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Design of Relay Selection Algorithm for Internet of Vehicles

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Abstract

The Fifth Generation of Mobile Communication/ Beyong Fifth Generation of Mobile Communication (5G/B5G) is an indispensable communication technology in the wireless communication system. Its ultimate goal is to realize the information exchange between the vehicle and all the surrounding wireless communication devices. However, a large amount of interactive information is widely spread, user nodes have strong mobility and openness, and the network topology changes rapidly in the Internet of Vehicles (IoV), which makes the communication links change frequently and interrupt easily. In this paper, the relay cooperative transmission technology is applied to the IoV. Based on the design of relay selection algorithm and the analysis of system performance, the influence of relay selection algorithm on the reliability and stability of IoV communication is studied. Simulation results show that the proposed scheme can significantly improve the system throughput and relay switching times.

Keywords

IoV; Relay Selection; Performance Analysis.

1. Introduction

Vehicle AdHoc Networks (VANET), as an application of Mobile AdHoc Networks (MANET) in the automotive industry, has attracted much attention. However, in the 5G era, as a cutting-edge technology [1], the Internet of Things (IoT) is gradually transforming the Internet into a fully integrated Internet of the future, while pushing various existing research fields to develop in new directions. Geared to the needs of intelligent transportation system (ITS) Intelligent Transport System, vehicle automatic control, and the application of intelligent network information service demand, VANET need to accelerate the pace of change in technology, to constantly meet the needs of people, vehicles, environment together. In this context, IoV technology emerged, which aims to achieve information exchange between vehicles and all entities that may be related to vehicles, in order to reduce accidents, traffic congestion, and provide other information services [2].

However, vehicle nodes move rapidly, network topology changes frequently, urban road traffic environment is complex in the IoV, and the existence of ultra-intensive network will cause serious communication interference. These problems will hinder the further development of IoV. Therefore, how to improve the communication quality of IoV and ensure reliable communication will be the focus of future research. In recent years, the relay cooperation technology has become more and more mature, and the source node can use a large number of relay nodes to assist in transmitting data, which not only expands the communication range, but also improves the diversity gain of the system. Research on the application of relay synergistic technology in the IoV emerges in an endless series. Literature [3] attempted to apply the shortest path based relay selection algorithm to the IoV. This method selects the node with the smallest hop distance from the user node as the relay, which is difficult to adapt to the IoV where network congestion may occur frequently. Therefore, some researchers proposed a relay selection algorithm based on the residual energy of nodes [4] and a relay selection algorithm based on the minimum load [5].

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In many studies, RoadSideUnit (RSU) were usually used to provide relay service for vehicles that can greatly reduce the delay. However, the characteristics of the IoV, such as dynamic topology structure and high-speed movement of vehicle nodes, which will affect the stable link between the vehicle and the RSU, leading to frequent link switching and additional delay. Consequently, some researchers proposed that mobile vehicles should be regarded as relay nodes to provide users with network access services, which can not only reduce equipment costs but also better adapt to the dynamic changes of the IoV [6]. However, the above algorithm considers too single factors and cannot fully meet the needs of most applications. The best solution is to integrate and analyze multiple influencing factors. Literature [7] proposed a multi-objective optimization mobile relay selection method, and the higher the predicted value of node handover (that is, the time the relay node stays in the cross area between the user's communication range and the non-shadowed area is longer than the communication time), the higher the predicted value of throughput will be selected as the optimal relay.

Based on the above, in view of the city road Vehicle to Infrastructure (V2I) communication in the scene, a large number of mobile vehicles are considered as candidate relays in this paper, and the performance parameters such as delay, bandwidth, node handoff predictive value and the demand of user vehicles are considered comprehensively. Then, a simple linear weighting method is used to find the optimal relay. This scheme will improve the data transmission rate, reduce the time delay, and alleviate the link instability caused by the vehicle nodes entering the shadow area. This more comprehensive and multi-angle relay selection method is more suitable for various needs of future IoV and can effectively improve user Quality of Service (QoS) satisfaction.

