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The future of vehicle crash avoidance through VANETs

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ABSTRACT

Vehicular ad-hoc network (VANET) is the research topic of great magnitude of recent times because of its extraordinary characteristics such as topology and unsurprising portability. VANET catches the great attention of both academia and industry due to its potential applications of real life. As a result of the high growth rate in the population, issues related to traffic control is emerging exponentially. Moreover, the gain in traffic has also enlarged the number of traffic accidents and roads are becoming unsafe day by day; due to the road accidents and deaths are reporting at a very high rate. In this paper, the introduction of VANET along with its architecture, characteristics and communication types is presented. Furthermore, the main goal of this paper is to exploit the maximum safety applications of the VANET to provide safety against different misfortunes like accidents etc. on the roads. It is concluded from contemporary literature, the implementation of VANET is promising to decrease the substantial rate of road accidents.

1. Introduction

With the evolution of vehicle organizations and remote corresponding innovation, vehicular ad hoc networks (VANET) are seemingly like to be a standout amongst much encouraging research fields. Vehicular ad hoc networks (VANETs) which use the vehicles as mobile nodes are a subset of mobile ad hoc networks (MANETs) to give current information among adjacent vehicles and between other vehicles and side by side roadside assets/appliances (Doetzer et al., 2005). The main goal of this system is to fix the issues of movement in vehicles. The motivation driving the VANET is to offer prosperity to customers. It reduces the final rate and ensures more safe travel by diminishing accidents. Security and non-prosperity are two basic potential utilization of VANET. Specifically, the nodes (vehicles) in VANETs are affected to road topology while movement, thus if the road information is approachable, we can anticipate the upcoming position of a vehicle; likewise, vehicles can manage huge computing, corresponding, and investigate capacities and in addition to giving nonstop broadcasting control themselves to guide these functions.

Nevertheless, VANETs are additionally along with a few testing techniques, for example, most probably substantial scale and high mobility. The vehicle in the vehicular surroundings is well more powerful because most cars more often are at a rapid speed and modified their current position perpetually. The high portability is similarly immediate a dynamical system topology, while the connectivity between vehicles connects and disconnect every time. In addition, VANETs have a conceivably substantial scale which can incorporate many members and extend the complete road network (Da Cunha et al., 2014). VANET has numerous extraordinary qualities that mark it as unique from other mobile ad hoc networks; probably the most essential qualities are: dispersed correspondence, high mobility, no confinements of network size, self-association, road structure limitations, and all of these qualities made VANETs environment a stimulating one for creating proficient routing conventions (Mohammad et al., 2011).

In VANETs, vehicles can interact with each other (V2V, Vehicle-to-Vehicle interactions) additionally they can associate with a framework (V2I, Vehicle-to-Infrastructure) to get some assistance. This framework is situated along the roads. System nodes in VANETs are very portable; hence the system topology is consistently evolving (Jakubiak and Koucheryavy, 2008). Likewise, the correspondence

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link condition between two vehicles experiences quick variation and it is inclined to disconnection because of the vehicular movements. Luckily, their mobility can be foreseeable along the roads since it is subjected to the traffic network and its limitations (Kamini and Kumar, 2010). VANETs have the ordinarily higher computational capacity and higher transmission control than MANETs. VANETs applications varieties are characterized into safety and non-safety. There are numerous troubles in VANET frameworks plan and usage, including security, protection, routing, availability, and quality of services.

1.1. Overview of VANETs

VANET is the type of Network in which wires through data are connected like mobile circulated applications which run in a vehicle. VANET basically is the form of MANET where the vehicles act as a mobile and do contact with each other. Nodes are equal to the vehicle here or RSU. It had a better plan and storage capacity (Liang et al., 2015). Its main component is the Intelligent Transportation System (ITS). It is also a general term in Inter Vehicle Communication (IVS). In the research area, it made more interest in developing more security applications. The basic goal of VANET is to facilitate road safety information among the nodes (vehicle) therefore the continual/regular on the network which is specifically representing the role of security. ITS is a basic hope/wish to provide a solution for accidental security/immunity of traveler and traffic congestion problems. The ITS improved the driving environment by integrating information technology in transport systems (Elahi et al., 2017).

