Vehicular Streaming Handoff Control Mechanism based on the Prediction Buffer Control

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Abstract. Because vehicles run in high speed environments, data transmission may be interrupted by the handoff between various roadside units (RSUs). This study focuses on the roadside-to-vehicle (R2V) network environment, and uses the dedicated short range communication (DSRC) to achieve seamless handoff control on a streaming service. To achieve this goal, each vehicle is equipped with the global positioning system (GPS) to collect the vehicular position information. Then the information will be exchanged between two ends of the communication by DSRC. According to the collected positioning information, the vehicle can estimate the link expiration time (LET) between the two communicating vehicles. Furthermore, this paper studies two cases of handoff in vehicular networks which are the non-overlapping handoff and the overlapping handoff. A simple formula is designed to calculate the vehicular total buffer size and to adjust the transmission of the data flow in these two cases. Finally, we used the network simulator to estimate the performance of our proposed mechanism. The simulation results show that can predict dynamic buffer size and achieve seamless handoff control for R2V. In addition, the completion ratio of QoS reaches 96.8% when the moving speed is 60 km/h.

Keywords: dedicated short range communication, seamless handoff control, telematics, Vehicular.

1 Introduction

Wireless devices used in vehicles and road-side are called on-board units (OBUs) and road-side units (RSUs), respectively. We can establish the intelligent transportation systems (ITSs) based on the OBUs and RSUs to provide services [1], such as car safety, fleet management, driver assistance, and emergency roadside assistance. However, multimedia streaming services are one of the crucial future research topics in the vehicular ad hoc networks (VANET) environment [2]. Therefore, wireless streaming technology develops a real-time video streaming protocol to deliver video packets. With the improvement of video quality, the performance metrics for the delivery of real-time video packets will be focused on the delay time and the packet loss in a wireless environment. The video playback smoothness and quality of service are usually used for system adjustment in multimedia streaming control [3][4]. Because vehicles move at high speeds, users frequently go forward to access wave base service set (WBSS) area on the road. Under a mobile network, a scheme for buffer control was designed to reduce packet loss for mobile nodes in the handoff process [5]. IEEE 802.11p is an approved amendment to the IEEE 802.11 standard to add wireless access in vehicular environments (WAVE). We use IEEE 802.11p wireless network standard to build a telematics system and personalize safety services. The main objective of this study is to provide a smooth streaming service in the situation of road-side unit distribution. A GPS is used to collect the parameters of vehicles and road-side units, such as the current position and the forward direction. These parameters are used to predict the link expiration time. Then, with the estimation of the LET, we can predict dynamic buffer size and achieve seamless handoff control for R2V.

The reminder of this paper is organized as follows. Section 2 describes seamless handoff decision models. The predictable dynamic buffer control mechanism is discussed in Section 3. Some simulation results are shown in Section 4. Finally, we give a brief conclusion in Section 5.

$v_{1} \sin □ 1 □ v_{2} \sin □ 2 \quad y_{1}$

2 Seamless Handoff Decision Models

Because of the frequent change of Vehicle Network (VANET) topology, vehicles driving on the road exhibit several unexpected behaviors. Under such an unstable environment, this study explores the manner that vehicles can use the transmission control mechanism by DSRC to smoothen the packet delivery. The deployment of RSUs is a vital part of the telematics environment. How to connect with a stable source to establish a smooth transmission path on the road is a crucial research issue.

$v_{1} \cos □ 1 □ v_{2} \cos □ 2$

2.1 Link expiration time

This section presents the LET prediction method. If the motion parameters of two neighbors are determined, the duration that these two mobile nodes remain connected can be determined. Assume that two mobiles, 1 and 2, are within the hearing range of each other, and the transmission range is r. Let (x_1, y_1) and (x_2, y_2) be the position of the mobiles 1 and 2, respectively. Let v_1 and v_2 be the speeds of mobiles 1 and 2, and

and be the headings of mobiles 1 and 2, respectively. Therefore, D_t is the duration for which they remain connected, denoted as Equation (1)

$^2+$

$^2 + ^2) ^2 ($

Where

a = b =

c = d =

2.2 Judgment method of handoff

As we mentioned before, according to the transmission coverage of RSU, there are two handoff cases which are non-overlapping and overlapping handoff as shown in Fig. 1. Following, we simply describe how to determine which handoff case is encountered for a vehicle.

