Efficient Detouring of Vehicles after Accident

Hamayoun Shahwani, Muhammad Ashraf, Muhammad Umar Chaudhry

ABSTRACT--- This paper considers the detouring of vehicles after accident. Detouring is necessary to mitigate traffic congestion around the accident area. This work is the continuation of our previous work in which we proposed an effective way of processing and dissemination of accident information to the vehicles moving towards the accident area. The work in this paper shows the efficiency of detouring of vehicles after receiving information about the accident. The results show that receiving information on-time will help in improving the efficiency of detouring of vehicles from the accident area and minimizing the traffic congestion.

Index Terms: VANET, detouring, efficiency.

I. INTRODUCTION

Vehicular Ad-hoc Networks (VANET) have been considered to provide communication services using Dedicated Short Range Communication (DSRC) at a very low-cost. DSRC is a standardized service for VANET by IEEE [1]. VANET usually consists of on-board units on vehicles and road side unit (RSU), on-board unit may contain tens of sensors. Vehicles sense data and send it to the RSU for further process. VANET help drivers to cooperate and exchange information about road conditions. Two types of information are exchanged in VANET i.e., delay-tolerant and delay-intolerant. Delay-intolerant is usually used for safety-based information such as accidents, hurdles, etc. and delay-tolerant is used for non-safety information such as infotainment.

Some efficient data dissemination routing protocols for delay-tolerant vehicular network have been proposed [2, 3, 4]. These papers propose important ways of selecting appropriate vehicle that forwards the packet towards destination to minimize the packet delivery delay. Much research has also been done on delay-intolerant data dissemination [5, 6, 7]. The purpose of delay-intolerant data dissemination is to promptly send the information to other vehicles that might be affected by the accident.

For both delay-tolerant and delay-intolerant data dissemination, clustering is considered to be an efficient way for reliable driving. Clustering algorithms based on speed [8], traffic flow [9], trajectory [10] and many more have been proposed in VANET.

Vehicles are getting smarter day by day. These smarter vehicles share traffic statistics via vehicle-to-infrastructure (V2I) communication or vehicle-to-vehicle (V2V) communication with road side unit (RSU) or among vehicles for smoother traffic flow. Vehicles periodically send their information such as trajectories, current position, and speed and so on to the traffic control system (TCC). Vehicles that encounter an accident send the information towards the vehicles that are going to use the same route in near future. This paper shows the efficiency of rerouting after data dissemination to overcome the traffic congestion problem after accident.

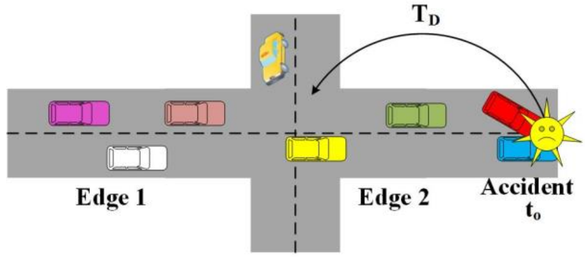

Fig. 1. System model showing accident scenario.

Rest of the paper is organized as follows: Section II summarizes related works on delay-tolerant and delay intolerant data dissemination. Section III explains our proposed system model. Section IV shows the performance evaluation. In Section V, the paper is concluded along with future work.

II. RELATED WORK

Many delay-intolerant protocols have been proposed for the safe traffic flow. Accidents can be prevented by timely informing the drivers. Mostly accidents occur due to speed, lane change or traffic signal violation. For all these situations some prior information is needed to be send such that speed warning, traffic signal violation warning, lane change warning [11].

Authors in [5] propose a mechanism to use path diversity to provide reliability where a message is disseminated by two different paths and by their cooperation this message is disseminated in short delay. In their mechanism, one auxiliary node is also selected for each relay node by sender node and then both the nodes are supposed to resend the received packet without any acknowledgement which shortens the number of overheads. Relay node has the responsibility to select the next relay node and auxiliary node.