1.2. Possible types of communications

V2V (vehicle-to-vehicle): an ad hoc network, V2V communication provides interconnection between vehicles. In V2V vehicle can accept broadcast messages and exchange information about road conditions, traffic issues etc. with other vehicles.

V2I (vehicle-to-infrastructure): V2I communication is that type of communication, in which information will be broadcast between vehicles and substructure like intelligent transportation system (ITS) to discuss the road information such as conditions and safety, security of roads etc.

1.3. Characteristics of VANET

VANET basically is the subpart of MANET. It is a substructure/infrastructure less network in which vehicles and Road Side Unit (RSU) are also called as nodes. VANET is the application of MANET which had its different characteristics.

High power of movement: In vehicular ad hoc network (VANET), vehicles move at high speed which is hard to measure the vehicle's current situation and provide safety for vehicle privacy.

Rapidly changing network topology: In VANET, nodes are just like a highly mobile in nature and the speed of vehicles are also random so that the positions of vehicles or nodes will change continually. It provides the information about entire network attacks and makes hard to find the behavior of a network.

Continually exchange of information: VANET is ad hoc network. It encourages the nodes to collect information from the nearby vehicle and RSU. Therefore nodes interchange their information in an irregular manner. Limited Bandwidth: In VANET, (DSRC) band should be measured in a limited way, Width of DSRC band should be 27 MHZ. The output should be 27 Mbps (Su, 2010).

1.4. Dedicated short range communication (DSRC)

DSRC is a model whose purpose is to bring the vehicular network to North America. Traffics helping resources have many problems in the United States and all over the world. Due to this dangerous problem, in 1999 there were 41,611 deaths in 6, 279, 00 motor vehicle accidents in the United States. United States Congress passed the demonstrative surface of Transportation Efficiency Act of 1991 that generated the first creation of intelligent transportation system (ITS). Purpose of ITS program is to improve the safety in transportation infrastructure (Guo and Balon, 2006). The transmission rate of the first generation of the DSRC system which operates at 915 MHz is 0.5 Mb/s. This project was basically used for commercial vehicles and also for tolls collection. E-Zpass application is the example of the First generation of DSRC which is used for electronic toll collection. In 1997 second generation of DSRC was started when ITS America requested that the Federal communication commission (FCC) assign further 75 MHz of bandwidth. For the second generation of DSRC, the FCC assigned 75 MHz of bandwidth in 5.9 GHz band in October 1999 (Soomro and Hasbullah, 2010). The basic goal of this project is to give permission for the drivers to receive current information about the nearby environment for reducing the traffic accidents. Moreover 5.9 GHz DSRC must have an inexpensive and innovative. Furthermore, no usage fee from the user should be required by 5.9 GHz DSRC to access the network (Kenney, 2011).

1.5. Road side unit (RSU)

It is a signaling device that is rigid with the roadside or nearby areas, for example, roads crossing each other or parking places. It is equipped with a system tool for a DSRC based on IEEE 802.11p radio innovation. It has the ability to be accoutered with other system tools so that it can be used for the basic purpose of communicating inside the infrastructural network (Liang et al., 2015).

1.6. On board unit (OBU)

It is a device affixed on the on board of a vehicle. It is a wave device with the basic purpose of communicating with the on board units of other vehicles and the Road Side Unit (RSU). It contains an RCP (resource command processor), a user interface and a specialized interface. A read/write memory is used for storing up and recovering the information. The specialized interface makes it possible to connect the OBU with other OBU's. The wireless passage of information is based on IEEE 802.11p radio technology. For non-safety applications that are based on the other standards and technologies of IEEE such as 802.11aq/b/g/n (Jakubiak and Koucheryavy, 2008). It also provides communicating facilities to the AU and shares data on the base of other OBU's of the network. In VANET, the OBU serves the basic functionality of wireless radio access ad-hoc and geological routing, over-crowding control on the network, consistent transfer of messages and security of data.

2. Applications of VANETs

VANET applications are used for a variety of purposes. They provide their services in application ranging from road safety to infotainment, from business applications to making the use of coordination technologies. Along with it, VANET applications can be categorized into two basic categories:

- Non-Safety Applications
- Safety Applications.

