nodes when selecting the best route for forwarding data. The literature [9] proposes a vehicle density and load-aware routing protocol called VDLA, where the routing of VDLA is based on the real-time vehicle

density, the traffic load on the corresponding road segment, and the distance to the destination. The protocol collects information about these metrics through a decentralized mechanism to avoid sending packets to paths where the network is disconnected, balancing the network load to reduce network congestion. In a simulation, VDLA is compared with GPCR, and the results show that VDLA outperforms GPCR in terms of average end-to-end delay and packet delivery rate. The literature [10] argues that there are two nonnegligible factors in routing protocol design in urban environments, i.e., uneven distribution of vehicles due to traffic signals and network congestion due to high traffic demand during peak hours. This leads to the proposal of a greedy traffic signal and queue-aware routing protocol GTLQR, which jointly considers street smoothness, channel quality, relative distance, and queuing delay to mitigate packet loss caused by vehicle aggregation at intersections and to balance the load between traffic vehicles. By performance evaluation, this protocol outperforms both TLRC and GLSR-L protocols in terms of packet delivery rate and average end-to-end delay. Literature [11] proposed a stable routing protocol that uses a cognitive agent with fuzzy logic BDI architecture to find stable paths by using speed, direction, and connection survival as parameters. This protocol improves the packet delivery rate to some extent and maintains the routing reliability. The literature [12] considers three important parameters of mobile self-assembling networks: mobility of nodes, the energy of nodes, and packet loss rate of nodes, and the scheme uses fuzzy logic to combine these three metrics to get the decisive parameters for routing. An efficient and stable routing algorithm ESRA-MD based on user mobility and node density is proposed in the literature [13]. The algorithm selects the optimal route based on the number of hops and link duration to adapt to the possible changes in the urban vehicular environment. Simulation results verify that the ESRA-MD algorithm provides significant improvement in data delivery rate, end-to-end delay, and routing overhead compared to the ARP-QD protocol. The literature [14] uses the nonorthogonal multiple access technique for the content distribution process of multiple vehicles and proposes a power allocation scheme with the highest content decoding rate for different vehicles' content caching to serve multiple vehicles at the same moment. In the literature [15], multiple input and multiple output techniques are introduced in the network architecture of cellular vehicular links to study the communication between a large number of vehicles and base stations, and the interference cancellation between vehicles is analyzed and studied to improve the communication quality considering the complexity of the network environment.

Many wireless technologies such as GPRS, IEEE 802.11p, and IEEE 802.16 have been proposed for reliable traffic information communication. Before this technology gets off the ground and achieves the desired results, a series of outdoor experiments should be conducted to test it, but most of these experiments are costly and highly complex.

3. Research on Distributed In-Vehicle Wireless Self-Organized Routing Protocol Distribution Mechanism

3.1. Principles of Distributed In-Vehicle Wireless Self-Organized Routing. The commonly accepted routing protocols for wireless self-organizing networks are DSR, AODV, OLSR, and ZRP. These protocols generally build routing tables in a broadcast multicast manner and are centered on reducing broadcast storms. Through the study of routing protocols, which are the core part, self-organized networks have been continuously developed and updated.

3.1.1. OLSR (Optimized Link State Routing). The OLSR routing protocol is a planar topology first response routing protocol that is currently used by the IETF as a routing protocol standard for wireless self-organizing networks. OLSR uses two types of control message packets: the Hello packet and the TC (topology control) packet. OLSR uses periodic broadcast of Hello packets to establish the state of neighboring nodes. The link states between nodes include an asymmetric link, symmetric link, MPR link (multipoint relay), and failing link. Due to the presence of MPR nodes, the OLSR routing protocol can achieve selective flooding instead of undifferentiated nonselective flooding, reducing some network overhead as shown in Figure 1.

As Figure 2 shows, OLSR obtains the two tables needed for route computation through Hello and TC packets: the neighbor table and the topology table. Based on these two tables, the node computes the routing table for the current moment using the Dijkstra shortest path algorithm node for directed graphs.