Authors in [12] propose a collision warning safety message dissemination via V2V communication. This paper promises to achieve low-latency in delivering emergency warning messages by designing an effective protocol. Authors introduce a new category of vehicles i.e., abnormal vehicles (AV), vehicles applying brakes suddenly or moving

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in abnormal way may generate an emergency warning message and send it to other vehicles. Vehicles become alert by getting such warning messages and help in preventing further accident and overall congestion control. A new routing protocol proposed by [7], called intersection based delay sensitive routing using ant colony optimization. Authors use ant colony optimization to find some optimal and robust route to disseminate the data with minimum delay. The front ants incharge of surveying routes that consists of a series of intersections and these intersections are selected considering local and global delay between current intersection position to the destination. The ants at the back are incharge of collecting global delay and then update ant pheromone on the explored routes. Next intersection is dynamically chosen and then data packets are forwarded by utilizing updated ant pheromone.

Dissemination of delay-tolerant and infotainment data is used for driver's and passenger's comfort such as locating mall, coffee shop, some attraction point etc. User applications such as video-conferencing, weather information or Internet access such as data transfer, Web browsing, music download and interactive games, to roadside service applications, such as location and price lists of restaurants or gas-stations are presented in [13]. Authors in [14] propose infotainment traffic flow dissemination in an urban VANET by extending the coverage area of RSU via some algorithms that allow the data to transmit in multiple directions after crossing the road intersection. This transmission is done without using beacon messages.

III. SYSTEM MODEL

Timely rerouting of vehicles is much important to avoid further accident and traffic congestion around the accident area. Assumptions of our paper are as follows:

- We assume that the vehicles are equipped with GPS devices.
- Vehicles share their trajectories, position, speed and other necessary information to infrastructure (RSU).

In Fig.1 we can see an accident happened at some point at time 't_o' and the information of accident is sent toward the junction in time 'T_D' following the concept of our previous work [15]. In [15], we proposed that the information is sent to the junction by selecting an appropriate position for processing and disseminating information among cluster head, RSU, and cloud.

$$X = \min [CLD, RSU, CH] \quad (1)$$

$$\min \sum T_{CH} . X_{CH} + T_{RSU} . X_{RSU} + T_{CLD}. X_{CLD} \quad (2)$$

where CLD, RSU and CH represent cloud, road side unit and cluster head respectively. XCH + XRSU + XCLD =1, showing that among the three only one is selected for processing data. TCH, TRSU, and TCLD are the total delivery time when processing position selected is CH, RSU or cloud respectively. Equations (1) and (2) showing the selection of appropriate processing position to disseminate the information on time. From (1) we can select one among three on estimated cost and delivery time and from (2) we get the actual delivery time. Once the vehicles receive information about accident at junction they will start detouring to avoid the accident edge.

We calculate the efficiency of detouring with and without dissemination of information. We denote number of vehicles as '$N_{i, j, k}$', N is the number of vehicles, where 'i' shows edge number, 'j' shows time, and 'k' shows that the data is disseminated or not. Efficiency of detouring without dissemination is given by $E1$ as follows:

$$E_1 = \frac{N_{1,1,1}}{(N_{1,1,1}) + (N_{2,2,1} - N_{2,1,1})} \times 100 \quad (3)$$

Efficiency of detouring with dissemination is given by E2 as follows:

$$E_2 = \frac{N_{1,1,2}}{(N_{1,1,2}) + (N_{2,2,2} - N_{2,1,2})} \times 100 \quad (4)$$

Where '$i = 1$' shows edge 1 and '$i = 2$' shows edge 2, '$j = 1$' shows the time at which the accident happened and '$j = 2$' shows the time at which the vehicle at junction starts rerouting, and '$k = 1$' shows without data dissemination and '$k=2$' shows with data dissemination.

Algorithm 1 explains the concept of our work, it explains that when accident happens, the position of accident and time are noted and the delivery time to the junction is calculated. In the end efficiency is calculated.

