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An Efficient Safety Message Transmission Protocol for Secure Grouping of Vehicles VANET

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Abstract: VANETS have been a vital part in the associated vehicle venture , which has been driven by the U.S Department of Transportation in an e ort to enhance driver wellbeing and help individuals drive vehicles all the more effectively. The associated vehicle venture has be-come a promising answer for astute transportation framework. Thus, numerous auto mak-ers are starting to build up the associated vehicles. The improvement and trial of associated vehicles requires numerous testbeds in different areas. the VANETs standards have distinguished channel structures. The VANETs standard supports six service channels (SCHs) and one control channel (CCH). Each of these seven channels has a 10 MHz bandwidth and a 50 ms interval sharing a 100 ms interval equally. Vehicles are free to join any one of six service channels during SCH intervals. Usually safety information is transmitted in a short-text message format. This short message ensures fast and reliable delivery in restricted (e.g., 10 MHz) and unreliable channels in VANETs. the proposed algorithm for utilizing multiple channels is to divide the entire multimedia safety application information into packets considering the number of available SCHs and deliver the packets in each SCH. This scheme is called divide-and-deliver. This approach minimizes the amount of bandwidth used in each channel when delivering multimedia messages. With the multi-hop forwarding, the divide-and-deliver scheme, however, can deliver multimedia messages quickly to the target vehicle or infrastructure with fewer CCH intervals.

I. INTRODUCTION

The VANETs standards have distinguished channel structures. The VANETs standard [1] supports six service channels (SCHs) and one control channel (CCH). Each of these seven channels has a 10 MHz bandwidth and a 50 ms interval sharing a 100 ms interval equally. Vehicles are free to join any one of six service channels during SCH intervals. However, all vehicles should stay on a single control channel during CCH intervals for disseminating or listening to safety information. In addition, periodic beacon messages from vehicles will be broadcasted in this CCH channel. Even though the standard supports multiple channels, a lot of traffic will be disseminated on a single control channel. Alternatively, users can also enjoy the benefits of using rich mul-timedia content Usually safety information is transmitted in a short-text message format. This short message ensures fast and reliable delivery in restricted (e.g., 10 MHz) and unreliable channels in VANETs. (e.g., video, audio) to easily recognize and understand the information. Some studies already address the significance of multimedia information in safety applications [2, 3].

For the multiple channels, one interestign approach is aggregating multiple channels. This is called channel aggregation [4][5][6]. This channel aggregation is a new feature in LTE-advanced technology which improves throughput rapidly

Network coding is a packet-level coding technique to mix information from every packet enabling each packet to have information from other packets. Originally network coding was proposed for efficienttmulticast protocol in [7]. Two packets are under an exclusive-or (XOR) operation creating one coded packet. A receiver can decode each packet if it has one coded packet and any one of original two packets. This coding technique helps reducing the complexity of multicast routing as well as achieving the maximum data transfer rate from a source. This characteristic brings many interests on the network coding area [8][9].

II. PROPOSED WORK

The concept of the divide-and-deliver scheme involves dividing the information into smaller packets and delivering them on each channel. If there are N channels and the size of in-formation is S bytes, each channel will deliver S/N bytes. If the S /N is larger than the maximum size of a packet, they will be delivered as several packets.

Until packets arrive at the target location, the packets will go through both SCH and CCH intervals repeatedly. After vehicles receive packets in CCH intervals, they need to select one of the SCH channels while preparing the next SCH interval. For the selection of the next SCH channel, a common rule between vehicles should exist regarding which channel a vehicle can choose and which packets they can deliver. Without that rule, the packets cannot be delivered to the target location successfully.

Fig. 1 shows the case of duplicated packets without a rule. For example, the number of original packets is four. In the T1 interval, all vehicles receive four packets. In the T2 interval (SCH), vehicles select one of the channels and decide which packet they will send in the channel. The number inside a shape (rectangle or hexagon) represents the selected packet. Each packet is delivered to another vehicle in the T2 interval. In the

T3 interval (CCH), a vehicle receiving a packet in the T2 starts broadcasting the received packet. Then, the packet 4 has been missing while the packet 3 is duplicated. As seen from this example, divide-and-deliver scheme could not forward the original information to the end point without a rule that restricts the selection of packets to be forwarded in a given channel.