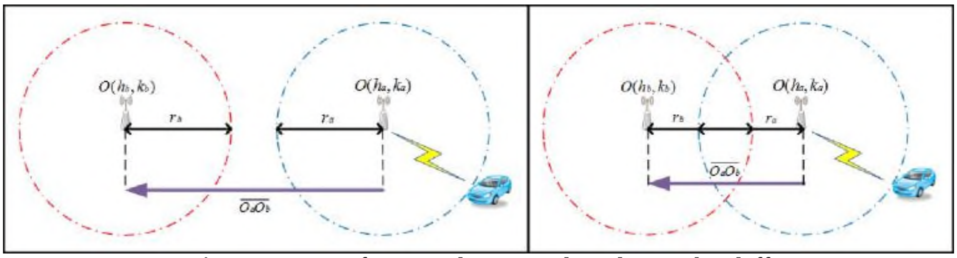

Fig. 1. Situation of non-overlapping and overlapping handoff

Assume that the position of two RSUs are and , and the transmission ranges are and , respectively. The distance of two RSUs is denoted as . According to the observation, we can obtain the relation of and the transmission ranges, and , as shown in the Equation (2) for non-overlapping handoff and Equation (3) for overlapping handoff.

(2)

(3)

3 Predictable Dynamic Buffer Control Mechanism

In the telematics environment of this work, vehicles usually require connecting to RSUs to access external networks. The handoff process will be initiated when a vehicle moves from the coverage of one RSU to another RSU's. If the handoff process consumes too much time and causes a higher delay of the data transmission, it will affect the quality of network transmission, especially for the real-time transmission. To prevent the influence on the real-time traffics, the multimedia streaming will be downloaded in advance to the client's buffer. Therefore, it can alleviate the influence of any destabilizing factors, such as delay and jitter.

3.1 Non-overlapping handoff

In this situation, there is a disconnecting time before connecting to the new RSU. Therefore, we have to estimate the duration of disconnection. Before moving our of the transmission range of the RSU, as many as data packets download to the vehicle's buffer for the play of the disconnection period. When the vehicle enters the transmission range of the RSU_1, it needs to predict the total connecting time before leaving the transmission range. The method is the subtraction of RSU_2's transmission range of the vehicle entering contact and RSU_1's transmission range of the vehicle leaving contact. This value of subtraction represents the distance of disconnection, as shown in Fig. 2. (a) The value is subsequently used to divide the speed of the vehicle and obtain the disconnection time of D_t. Therefore, we use D_t and D_i to determine the adjustable bit rate of the vehicle when entering the RSU. We use the coordinates of the tangent point as the point of vehicle entry. We use tangent equation to calculate the next RSU communication range coordinate's point $P(X_2, Y_2)$. In addition, when the vehicle speed is fixed, we estimate the coordinate's point $P(X_1, Y_1)$ because of the division of connection time and speed. Subsequently, we use $P(X_2, Y_2)-P(X_1, Y_1)$ to obtain a distance of d_2, and determined the size of pre-buffer. This pre-buffer size is called D_t and is denoted as Equation (4)

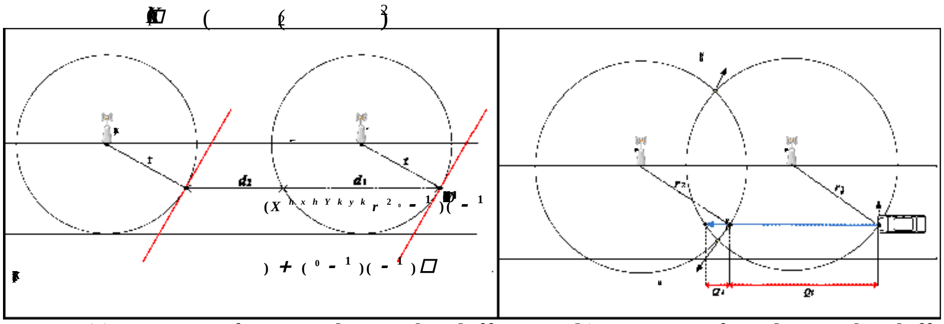

Fig. 2. (a). Situation of non-overlapping handoff Fig. 2. (b). Situation of overlapping handoff

(4)

(5)

3.2 Overlapping handoff

Fig. 2. (b) shows that a vehicle periodically receives the broadcast message from the RSU, if it enters the RSU (R_1) transmission range. The vehicle simultaneously calculates the prediction of D_t. Subsequently, we attempt to determine the Q_t. We express the vehicle entry point $P(X_0, Y_0)$ to (X_0). The contact of the (R_2) means the vehicle entry point $P(X_1, Y_1)$ to (X_1). The contact of the (R_1) means the vehicle leaving

point $P(X_2, Y_2)$ to (X_2). A calculation only performs in the X-axis, as follows Equation (5). Subsequently, it is easy to calculate Q'_t, as .

