A Survey on Routing in Vehicular Ad-Hoc Network

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Abstract*— A Vehicular Adhoc networks consist of more than one hosts that communicate with each other in the form of short-range or long-range wireless signals. To understand the concept behind Vehicular Adhoc network (VANET) we will discuss and analyze different vehicular routing process and different safety applications. Also, this survey paper gives you a brief comparison between Dedicated Short-Range Communication (DSRC) and other routing protocols to ensure which one works better in what scenario and gives you a wide idea regarding this topic.

Keywords—Vehicular ad hoc network (VANET), vehicle to vehicle (V2V), Dedicated Short Range Communication (DSRC), Adhoc on demand distance vector (AODV) and Dynamic source routing (DSR), Geographic Source Routing (GSR), Vector-based Tracking Detection (V-TRADE) and History-enhanced V-TRADE (HV-TRADE).

I. Introduction

Imagine a day where vehicles can communicate with one another, or divers will be warned of a potential crash in the vehicle they are driving, the technology to make this happen exists today and the future possibilities are just around the corner. In this survey paper, we will discuss the Vehicular Ad Hoc network including wireless protocols like Dedicated Short Range Communications or DSRC. According to the research by Aditya Jain when DSRC [10], [13s] is combined with Global Positioning System (GPS), also known as Navstar GPS technology it produces a low-cost Vehicle to Vehicle or V2V system that also provides a 360-degree view of similarity-equipped vehicles within a particular communication range. Transmitted messages sent to all vehicle include each vehicle's current GPS positions, latitude, longitude, vehicle speed, acceleration, breaking situation and heading. Also, we will discuss the future possibilities of this technology and what are the things which are done in the past.

The rest of the research paper is divided into seven sections. In section II the characteristics of the vehicle tracking system are discussed in the form of path history and path prediction. Then in section III Dedicated short-range communication protocols is shown and followed by safety applications in section IV. Further, in section V different routing protocols and the comparison between DSRC is shown in brief. Finally, in section VI and VII future work and conclusion is discussed followed by the references in section VIII.

II. Characteristics

To understand the network parameters, we were required to go through a lot of papers to understand the which network parameters best fits our purpose. Vehicle control information such as breaks, transmission state, speed, steering wheel angle, heading, acceleration, vehicles path history, path prediction, and GPS positions will be analyzed in depth and the potential for improving this on-going technology.

A. Path History

According to Cesar Barrios in his thesis research [12] "path history is a set of previous positions which provide a history of where a vehicle has been. It represents about 300 meters of the vehicle's past path of travel. Only the points necessary to decline its path history are transmitted". For example, when a vehicle is driving down a straight road only a few data points are needed to represent its path history. When that same vehicle enters the curve or a set of curves, more data points are needed to represent its path history.

B. Path Prediction

Path prediction allows a vehicle to provide its future trajectory and its confidence in the trajectory. [12] The confidence will tend to be high on straight roadways or curve with a constant curvature and lover during lane changes or transitions in and out of curves. Path History and Path Prediction provides the vehicle a dynamic map of the roadway geometry ahead of the road so that using this essential information the vehicle can perform a threat assessment by itself and predict potential crashes [10] upfront. It is important to understand that information transmitted by every vehicle is anonymous and does not include any personally identifying information such as name or license plate number. A sophisticated security system has been put in place to ensure that all information exchange between vehicle is authentic and can be trusted [8].

By employing common data, security and communication standards, V2V interoperability among automotive manufacturers has been achieved. Safety applications as well as the warning indicators can be developed freely by each automotive manufacturer due to that fact that all the vehicles communicate in the same way. [12] At the time when a crash is predicted, in that case the vehicle will immediately provide a warning to the driver either in the form of seat vibration or by some ringing tone or a visual display or combination of these indicators.[10] The system developed under this project are only intended to provide crash warnings, the diver is not going to lose the control of steering system and will not break automatically.

III. Dedicated Short-Range Communications

DSRC or Dedicated Short-Range Communications is a wireless communication technology which not only enables two or more vehicles to communicate with each other but also other road users without involving cellular or other infrastructure [8]. DSRC enabled vehicle sends its location, speed of the vehicle heading at the rate of 10 times per second in a secure and anonymous manner. Once the message is being sent all the surrounding vehicles receives the message and each vehicle estimates the risk imposed by the transmitting vehicle. In the year 2012 the Federal Communications Commission or FCC has allocated 75 MHz of spectrum in the 5.9 GHz bandwidth [9] for use by ITS vehicle safety and mobility applications. This range of the signal is being used in DSRC. Risks are defined as “safety applications” such as Emergency Electronic Brake Light or EEBL, Blind Spot Warning or BSW, Lane Change Warning or LCW and many others which are discussed in the following sections.

IV. Safety Applications

Road safety applications are one of the most important aspects of the V2V system and it is primarily gaining popularity due to the increasing amount of traffic on roads. Active safety applications are important because it decreases the number of fronts, rear and side collisions during the vehicle in motion. We will also discuss different scenarios and demonstrate some of the safety applications and discuss its advantages and disadvantages in the following sections that can be enabled using V2V technology.