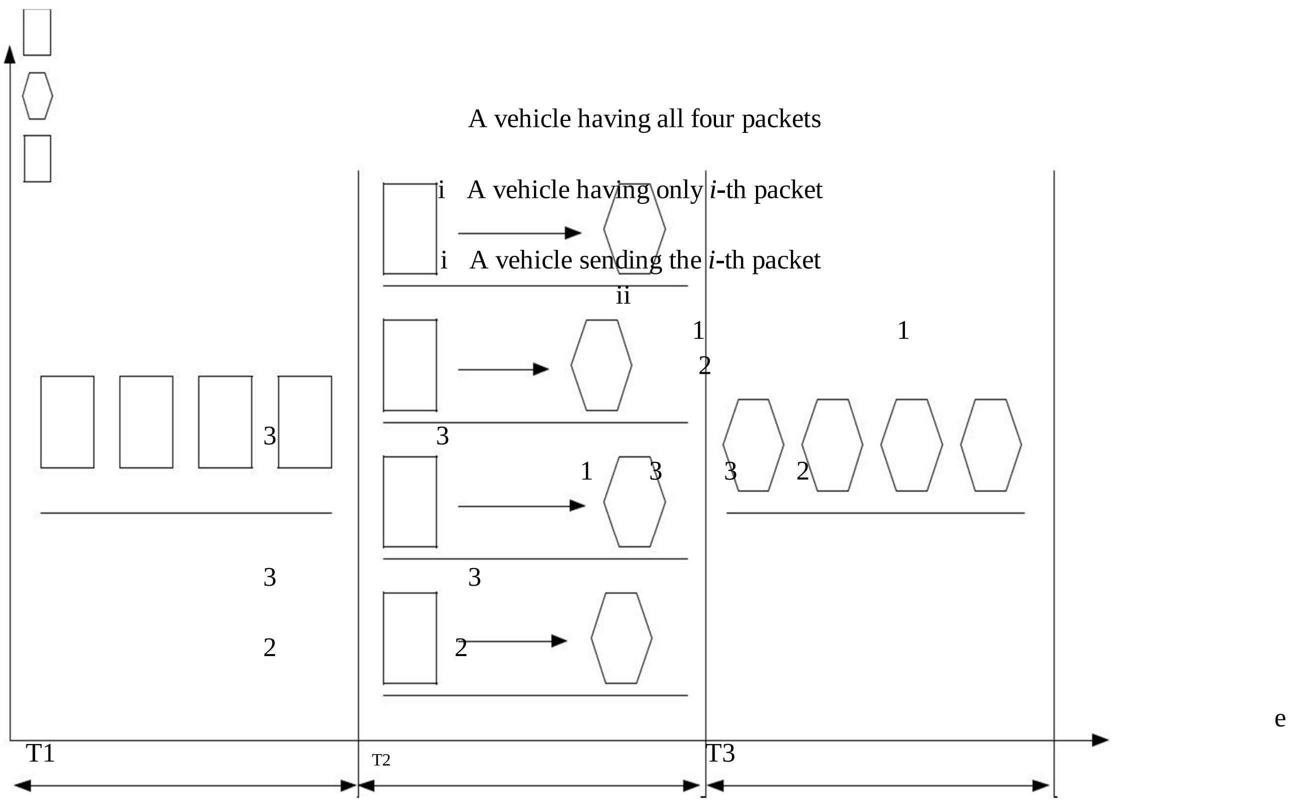

Fig. 1 Duplicated Packets over Multiple Channels

To solve this problem, a simple rule is used in this thesis.

A packet should be delivered through the same SCH channel from the first SCH interval until it arrives at the target point.

To apply this rule, a packet needs to include the previous SCH channel information.

Then, a vehicle knows which channel the received packets came from and the packets should be delivered in the next SCH interval.

This rule restricts the available channels for a vehicle to select in SCH intervals.

When a vehicle is selecting an SCH channel, it investigates all the packets it receives and creates a list of previous SCH channels.

Then, it chooses one of the channels from the list for the next SCH channel.

If a vehicle did not receive any packet to be rebroadcasted, it can choose any SCH channel freely.

With this rule, the event that sending duplicate packets across channels as shown in Fig 1 can be removed. Fig. 2 describes the above algorithm.