3.1.2. AODV (Ad Hoc On-Demand Distance Vector). The AODV protocol is a reactive routing protocol. It does not maintain global transmission information for the entire network. A valid path as perceived by a node is one in which at least one packet is transmitted during the time set for that path. Therefore, in AODV, route discovery packets are created and declared only when the source node must be connected to the destination node, and there is no valid path [16]. AODV dynamically builds the entire routing table, and each node maintains a counter to remove unused or invalid routes. The most essential disadvantage of AODV is that it does not support asymmetric links. It only supports symmetric links where both sides can send packets.

3.1.3. DSR (Dynamic Source Routing). DSR is also a widely used routing protocol. Since each packet in the DSR protocol contains a complete list of node routes, all nodes that send or receive packets will store routing information for backup, and DSR will quickly change the network topology to maintain better state performance whether the node moves or stays on the move at any time.

3.1.4. ZRP (Zone Routing Protocol). ZRP protocol combines the features of the prerouting protocol and reactive routing protocol, and it reduces the cost of routing control packets by limiting the propagation of active protocol update packets from nodes to a certain number of areas.
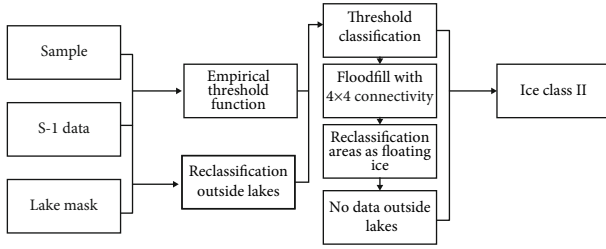
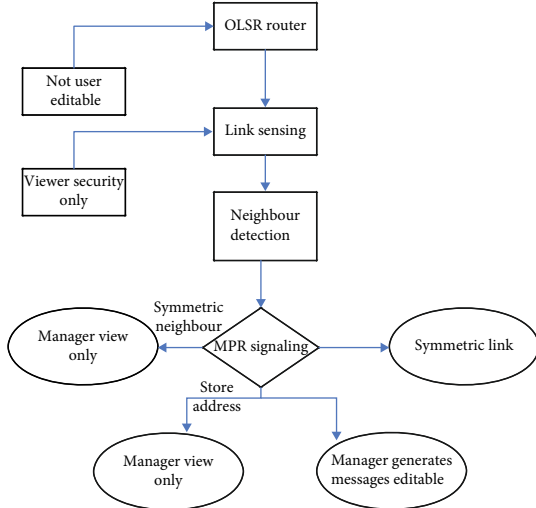Figure 1: Schematic diagram of selective flooding.

Figure 2: OLSR neighbor table state transfer diagram.

When communicating with nodes outside the area, reactive routing protocols are chosen to accomplish this.

Link detection is accomplished by periodically sending HELLO messages on the interfaces to check connectivity. A separate HELLO message is generated for each interface, and the link detection results are obtained by exchanging HELLO messages with other nodes in the network at regular intervals. The result of the link detection is a local link set describing the link between the "local interface" and the "remote interface," i.e., the interfaces on the neighboring nodes. If the link-layer provides enough information, it can be used to populate the local link set instead of the HELLO message exchange. Therefore, the delivery cycle of HELLO messages directly affects the generation of local link sets for each node in the network, which in turn affects the speed of network reconfiguration [17]. In practice, we can increase the value of the HELLP_INTERVAL parameter, to optimize the structure change, reduce the resource occupation, solve the problem of a relatively fixed number of satellites, and make the protocol more universal.

The purpose of MPR selection is to enable a node to select a subset of its neighbors so that broadcast messages retransmitted by these selected neighbors will be received by all nodes two hops away. The information needed to perform this calculation is obtained by periodically exchanging HELLO messages. The purpose of MPR node selection is to select nodes from the one-hop neighbor nodes to forward TC messages so that the two-hop neighbor nodes can all

receive the TC messages sent by this node. That is, the election of MPR nodes is to elect the smallest set that can cover all the second-hop neighbors from the one-hop neighbors. The core of the resulting election algorithm is to ensure full coverage of the second-hop neighbors and to minimize the number of selected MPR nodes.