A management mechanism is required for the transmission and buffer controller to achieve smooth video playback. We use the pre-buffer to dynamically adjust transmission rate to provide seamless handoff of streaming service. To dynamically adjust transmission rate to control buffer size, we use the video playback time of interruption to determine transmission variation rate, which is denoted as Equation (6).

$$\text{Transmission Variation Rate} = \quad (6)$$

Where

D'_t : Network interruption time (sec.) FR : Frame rate (fps)

FS : Frame size (Kbyte) PB : Pre-Buffer time (sec.)

4 Experiments and Performance Evaluation

We would like to examine the performance of the proposed scheme. A simple topology is used in our simulation which is a one-dimensional highway. The simulation tool is the NS-2. We use the parameter sets of IEEE 802.11p physical (PHY) and medium access control (MAC) Layer. The moving speed is 80 km/h. The maximal transmission range is 1061 meter. Fig. 3. (a) shows the adjusted transmission rate and actual receive rate. The distance between two RSUs is varied from 1000 to 3000 meters. Once the distance between two RSUs is over 1600m, it will change to the non-overlapping case. As mentioned before, the vehicle will encounter a disconnecting duration. Therefore, the Equation (6) is used to determine the buffer size that has to be downloaded in advance, and the adjusted transmission rate to meet the download requirement.

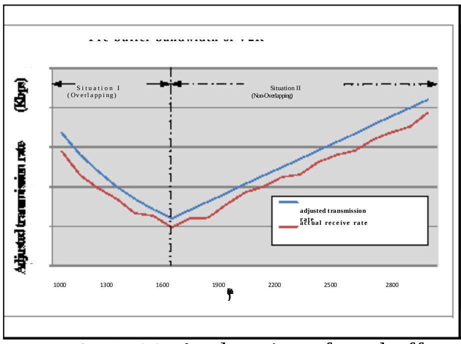

Fig. 3. (a). Analyzation of pre-buffer bandwidth

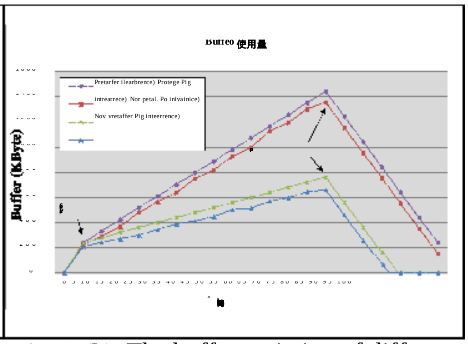

Fig. 3. (b). The buffer variation of different situation

Fig. 3. (b) shows the utilization of buffers at the client. When the vehicle starts to download data, it will pre-load data into the buffer first for approximately 5 second before playing. According to our scheme, the transmission rate of RSU will be

adjusted to download data in advance to prevent the interruption of disconnection. The utilization of buffer will be raised until the disconnection period starts. As we can see in Fig. 3.(b), the vehicle is out of the transmission range of the first RSU at 70 second. The client starts to consume the pre-downloaded data in the buffer at 70 second. In our scheme, the pre-downloaded data is sufficient for the play during the disconnection period till 100 second. However, without adaptive scheme, the play of data frame can only be lasted to 86.5 second. This causes an interruption of playing data frame about 13.5 second.

5 Conclusion

This study is focused on the sparse deployment of RSUs in the R2V communication environment. We propose a pre-buffered scheme that uses the concept of LET to perform buffer and flow control. It can achieve seamless handoff to offer a smooth video for clients. The NS2 simulation demonstrates that the scheme is feasible in a one-dimensional environment on the road. Although the RSU distribution is variable, we can predict the connection time and control the transmission rate to download data in advance before disconnection taken place. The pre-downloaded data can be played during the disconnection period. Future studies will expand the link time prediction from a one-dimensional road to a two-dimensional urban city, and the moving speed of vehicles will be dynamically changed to examine the performance of the proposed scheme for streaming service.

Acknowledgments

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