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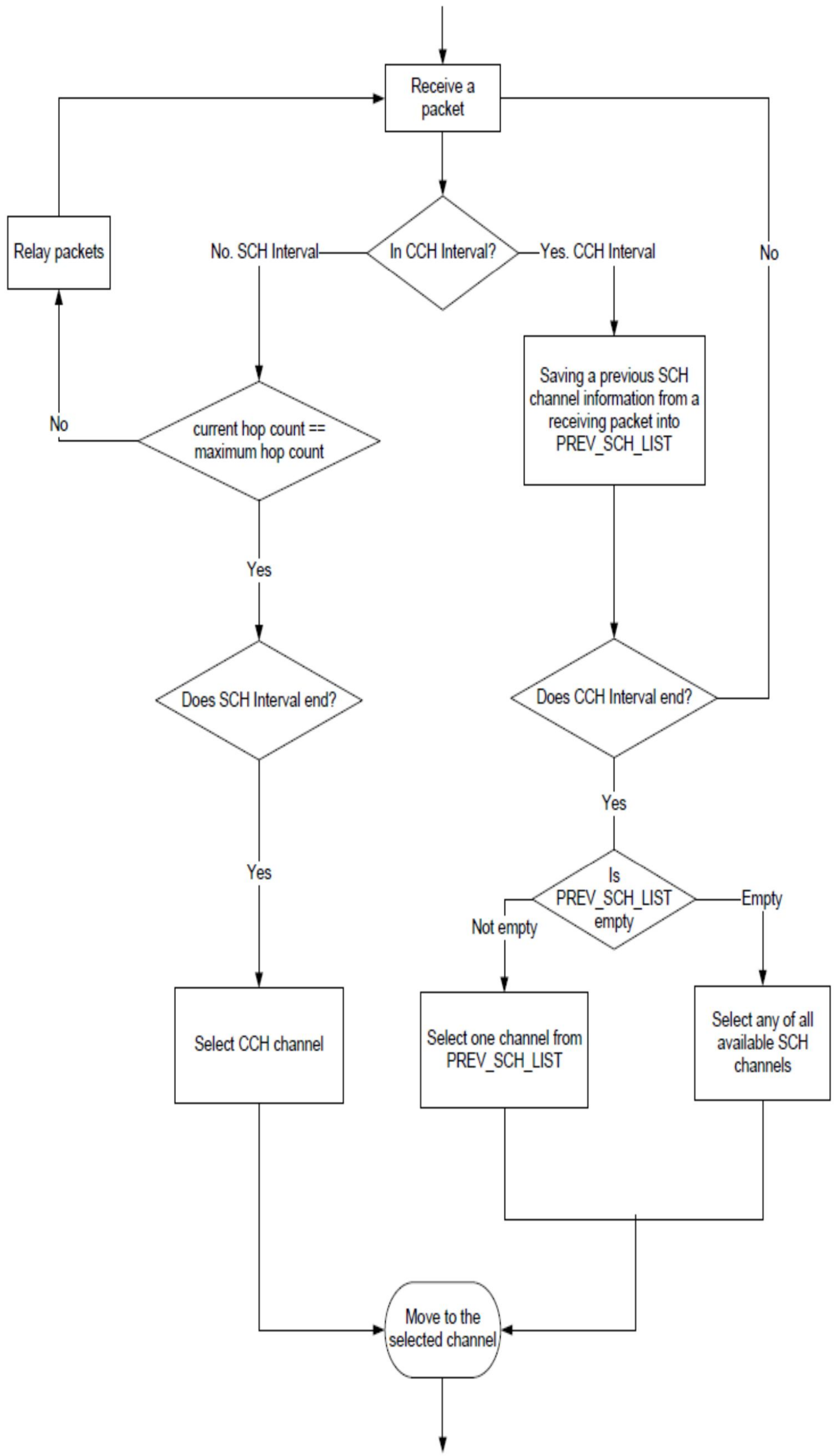