As shown in Figure 3, when a vehicle leaves the communication range of the roadside unit, to extend the communication time between the vehicle and the roadside unit, the target vehicle can establish a communication link with the roadside unit through a relay node. Consider an adaptive multirelay selection scheme for delay-tolerant class applications that integrates multiple conditions such as limited cache time, communication time, relative speed, and distance between the target vehicle and its neighboring vehicles to rank single-hop neighbor nodes, which allows the roadside unit to periodically select multiple relay vehicles based on the location of the target vehicle and the amount of outstanding data to be downloaded [18]. The roadside unit predicts the connection time between it and the target vehicle periodically to determine whether relay selection is required; the roadside unit calculates the available cache size for each relay vehicle to allocate the target vehicle's download data. The requested data is retrieved for the target vehicle within the communication dark zone by the above mechanism to complete the download of the requested data if possible.

By periodically exchanging information with surrounding vehicles, the relative distance can be calculated based on the time of information propagation, so that the location relationship between vehicles can be obtained to form a subcluster and establish a neighbor table. The set of neighbor nodes of vehicle V_i at moment t can be expressed as

$$N_{vi} = \Pi(V_i t + \theta) + \eta. \tag{1}$$

To obtain a relatively stable speed of the vehicles within the cluster, we use the average speed of the vehicles within the cluster to characterize the stability of the cluster and filter the vehicle nodes within the above set of pairs of neighboring nodes by motion consistency to remove the vehicle nodes within the cluster with a large difference from the average speed [19], to ensure that the cluster can travel on the road in a relatively stable manner. Specifically, the average speed of the vehicles within the cluster at time t can be expressed as

$$\overline{v_i} = \frac{\delta x}{\delta t} \left(\frac{n!}{r!(n-r)!} x^\gamma + \mu \right), \tag{2}$$

where $N(t)$ denotes the number of elements in the set of neighboring nodes of V_i at time t and V_{it} represents the nth element within the set N_{vi} of neighboring nodes of $_{Vi}$ at time t. If the velocity of V_{jn} satisfies the following equation, it will be removed.

$$N(t) = \sum_{i=1}^{n} (N_{vi} \cdot V_{in}) + A. \tag{3}$$
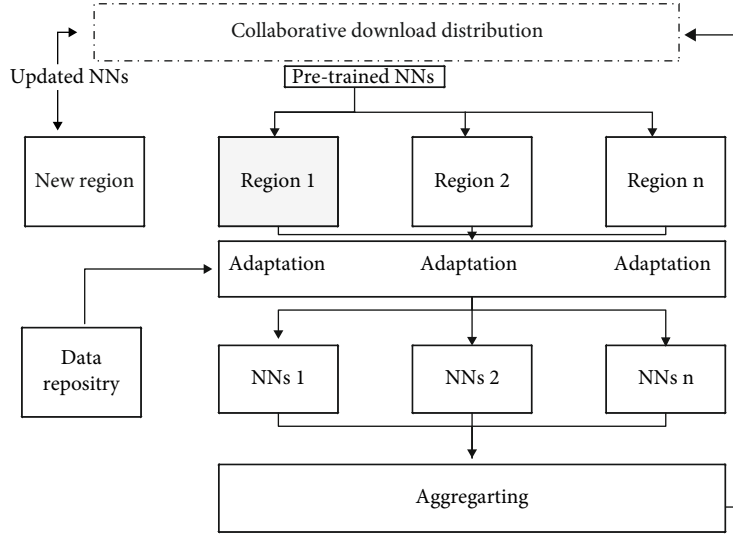
FIGURE 3: The collaborative download distribution of content based on relay vehicles.