Algorithm 1. Rerouting efficiency

Input: Accident position (P_A), Accident time (t_o), Speed (s), Period (V), Dissemination time (T_D)

Output: Efficiencies (E_1, E_2)

begin

  While Accident happened **do**

  read accident position and time

  calculate E_1, E_2

  end

end

IV. PERFORMANCE EVALUATION & RESULTS

In this section, we evaluate the performance of our proposed efficient way of rerouting of vehicles in time of accident. Our performance shows the efficiency of with and without data dissemination towards the vehicle around the junction. Our work is focusing on the delay-intolerant data dissemination, and we need to disseminate the data as soon as possible to the junction, so that the vehicles having the accident edge in their trajectories can detour on-time and avoid being part of traffic congestion. In Fig.2 we can see the efficiency of rerouting of vehicles when the data is disseminated and when data is not disseminated. Efficiency decreases with speed of vehicles because the vehicles enter the accident edge before getting the information. For without dissemination of data, performance is not so good because vehicles enter the edge until the end of the junction, and then the other vehicles detour from that edge. Same is the case with Fig.3 that shows efficiency with respect to delivery time of data. For without dissemination we can see efficiency remains constant. In Fig.4 efficiency is shown with respect to number of vehicles but here the number of vehicle is not taken directly instead it is taken as a period that explains the insertion of vehicles with time. Simulation done in MATLAB and the parameters are shown in Table I.

TABLE I. SIMULATION PARAMETERS

No	Parameter	Value
1	Length of vehicle	2.5m
2	Edge Length	500m
3	Min-gap between vehicles	2.5m
4	Vehicles insertion period	1, 1.5, 2, 2.5
5	T_D	3, 5, 7, 9 (sec)
6	Speed of vehicles	10, 14, 18, 22 (m/sec)

V. CONCLUSIONS

This paper proposed the detouring of vehicles after accident. This work was a continuation of our previous work in which we proposed an effective way of processing and dissemination of accident information to the vehicles moving towards the accident area. The work in this paper showed the efficiency of detouring of vehicles after receiving information about the accident. We have shown that on time data dissemination helps improving the efficiency of detouring of vehicles and minimizing traffic congestion. For future work we will try to calculate End-to-End delay of vehicles using the same idea in a more complex scenario.

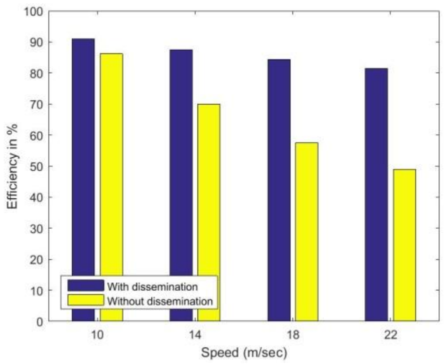

Fig. 2. Efficiency of with and without dissemination with respect to speed of vehicles.

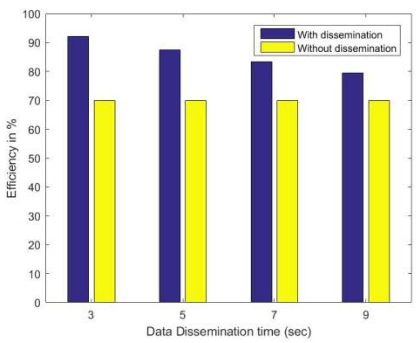

Fig. 3. Efficiency of with and without dissemination with respect to dissemination time.

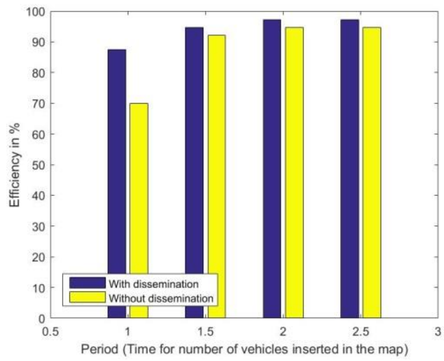

Fig. 4. Efficiency of with and without dissemination with respect to number of vehicles inserted.

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