Fig 2 Flowchart for Channel Selection in Divide-and-Deliver Method

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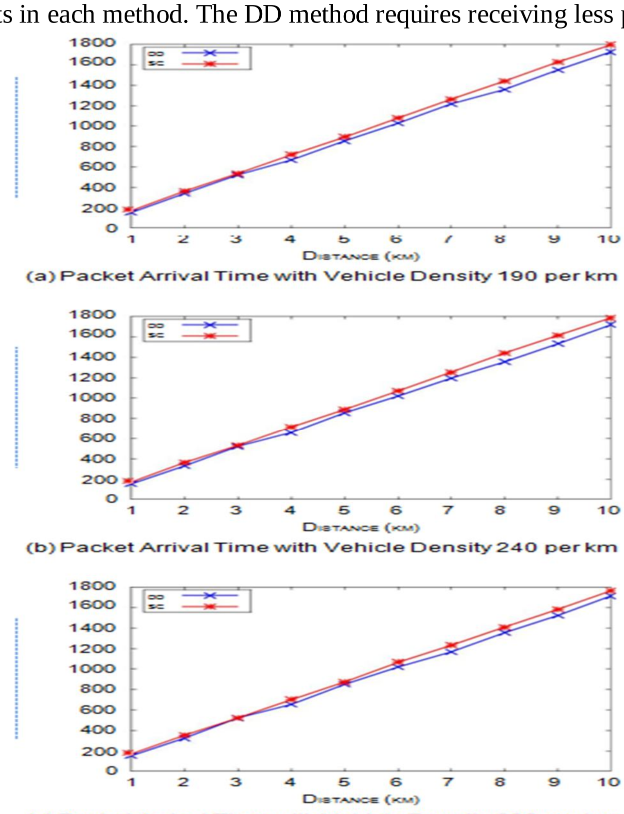
III. RESULTS AND DISCUSSION

In this section, the delay between divide-and-deliver (DD) method and the single channel method (SC) will be shown by simulations. For the simulation, NS-3 is used [10]. The packets are generated at 0-km point and delivered to the end point at 10-km. The arrival of packets is measured every kilometer, which shows the delay at each kilometer. The size of the packet is 1K byte and the number of packets sent in the common channel interval is 12. This amount of packets prevents multi-hop delivery in a single channel since it occupies more than 70% of the bandwidth in a channel. For the high density environment, three density settings are used: 190, 240 and 290 vehicles per kilometer, respectively. To compare the delay and reliability, two algorithms (DD and SC) are used as described in the previous sections. First, the delay of single hop case in SCH intervals will be investigated. Then, the delay of multi-hop case of the DD method will be explained. Fig 3 shows the delay of single hop case in SCH intervals for both methods. The delay is measured at each point with various vehicle densities. The delay increases as the distance (or location) of the measuring points increase. In higher density situations, packets arrive at each measuring point faster than lower density case. For the comparison, Fig 4 shows the difference of packet delay at the same measuring point (10 km point) with different densities. Even though the difference is small, the delay decreases as the density increases. This delay change according to the density is seen inboth methods. This difference in delay is due to the distribution of vehicles. When vehicle density is high, there is higher chance of vehicles that exist at the edge of radio range from a source vehicle. These vehicles farther from a source vehicle have a longer hop distance and the total delay from the source to the final destination will be shorter. Therefore, the performance of total delay from the source to the destination has a direct correlation with the one-hop distance. Fig 5 shows the change of one-hop distance when the vehicle densities vary. As expected, the hop distance increases as the densities go higher. In SCH and CCH intervals, distinctive differences in one-hop distance can be observed due to the vehicle density differences between the two channels. Since all the vehicles stay on the same channel in CCH intervals, the vehicle density is higher in CCH intervals than SCH intervals. So, even in the same vehicle density, there is another density difference according to the intervals. The hop distance in the CCH intervals is higher than in the SCH intervals. Fig 6 shows the hop-distance in CCH and SCH intervals, respectively. When the higher vehicle density reduces the delay in both methods, there are differences between two methods in the same density. As shown in Fig 3 and Fig 4, though the delay difference is small, the DD method has less delay than the SC method. The small delay in the DD method is explained by the longer one-hop distance of the DD method in Fig 5. This longer hop-distance is caused by the difference in the number of required receiving packets in each method. The DD method requires receiving less packets than the SC method.