In cluster head selection and entry factor, when the target vehicle enters the communication coverage of the roadside unit RSU_i, before it will build a cluster with vehicles traveling in the same direction, the target vehicle is directly identified as the cluster head of the cluster C of collaborating vehicles traveling in the same direction, to ensure that the members of the cluster better collaborate with the target vehicle to complete the download of large file contents. When the target vehicle enters the dark area of communication, a reverse cooperative vehicle cluster S is formed. If the cluster contains only 1 collaborative vehicle node that has prefetched data items in R, this vehicle node will be selected as the cluster head of its cluster; if the cluster contains 2 and more collaborative vehicle nodes that have prefetched M data items, it is more expected in our mechanism that the cluster head of each cluster will be the requesting vehicle or the collaborative vehicle that has prefetched N data items. Therefore, for the above case, we split the clusters by the entry factor; specifically, the entry factor is calculated based on the vehicle's velocity information at the current moment, its location information, and its distance to the nearby cluster head.

$$RSU_i = R \cdot M^N \cdot \sum_{i=1}^{n} \left(V_i - \bar{V} \right)^2. \tag{4}$$

The dynamic change of the vehicle cluster structure in the time domain by the changing motion of the vehicles is "generation-maintenance-reconfiguration," so the cluster structure needs to be maintained and adjusted periodically to make it stable. The cluster head needs to update the list of cluster members in the cluster at the current moment if new vehicles join or leave the cluster.

3.2. Routing Maintenance and Performance Metrics. Due to node energy depletion, path disconnection caused by node mobility destroys link connectivity and invalidates otherwise efficient paths, which seriously affects the overall performance of the network. The EAODV routing algorithm maintains the detection mechanism of the original AODV routing protocol in the process of route maintenance, while monitoring the energy and stability situation of each node and the routing efficiency factor on each path, according to the following three, the corresponding routine maintenance is performed according to the following three situations. (1) Path disruption. When a route break is detected through the propagation of HELLO messages, a RERR message is sent back to the source node through the reverse path, and the failed route is removed from the routing table. When the source node receives the RERR message, it will initiate a new route discovery if a route is required. (2) Route nonconformity. If the primary route path efficiency factor is less than the alternate route, the alternate route is used as the primary route, at which point the primary route is used as the alternate route. If the route efficiency factor of a route is low enough or the node speed node load is high enough, it means that this route is not suitable for transmitting data and will be removed from the routing table. If the alternate route also fails, the route discovery process is reopened. (3) Survival period exceeded. One field in the routing table is the survival period, which indicates that the RREP packet can be validly received within a specified period. For example, there is a route that has successfully established a link, but no data communication has taken place within the specified period. Then, it will become a failed route, and it will be removed from the routing table [20].

The performance of routing protocols can be evaluated by considering the following metrics.

(1) *Average End-to-End Delay*. The average time it takes to successfully route a packet from a source node through a network relay node to a destination node. This delay includes a large number of smaller network delays, including all potential delays caused by buffering delays in the route discovery process,

router interface queue queuing, MAC retransmission, propagation, and transmission time delays. The average end-to-end delay reflects the effectiveness of the protocol and can be determined using the following formula

$$\ddot{x} = \frac{\delta y}{\delta x}\left(\gamma\sqrt{y^2 + x^2} + y^3 + c\right). \tag{5}$$

(2) *Packet Delivery Rate*. The ratio of the total number of data packets received by the destination node to the total number of data packets sent by the source node. Packet delivery rate is an important performance metric that reflects how successfully the protocol delivers data packets from the source node to the destination node. The main reasons for the nondelivery of packets to the destination node can be packet conflicts in the MAC layer, network partitioning, routing loops, interface queue loss, etc. The packet delivery rate reflects the integrity and correctness of the protocol

(3) *Network Survival Time*. It is the time when the energy reserve of a node is reduced to zero. It is one of the important metrics to evaluate the energy efficiency of routing protocols relative to network partitioning. In wireless self-organizing networks, especially in those with densely distributed nodes, the disappearance of the first node rarely leads to a complete failure of the network. As the number of dead nodes increases, the network is partitioned. Even with partitioning, end-to-end transmission is still feasible in each partition. The network is active if at least one pair of adjacent nodes is working since they can transmit to each other and keep the network active