A. Emergency Electronic Break Lights or EEBL

According to Indian government given in reference [11] this safety application can notify a driver of a hard-breaking vehicle in the path ahead. For example, if three or more vehicles are traveling in the same lane, and you are the driver of the last vehicle. [13] In this situation you are not aware of the first vehicle in motion due to the view is blocked by the vehicle directly in front of you. Unfortunately, the first vehicle slams on its breaks. Because of V2V communication, your vehicle can provide a warning of the hard-breaking vehicle ahead, way before you see brake lights from the vehicle directly in front of you. This warning will enable you to drive safely and avoid a potential crash. In the following sections we will discuss other safety feature.

B. Blind Spot Warning or BSW

The Blindspot warning lets a driver know that there is a vehicle that may not be visibly positioned in the driver's blind spot or hidden due to fog or rain. [10] Because of vehicle to vehicle communication, a blind spot advisory will be issued to make you aware of the presence of this vehicle [12].

C. Lane Change Warning or LCW

It is a safety application intended to provide a warning if a driver wants to change the lanes into a zone that will soon be occupied by a faster moving vehicle traveling in the same direction [10], [13]. Using the data obtained through V2V communication, your vehicle predicts that this vehicle will soon be in this zone. If you attempt to make a lane change, a warning will be provided by letting you know that the lane change should not be attempted.

D. Forward Collison Warning or FCW

It is intended to warn the driver of a potential rear-end rash with a stopped or slower moving vehicle ahead [12], [13]. For example, you are driving over a small hill and ahead in your lane is a slower moving vehicle. The vehicle ahead is wirelessly sending its information allowing your vehicle to provide a warning if you are approaching too quickly and are in a potential rear-end crash situation. According to Zhipeng Di in his paper [5] This will enable you to slow to a safe speed and distance behind the slower moving vehicle. Now consider that a vehicle ahead of you has, for example, run out of gas and stopped in your lane. If a vehicle directly in front of you makes a late lane change around a stopped vehicle in the road. [10], [13] Even though you can't see that stopped vehicle, because of V2V communication, your vehicle is aware of the stopped vehicle and provides you with a warning ahead of the time so that you can safely slow down your car before reaching near the stopped vehicle ahead.

E. Do Not Pass Warning or DNPW

If a driver is attempting to pass a slower moving vehicle this safety application lets the driver know that it is not safe to attempt to pass because there is a vehicle coming in the way from the upcoming traffic in the passing zone. Using V2V communication, your vehicle is continually looking for the cars in your intended passing zone. [10] If a vehicle is detected in the passing zone, a drier advisory is provided; letting you know that the passing situation is potentially unsafe. Should you attempt to pass the slower vehicle, the advisory escalates to a warning, so you can stop the attempting maneuver and remain in your lane.

F. Intersection Movement Assist or IMA

Intersection movement assist is one of the most safety features in v2v system, [12] where it is used to warn the driver if it is not safe to enter the intersection because of high probability of crash with a vehicle which is on an adjacent approach to the same intersection from either the left or the right side [10]. If the intersection vehicle is detected using V2V communication, a driver warning is provided if it is unsafe for you to enter the intersection.

G. Left Turn Assist or LTA

It is intended to warn the driver, when making a left turn, that it may not be able to proceed because of oncoming traffic. [10] For example, you are approaching an intersection and get into the left lane to turn left, you think there is no upcoming vehicle, but a warning is provided indicating that upcoming traffic has been detected using the V2V communication and it is not safe to complete the turn [13].

V. Routing Protocols

Since routing in VANET is very dynamic and challenging. We have discussed the five most important routing protocols that can be used to broaden our research regarding this topic. So, the potential five protocols are Adhoc routing, position-based routing, cluster-based routing, broadcast routing, and Geocast routing. These techniques are discussed briefly in the following points.

A. Adhoc Routing Protocols

In a typical Adhoc network the nodes are not aware of the fact that which way it should route the packets but in case of Adhoc routing protocol the nodes are intelligent, which means it decides which way it should route the packets during a packet transfer between two nodes or two peers. The problem with Adhoc routing is that it sends a broadcast message to every other node by announcing that it wants to send a particular packet in a network, which means it utilizes a lot of bandwidth and also cost associated with it. Each neighboring node learns about others nearby nodes. Also, it learns how to send or receive packets to and from them and additionally announces the information to all other neighboring nodes of that particular node. Sometimes it creates a table in the form of the destination address and updates itself if it receives new destination address each time. [10] Of course, the drawback here is it takes a lot of time in response. Since in vehicle to vehicle (V2V) communication delay cannot be too long. It must be as quick as possible. Protocols like Adhoc on demand distance vector (AODV) and Dynamic source routing (DSR) can be very helpful with low bandwidth, low delay, short-range transmission rate.