(a) Packet Arrival Time with Vehicle Density 190 per km

(b) Packet Arrival Time with Vehicle Density 240 per km

(c) Packet Arrival Time with Vehicle Density 290 per km

Fig 3 Packet Arrival Times

When a wireless channel status is good, the difference between two methods can be small. However, in a real situation, the vehicle at the edge of radio range would have a low Signal-to-Noise Ratio (SNR) value. Also the wireless channel for mobile communication includes fading. So, to compare the performance of two methods, considering the various bit error rates (BER) is useful. To show the effectivenessof each method, three metrics (one-hop distance, number of hops and packet arrival time) are compared and all these metrics are closely related.

Fig 7 shows the one hop distance according to different BERs. When the BER is good enough, both the DD and SC method have a similar one-hop distance since there is a small chance of a packet dropping. However, as the channel becomes worse, the BER deteriorates accordingly and the one-hop distance between the transceiver changes. Generally, the one-hop distance starts decreasing in both methods. However, while the distance decreases slowly in the DD method, the SC method shows a rapid decrease. The slow decrease shows the DD method is resilient in low BER situations mostly because of the reduced packets will reduce the probability of packet loss in the DD approach. This resilience is connected to a longer one-hop distance in the DD method. The one-hop distance is decided by a relay vehicle. The relay vehicle is usually selected from the vehicles that are located closely to the edge of the radio range. Those vehicles usually experience lower BER than other vehicles that are closer to a source vehicle. So, the better performance in the low BER implies the better chance of the vehicles at the edge of the radio range receiving packets successfully.

Figure 8 shows the number of hops when packets arrive at the target device which is 10 km away from the packet origination. The DD has a smaller number of hops since it has a longer one-hop distance.

Figure 9 shows the delay to the target point in different BERs. By the larger one-hop distance and smaller number of hops, the DD method shows smaller delays reaching the target location at 10 km than the SC method.