4. Experimental Verification and Conclusions

To obtain the data volume as well as the data interactions of the data transfer mechanisms in one information cycle, we can plot the variation curve of the data volume with the length of the cache window. As can be seen from Figure 4, the mechanism proposed in this section significantly outperforms the other two mechanisms in the metric of video data download volume [21]. Specifically, when $M < 50$, the video requesting vehicle enters the communication range of the roadside unit and starts downloading video streams, and when driving away from the communication range, the video requesting vehicle will rely on the relay node to continue establishing communication links with the roadside unit, so the QDAVS mechanism and our proposed mechanism obtain significantly better data volume than the TAVS mechanism; in addition, we use the TOPSIS-based; we use the TOPSIS-based multicriteria decision method to select the optimal relay node to establish a communication link with higher download and transmission rates and thus
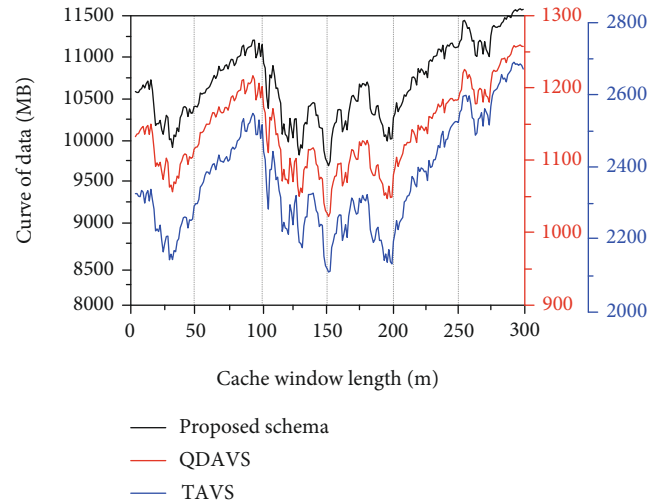

FIGURE 4: Curve of data volume with cache window length.

obtain higher data download. As can be seen from Figure 4, after the vehicle leaves the range of the roadside unit for some time, all three mechanisms experience a communication dark zone, i.e., a section without any access to the video stream. When $M > 150$, the carrying and forwarding of video streams by the reverse vehicle make our proposed mechanism significantly higher than the other two mechanisms in terms of data volume. The variation curve of data volume with cache window length is shown in the figure.

The variation curve of the average number of layers of SVC video streams with the length of the cache window is shown in Figure 5, which reflects the variation of the average number of layers of SVC video streams obtained in one cycle for each video stream delivery mechanism. From the figure, we can see that mechanism proposed in this section significantly outperforms the other two mechanisms in the metric of the average number of layers of SVC video streams. Specifically, the average layer count of SVC video streams for all three mechanisms decreases over time because the target vehicles enter the communication blind zone in the early stage of video stream downloading, and the restricted amount of data downloading makes the target vehicles choose to reduce the video quality for video playback. In addition, the relay mechanism we use makes the data download volume slightly higher than the other two types of mechanisms, and estimating the encounter time of the reverse vehicle makes our video quality degradation trend lower than the other two types of mechanisms. After the target vehicle encounters the reverse collaborating vehicle, our proposed mechanism obtains an improvement in video quality.