2. The system model

Figure 1 showed the proposed system model, which mainly considers the urban traffic environment. In the urban traffic environment, various signal interference or building shielding can easily create blind areas or shadows that hinder communication between users' vehicles and infrastructure. Therefore, the user vehicle in the shaded area can select the optimal relay to assist it in forwarding data according to the relay selection method presented in this chapter. On the one hand, the selected optimal relay should meet the requirements of user bandwidth and time delay and be superior to other candidates. On the other hand, the duration of the selected relay in the cross area between the user communication range and the non-shadowed region is longer than that of other candidates.

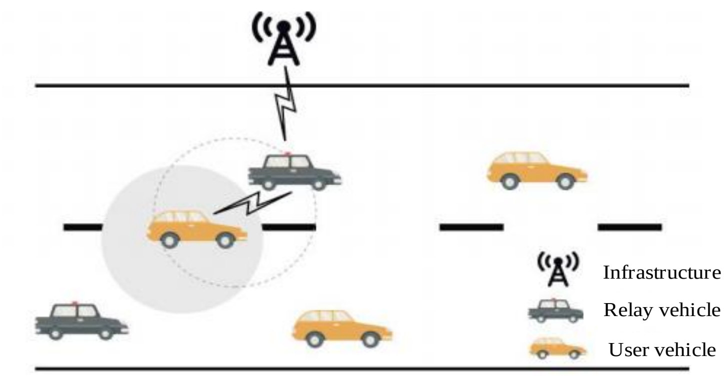

Fig. 1 System model

3. Relay selection scheme based on multi parameter decision making

The relay selection scheme based on multi parameter decision is mainly divided into the following parts.

First, determine whether direct communication is possible. The user vehicle analyzes the information from the base station or infrastructure. If the RSS is greater than or equal to the preset value of RSSTH,

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and the bandwidth and delay meet the needs of the user, the user vehicle switches to the direct communication mode to communicate with the base station or infrastructure. Instead, relay needs to be selected to forward the data.

Secondly, determine the candidate relay. The user vehicle will carry the bandwidth of the vehicle node and the delay to send around the vehicle. If the relay vehicle node receiving the user's vehicle message can provide higher bandwidth and lower delay than the user's vehicle, it will reply the confirmation message to the user's vehicle, which carries its own bandwidth, delay, speed, direction and other information, and become one of the candidate relays. If the user vehicle does not receive a reply confirmation message, the request will be terminated.

Secondly, determine the optimal relay. The normalized processing of these three attributes eliminates the difference of dimension and order of magnitude. Then, the weight value of each attribute is determined artificially. In this chapter, the three weight values are set as one third. Finally, the linear weighting function value Q is obtained. The candidate relay with the largest Q value is selected as the optimal relay for the user's vehicle.

Finally, the characteristics of multiple parameters of each candidate relay are normalized, and the weighted coefficients are allocated respectively, and the sum is added. The candidate relay with the largest sum value is the optimal relay. The parameters involved in this scheme are assigned the same weighting coefficients.

4. The simulation analysis

In this paper, OMNET++ simulation tool was used to evaluate the performance of the proposed scheme, and the proposed scheme was compared with random relay scheme and shortest path relay scheme in terms of throughput and relay handoff times respectively.

Fig. 2 shows the impact of changes in the communication range of the relay vehicle on the system throughput. As shown in the figure, with the expansion of the communication range of the relay vehicle, the number of available relays within the user's communication range increases, the chances for users to select the optimal relay increase, and the system throughput gradually increases. The histogram of the three relay selection methods all show an upward trend. Among them, the relay selection method proposed in this paper has more obvious advantages. The reason for this phenomenon is that this method takes the predicted handover value of nodes into consideration and selects the candidate relay with the highest available bandwidth and the longest time to assist users to forward data as the optimal relay, which reduces the relay handover times and packet loss rate in the communication process of users and enables more data to be transmitted accurately.