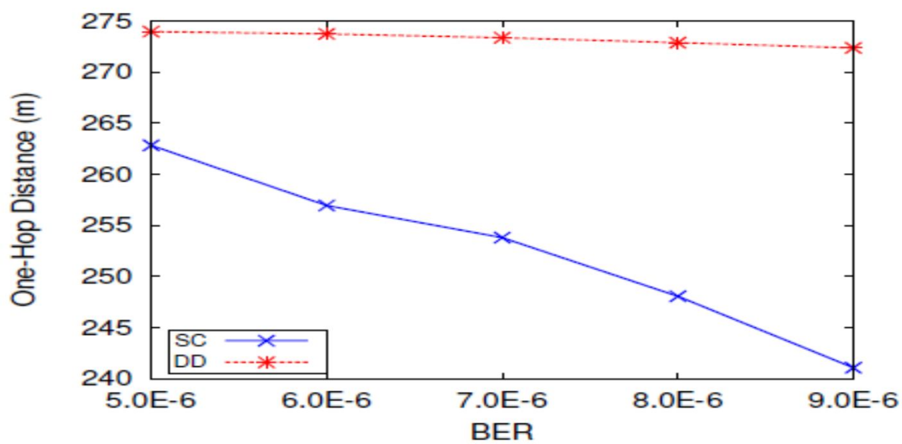


Fig. 4 One Hop Distance by BER

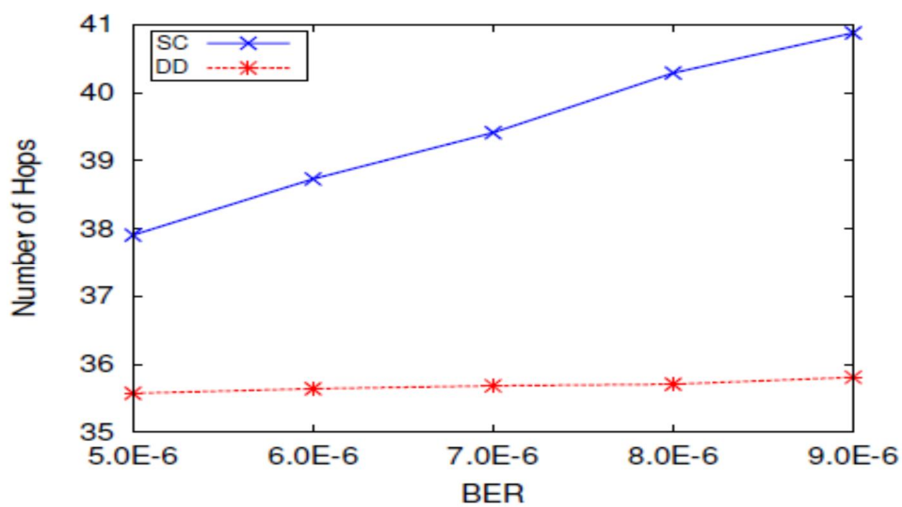


Fig 5 Number of Hops by BER

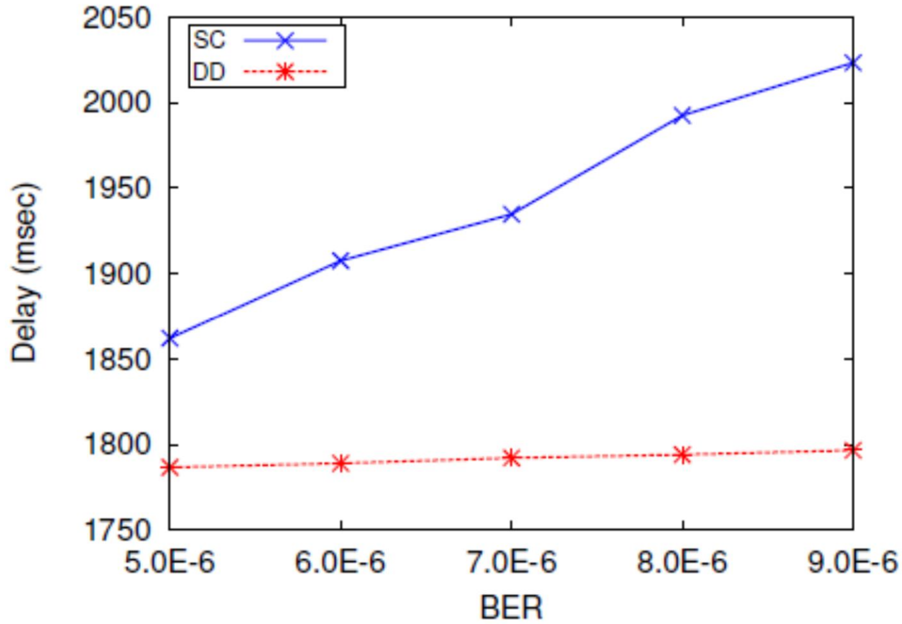
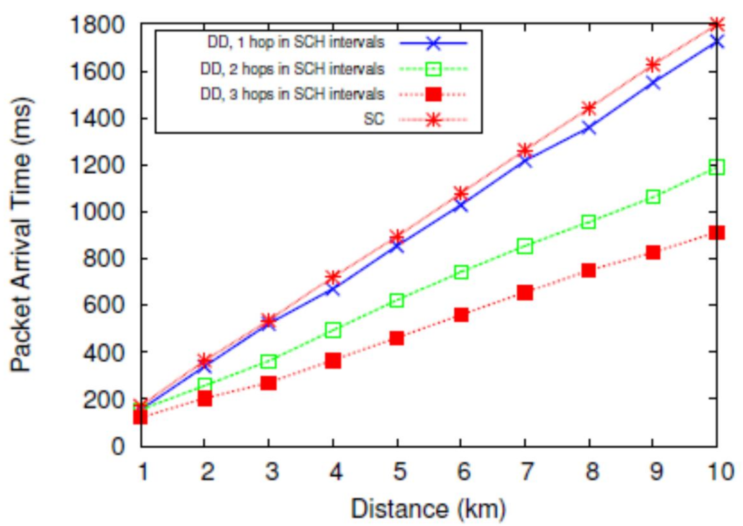


Fig 6 Delay by BER

These results are important and demonstrate the DD method brings better performance than the conventional single channel method even without using the multi-hop delivery in SCH intervals, which is the main strength of the DD method. Considering the varying characteristics of wireless channel in VANETs, the strong aspect of the DD method in low BER situation becomes critical.