2.1. Non-safety applications

As for their particular expected goal, non-safety applications can be characterized into a few sub-classes, for example, traffic accommodation and proficiency applications, infotainment applications, and solace/amusement applications. Since comfort and proficiency applications can be offered on an individual premise, they don't require standardization and collaboration among vehicles. The development of such applications and administrations in the market can be found in the current years, including some versatile administration offerings on cell phones (Elahi et al., 2017). Convenience and proficiency applications furnish drivers or travelers with some valuable data, for example, climate or traffic info and the area of eateries or hotels close-by (Nishtha, 2016). Infotainment applications may give administrations like media downloading and web-based games.

2.2. Safety applications

Security applications are utilized to spare the vehicles and traveler's life by accomplishing secure ride.V2V and V2I interact with each other by messages. Vehicle sensors are the one that is utilized to process information. RSU (Road Side Unit) accumulate the general data from the vehicle and send the warning notification (Kamini and Kumar, 2010). Two basic safety applications are Accident avoidance: Accident avoidance is used to secure vehicle from mishap through correspondence amongst V2V and V2I. Data is accumulated from the vehicle by RSU. Information is handled and sent the warning notification to the vehicle of this zone. These applications contain safety-related applications such as crash shirking and collaborative driving (e.g., for path combining) (Jakubiak and Koucheryavy, 2008). The basic normal for this classification is the pertinence to life-basic circumstances where the presence of service may avert life-endangering mishaps. Subsequently, the security of this class is compulsory, since the proper operation of any of these applications must be ensured indeed, even within the sight of attackers. Table 1 gives an overview of VANET's safety applications.

Table 1: VANET safety applications overview

	Situation/Purpose	Application Examples
Safety Applications	Dangerous road feature	1. Low bridge cautioning, 2. Collaborate message transformation, 3.Pedestrian crossing data, 4.Curve speed cautioning, 5. Infrastructure based road condition
	Abnormal traffic and road condition	1. Visibility Enhancement, 2.Work zone cautioning, 3.Real-time traffic, 4. Overcrowded road alert, 4. Automatic parking, 5. Road condition parking, 6.Traffic optimization, 7.Collaborative driving, 8.Emergency message broadcasting. 8. Left Turn Assist.
	Danger of collision	1. Emerging electronic brake lights, 2.Danger of Collision, 3. Lane change cautioning, 4.Forward collision cautioning, 5. Do not pass cautioning, 6. Intersection movement assists, 7. Traffic signal notification, 8. Head on collision cautioning, 9.vehicle overtaking cautioning, 10.Control loss cautioning, 11.Highway/Rail collision cautioning, 12. An emergency vehicle approaching the vehicle.
	Crash imminent	1. Pre-crash / sensing Cautioning, 2.Accident avoidance, 3.Road hazard control notification, 4. Vehicle safety inspection
	Incident occurs	1. Post-crash warning, 2. SOS service
	Criminal Offenses	1. Traffic vigilance, 2. Driver assistance, 3.Stop sign violation cautioning, 4. Stolen vehicle tracking, 5.wrong way driver cautioning.
	Climate Check	1. Weather condition

Emergency electric brake lights

This application of VANET deals with providing the driver a notification regarding any vehicle on the way that as applied a hard braking. For instance, there are three vehicles moving in the same direction and the driver of the last one cannot visualize the vehicle at first place because of the vehicle between them. If the vehicle applies the brake due to any reason the last one would not be able to visualize it. As a matter of fact, a major accident can occur. V2V communication can sort this problem out as the last vehicle will be given a warning of hard braking vehicle ahead (Fig. 1).

Blind spot cautioning

There can be situations where a driver may not be able to witness a vehicle due to it positioning in the driver's blind spot. V2V communication makes it easier for the drivers to observe that vehicle by providing a warning notification. For example, if the driver attempts to change the lane with a vehicle that cannot be seen by him due to the blind spot, this notification will serve as a lifesaver by making him understand that it is not advisory to change its lane (Fig. 2).