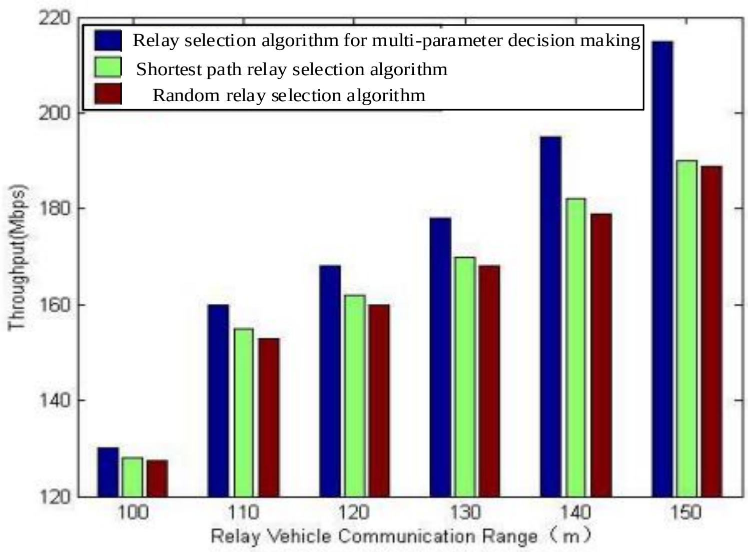

Fig. 2 The impact of relay vehicle communication range on throughput

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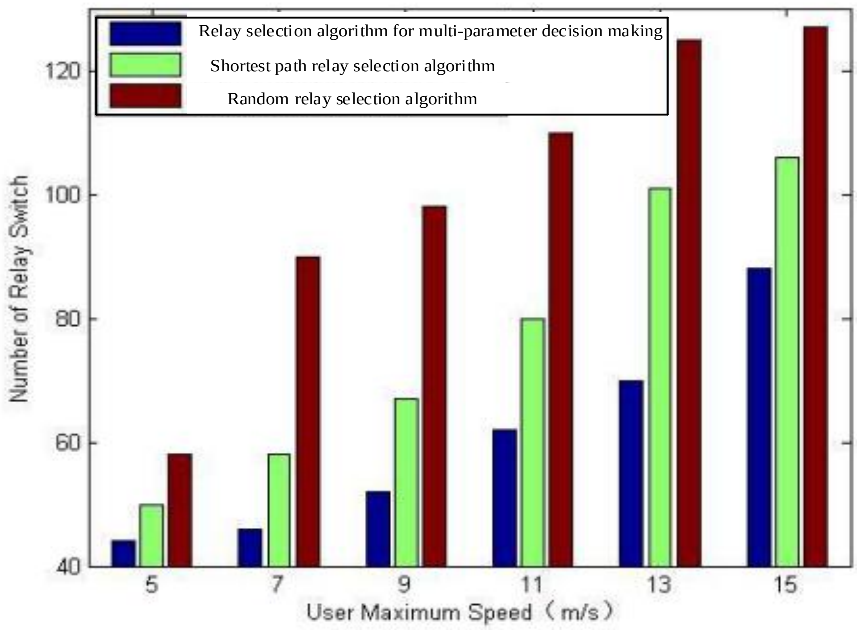

Fig. 3 The effect of user maximum speed on the number of relay switches

Figure 3 shows the influence of changes in the maximum speed of the user's vehicle on the number of relay switches. Among them, the communication range of the relay vehicle is fixed and takes 100m. As the relative speed of the user's vehicle increases, the relay switching becomes more frequent. Among the three relay selection methods, the multi parameter decision relay selection method proposed in this chapter has the least cumulative handoff times, because this method takes the node handoff prediction value as the selection basis of the optimal relay.

Acknowledgements

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