Next, the case when multi-hop delivery is used in SCH intervals is simulated. While the SC method cannot use multi-hop in a service channel, the DD method can use the multi-hop in SCH channels. Figure 10 shows the e ect of multi-hop forwarding in the service channel. The number of hops increases from one to three. As mentioned in Section the maximum number of hops in a channel is equal to the number of available channels, which is six in the current VANETs specification. However, in this thesis, the possible maximum number of hops is limited to three. If the number of hops becomes six, it will use most of the available bandwidth in the SCH intervals. Then, all other trafficthrough the SCH channels will be congested. In the simulation, the maximum number of hops is set to the half of the possible maximum number, which is three. Figure 10 shows the reduced end-to-end delay as the number of multi-hop varies in each channel.



(a) Packet Arrival Time with Vehicle Density 190 per km

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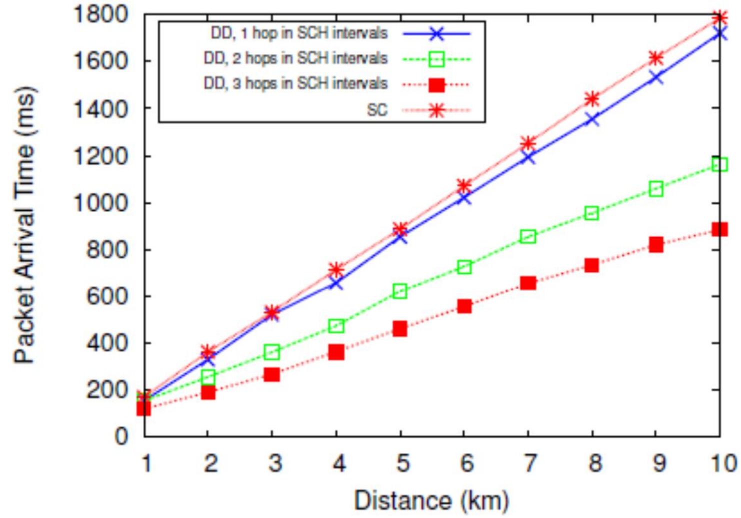
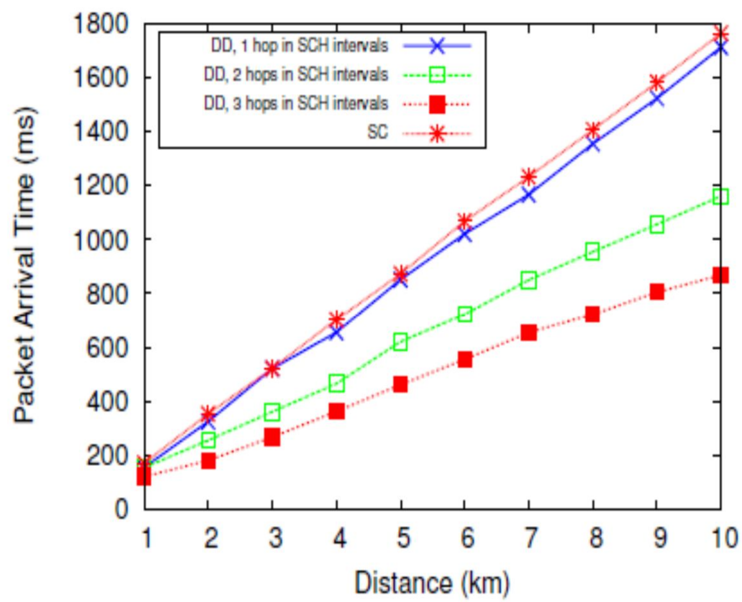


(b) Packet Arrival Time with Vehicle Density 240 per km



(c) Packet Arrival Time with Vehicle Density 290 per km

Fig 7 Packet Arrival Times with Multi-Hop in SCH Intervals

IV. CONCLUSION

While VANETs support multiple channels, the mixed structure of CCH intervals and SCH intervals is not efficient to deliver a large amount of information quickly since only one channel exists in CCH intervals. To reduce the excessive usage of the control channel, divide-and-deliver has been introduced in this research. The divide-and-deliver method provides a way to use multiple channels effciently. The multiple deliveries in SCH in-tervals that is not available to the conventional single channel method help deliver a large amount of safety information quickly. Also, the reduced number of packets that each vehi-cle receives makes divide-and-deliver more reliable in low BER environments. Consider-ing moving vehicles that experience various status of wireless channel, this reliable feature of divide-and-deliver becomes more important. In a lower BER environment, divide-and-deliver can forward packets with longer one-hop distances. This longer one-hop distance reduces the delay to the target location and consequently enables the proposed divide-and-deliver algorithm to be an effective tool to deliver safety information while utilizing multi-ple channels in VANETs.