The variation curve of video playback lag rate with cache window length is shown in Figure 6, which reflects the variation of video playback lag rate of each video streaming mechanism within one cycle. From the figure, we can recognize that the proposed mechanism in this paper significantly outperforms the other two mechanisms in the metric of video playback lag rate. Specifically, when there is no data
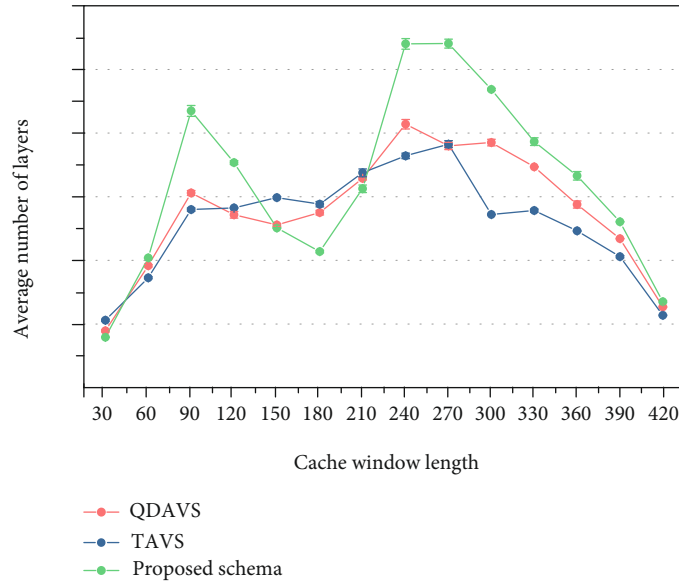
FIGURE 5: Curve of the average number of layers of video streams with the length of the cache window.
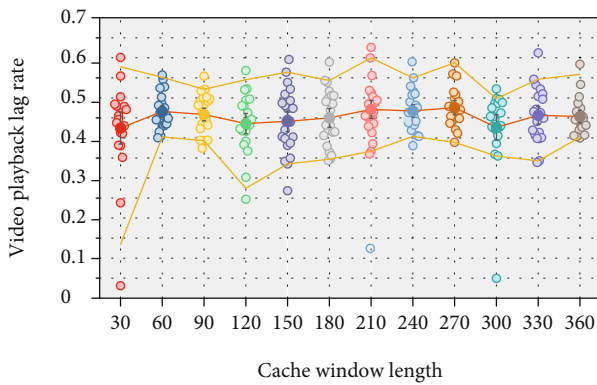

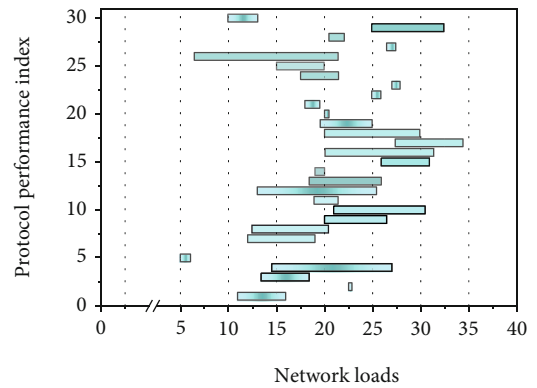FIGURE 6: The curve of video playback lag rate with cache window length.

FIGURE 7: Protocol performance under different network loads.

volume download source for the vehicle, all three types of mechanisms choose to reduce the video quality to mitigate the impact of the data download volume on the lag rate, and the QDAVS mechanism and the TAVS mechanism will lag earlier than our proposed mechanism. Overall, the playback stutter rate of our videos is significantly lower than the other two types of mechanisms, reducing the video playback stutter rate by approximately 48%.

Protocol performance testing under the influence of different network loads is essential to improve the actual user experience. The number of vehicles in simulation scenario 1 is set to 50, and the maximum speed limit is 15 m/s. The performance of AOMDV and PSLB protocols is tested for 20, 40, 60, 80, and 100 connections, respectively, by setting a different number of communication connections in the network to control the load level. As more and more connections are made in the network, the overall packet delivery rate tends to decrease. The difference between the packet delivery rate of AOMDV and PSLB protocols is not signifi-