B. Position Based Routing Protocols

Node movement in a Vehicular Adhoc network is common, the movement involves unidirectional or bidirectional movements, where a vehicle passes another vehicle or overtakes a vehicle in the same path. Thus, routing strategies that involve geographical location, maps, latitude, longitude, and other aspects are gaining popularity. GPSR or Greedy Perimeter Stateless Routing [7] is a technique that is really popular in the in the industry. It works in a combination of two different algorithms, first is a greedy routing algorithm and the other one is a local minimum algorithm. If one of these algorithms fails to determine the path, the other comes into play. There is one more routing technique called GSR or Geographic Source Routing which uses the street maps to determine the position of your vehicle. It takes help from the Reactive Location Service or RLS to get an accurate position in a crowded environment.

C. Cluster Based Routing Protocols

In order to provide scalability in terms of the communication node and the overhead, a cluster-based routing technique creates a virtual network infrastructure by using the existing clustering nodes in a particular distance. Figure 1.1 shows a typical cluster-based routing process where vehicles are distinguished between two types, one for normal vehicle and another for cluster head vehicle with the capability of creating a cluster of vehicles. Basically, this routing process can achieve performance [1] in terms of performance and scalability in a large network.

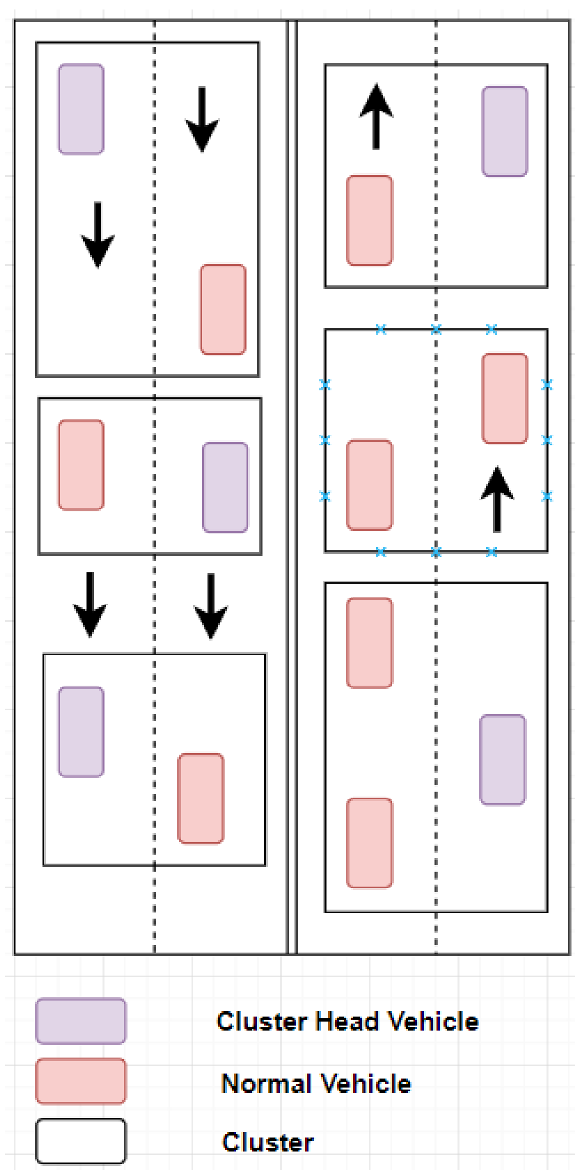

Figure 1.1 Cluster Based Routing

D. Broadcast Routing Protocols

Broadcast routing is one of the commonly used routing techniques where broadcasting is done in the form of emergency alerts, weather condition, road accidents, details about traffic, delays etc. In order to find an efficient route to send a packet sometimes broadcasting is also used in unicast routing technique. It uses the concept of flooding, where a particular source sends a message to all the other nodes, instead of the one which it has received from. Vector-based Tracking Detection or V-TRADE and History-enhanced V-TRADE or HV-TRADE are GPS [1] based message broadcasting protocols.

E. Geocast Routing Protocols

This is a typical example of location-based routing technique, where the main motivation is to deliver packets from a source to a particular destination [1] using Zone of Relevance or ZOR. Imagine a situation where two cars collided in a highway, and the sensor in the cars has identified that there is a crash happened, in this situation that car will let other upcoming cars know about the situation. But the cars which are coming from the opposite direction is not supposed to know about the situation because the path of that vehicle is clear. Hence Geocast routing protocols take this idea into consideration and send identifies which vehicle should know and which vehicle should not know about the details of the road. This technique is very hard to implement, and a lot of testing needed to be done before it is publicly accessible.

VI. Future Work

This survey paper gives a brief discussion on Vehicular Adhoc network or VANET and the routing protocol associated with it. We also looked at the potential future of vehicle in terms of the different application of DSRC or dedicated short-range communication. Also, some comparison is done between DSRC and some other routing protocols that are being widely used in the market. Further, the goal of the paper is achieved in terms of features and the potential future of VANET.

VII. Conclusion

The protocols or the safety applications are just the scenarios which we have seen now, these features can be implemented in a wider aspect regardless of model, make or manufacturer of different vehicles where more than one anonymous vehicle will be able to communicate with each other. The future of automotive is bright but the main challenges is to work vigorously in terms of testing and implementation of these features. Also, to make this technology cheap and associable by common people.

VIII. References

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