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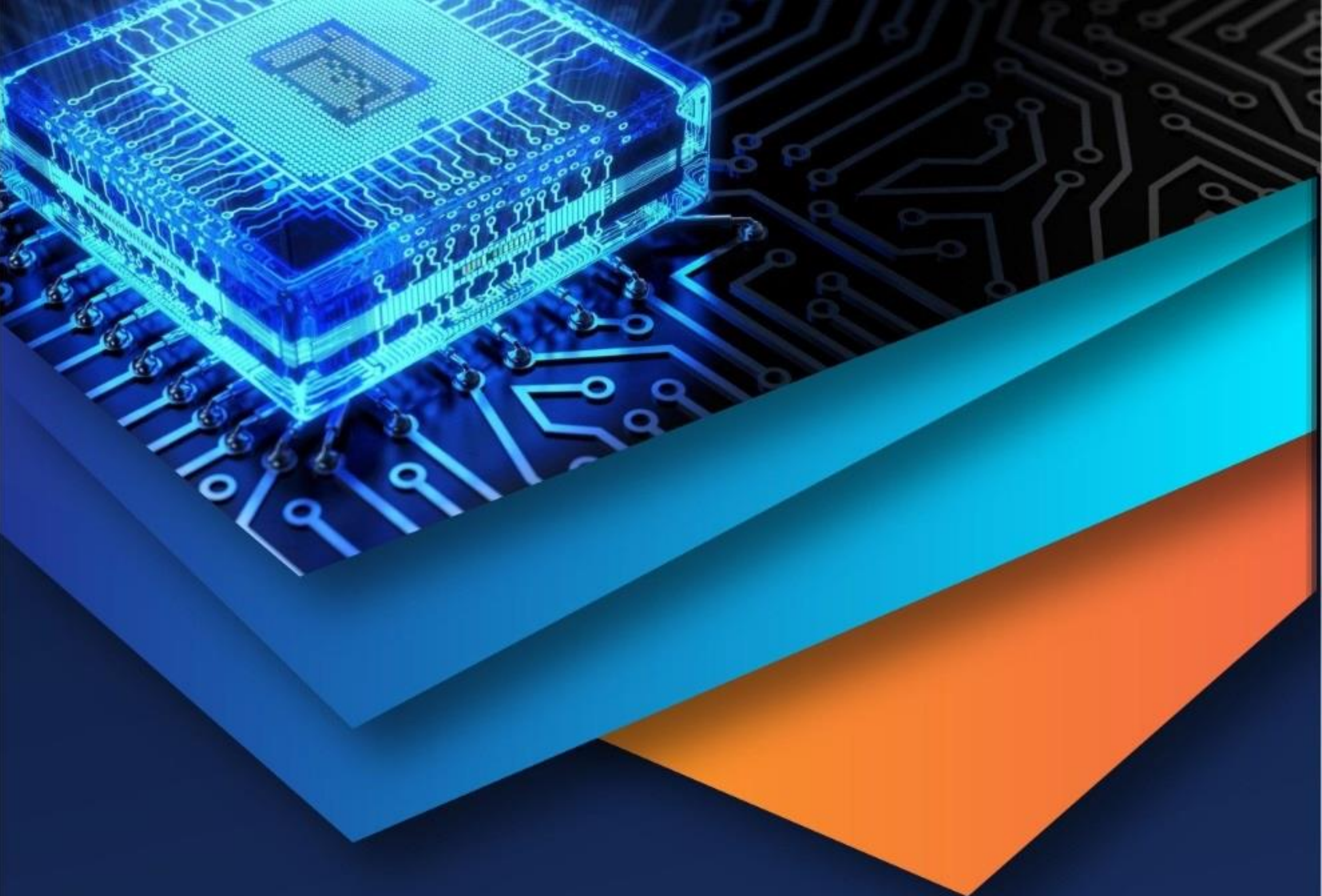

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