cant when the number of connections is small. As the number of connections increases, the network congestion increases, and the PSLB protocol reduces the network congestion and packet loss due to cache queue overflow by considering the load factor of the path during routing, so the packet delivery rate of PSLB is higher than that of AOMDV protocol. From Figure 7, it is clear that an increase in network load leads to an increase in network congestion, and the average end-to-end delay of both protocols grows. Since the AOMDV protocol does not take into account the load balancing factor, the data transmission is too dependent on some important nodes, and the packets are queued in the queue for a longer time, which leads to more transmission delay. Whereas PSLB protocol tends to avoid the paths with higher load for data transmission during routing, so the average end-to-end delay is less than the AOMDV protocol in all cases. The normalized routing overhead increases as the network load condition becomes heavier, and more control packets are required on average to transmit a data
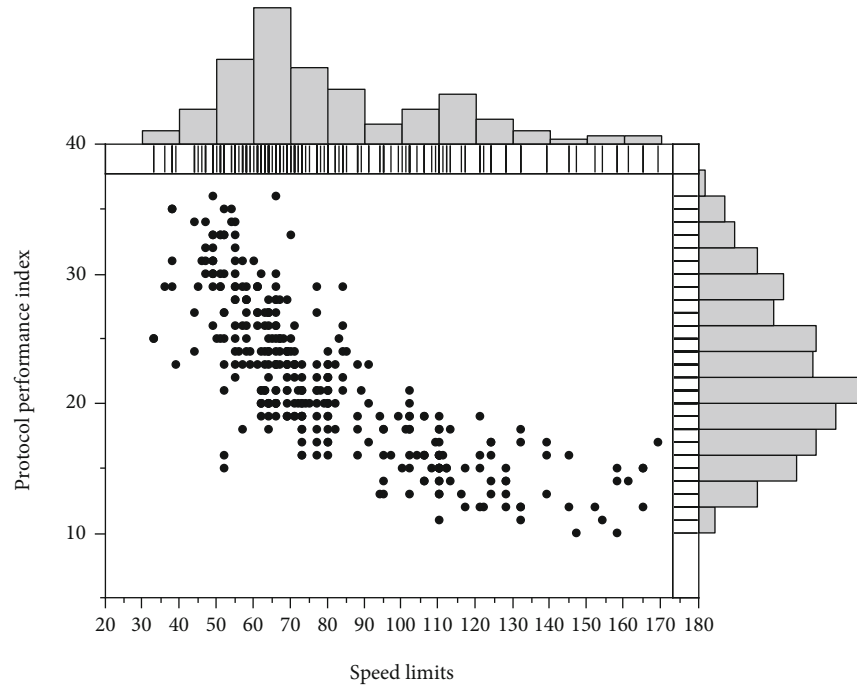
FIGURE 8: Protocol performance at different vehicle speed limits.

packet. Since the PSLB protocol considers both load balancing and path stability, the probability of link failure is lower, and the frequency of reinitiating route discovery is reduced, so the PSLB protocol has less normalized routing overhead in the same case.

To test the performance of the protocols under different vehicle mobility, this topic is implemented by controlling the maximum running speed of the vehicles. The number of vehicles in simulation scenario 2 is set to 50, the number of communication connections is 25, and the performance of the two protocols is tested at the maximum vehicle speed limits of 0, 5, 10, 15, 20, 25, and 30 m/s, respectively, as shown in Figure 8. The higher the maximum vehicle speed limit, the more mobile the vehicle is, the easier the connection breaks, and the packet delivery rate decreases indicating that the network transmission becomes more unreliable. The AOMDV protocol uses the first path found in the routing phase, which is not essentially the most stable and thus may cause more packet loss in the network. The PSLB protocol prefers a stable path in routing, reducing the number of packets lost due to packet loss due to routing failure. Therefore, the PSLB protocol has a higher packet delivery rate than the AOMDV protocol in the same situation. The average end-to-end delay of PSLB protocol is not much different from that of AOMDV protocol when the speed limit is low, and the performance of PSLB protocol is better than that of AOMDV protocol when the speed limit is high. It is because PSLB selects more stable paths for transmission, the small relative speed between nodes on the path, and long route survival time, which reduces the additional delay due to route failure. Normalized routing overhead increases rapidly with vehicle mobility; AOMDV protocol does not consider path stability during routing, so more control packets are used to reestablish connections during the route maintenance phase when the vehicle movement speed is high, and connection failures are frequent. PSLB protocol avoids using paths with high break probability and fewer additional control packets caused by retransmissions. Therefore, its normalized routing overhead is more significantly better than the AOMDV protocol at higher speed limits.

We propose a relay selection method based on the TOPSIS multicriteria decision to select relay nodes for target vehicles and improve the video download capacity of vehicles. The proposed adaptive video streaming transmission method reduces the video playback lag rate while improving the video quality, realizes smooth video playback, and thus improves the visual experience of invehicle users. In addition, a detailed description of the specific routing process of the proposed distributed invehicle wireless self-organizing network routing protocol distribution mechanism is given, along with the introduction of the path quality evaluation method based on parameters such as connectivity probability, transmission delay and connection strength, and the multipath selection method based on interpath distance, and finally, simulation experiments on the overall performance of routing and the impact of each parameter on routing are conducted, and the experimental results illustrate that the experimental results show that the routing mechanism has a large performance improvement in packet delivery rate and transmission delay compared to traditional routing protocol algorithms and can provide targeted and efficient routing services for different applications and specific data communication needs in different environments by adjusting the weights of each path quality assessment parameter.

5. Conclusions

In recent years, telematics has attracted much attention due to its broad prospects. Telematics not only performs well in traffic safety and operation efficiency class applications but also has more promising development prospects in realizing service class applications such as infotainment, audio, and video, which have been studied by many scholars. As an essential part of realizing various applications, the research of content distribution technology has faced great challenges in vehicular networking with high dynamic characteristics of vehicle nodes and low coverage of roadside units. In this paper, facing the challenges brought by the routing protocol distribution mechanism and applications of distributed in-vehicle wireless self-organizing networks, we propose a size-oriented collaborative download distribution mechanism and a quality-of-service oriented adaptive transmission method for video streaming by summarizing and analyzing the shortcomings in the existing research on collaborative communication-based content download distribution mechanism and video streaming transmission methods, and exploring the design requirements of both, and validating the performance. The main work is summarized as follows.

(1) Proposes a new protocol PSLB that is more adapted to the characteristics of VANETs, which takes into account the influences of both load balancing and path stability. First of all, the design idea of algorithm optimization is explained, the route grouping format is modified, the route selection mechanism is improved, and finally, the working process of the protocol is described in detail

(2) VANET simulation experiments were conducted using the traffic simulator VanetMobiSim and the network simulator NS2, and the superiority of the PSLB protocol was verified by comparing it with the AOMDV protocol and analyzing the optimization effect of the PSLB protocol

(3) Based on the rich application requirements and complex network characteristics of telematics, the research on the collaborative download mechanism of large file content with single-user requests and multiuser collaboration under V2I and V2V cooperative communication is conducted for the challenges faced by vehicles downloading large file content through roadside units in telematics in the highway scenario and proposes the collaborative download mechanism of building clusters for vehicles driving in the same direction, carrying prefetched data for vehicles driving in the opposite direction and building clusters to forward prefetched data. The content collaborative downloading and distribution mechanism is proposed. The target vehicle accesses the roadside unit in advance by building a cluster with the codriving collaborative vehicle before entering the communication range of the roadside unit, downloads data collaboratively through the codriving collaborative vehicle cluster, and receives the data downloaded collaboratively by the cluster members of the codriving collaborative vehicle cluster in the first half of the communication dark zone; in addition, we improve the channel access mechanism in V2V communication to reduce the data loss while ensuring the stability of the cluster structure, by reverse collaborative vehicles prefetch carry data and build clusters to forward data, to improve the amount of data obtained by the target vehicle through encounters with reverse vehicles in sparse scenarios, and further improve the amount of data downloaded. Based on this, we demonstrate the improvement of the proposed content collaborative download distribution mechanism in this paper in terms of data download volume, throughput, and other performance metrics through simulation verification and performance comparison with existing content collaborative download distribution mechanisms

(4) Facing the demand for smooth playback, low lag rate, and high video quality of video services from in-vehicle users, we propose a quality-of-service oriented adaptive transmission scheme for video streams and use a TOPSIS multicriteria decision-based relay selection method to select relay nodes for target vehicles and improve the video download from vehicles

Data Availability

The data used to support the findings of this study are available from the corresponding author upon request.

Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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