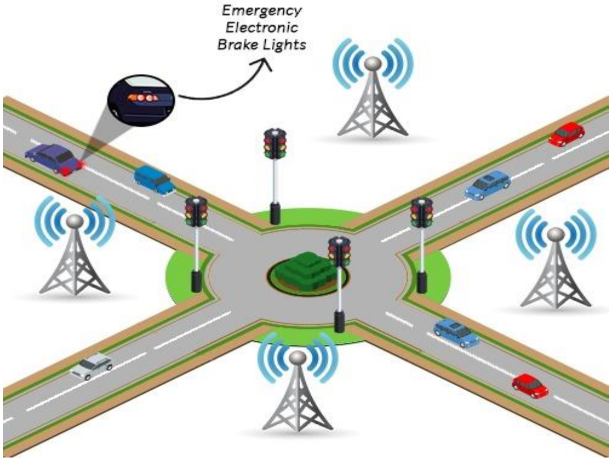

Fig. 1: Emergency electric brake lights

Fig. 2: Blind spot cautioning

Lane changing warning

This application deals with providing of a notification when the driver tends to change the lane in which he is traveling to another lane which will soon be taken over by another vehicle that is moving in a similar way. By the use of the useful information gathered through V2V communication, the vehicle becomes able to predict that it will soon pass through that way. A warning notification will be generated if the driver tends to change the lane that will show him that the changing of path ought not to be attempted (Fig. 3).

Fig. 3: Line changing warning

Forward collision warning

This application serves in situations where there is a need to notify the driver to save him from a backside crash by applying a stopped or slower movement on road. Assume in the path of a certain driver, there is a little slope with a vehicle ahead of him. By using V2V communication the vehicle that is ahead the first vehicle will remotely send data that will allow the first vehicle to generate a notification if it is moving in a fast speed and the situation of a backside crash is arising. The first driver will slow down its speed up to a harmless level and space (Eze et al., 2016). Consider that the gas level ran short for the vehicle ahead of the first vehicle and it has stopped on the way. Suppose there is a vehicle between the stopped vehicle and the first vehicle that will call out a late end change around the halted vehicle. As a matter of fact, the first vehicle will not be able to witness the halted vehicle still V2V communication will make it possible for him to have an idea about the situation by providing notification that will warn the driver just on time-saving him from a crash (Fig. 4).

Do not pass warning

Drivers should not try to pass the warning application that tries to notify the driver that it may not be safe to tend to pass a vehicle moving with slow speed. Due to this problem, all the vehicles attempt to search for other vehicles in their expected area zone from where they are traveling by using the vehicle to vehicle corresponding technology. If a vehicle is detected in the zone of passing, the driver of that vehicle is provided with a warning that alerts him of the danger that can occur if he tries to carry out passing. The warning heightens to a notice to the driver can stop the attempted passing and stay in his path. Fig. 5 shows the working of Do Not Pass Warning application.

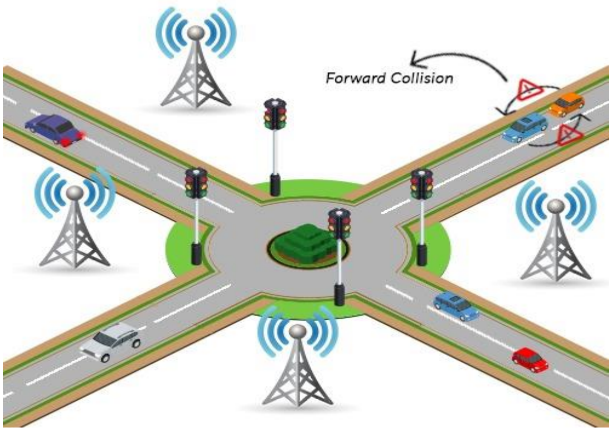

Fig. 4: Forward collision warning

Fig. 5: Do not pass warning

Intersecting motion assist

This application plans to caution the driver that it may not be safe and secure to move towards an intersecting point due to heightening the possibility of the occurring of a crash with the vehicle coming from neighbouring way from either of the right or the left ways. If this kind of a situation is detected then by using the V2V technology of communication, a driver warning could be generated that will alert the driver to stop proceeding towards the intersecting point (Elahi et al., 2017). Take into account a situation where the driver moves towards an intersection and another driver of a crossing vehicle neglects stopping and keep on moving then a warning alert notice would be given due to this violation of crossing traffic rules. This will help the drivers rectify their mistake and stop-motion towards intersection to possibly avoid a crash (Fig. 6).

Left/right turn assist

This safety application of VANET helps in cautioning the drivers who try' to make a left turn that it may not be at the best of their interest to take that turn. Suppose a driver moves towards an intersecting point and tries taking a left lane before taking a left turn through the intersection. The driver would be provided with a notice using vehicle to vehicle (V2V) communication when he frees the brakes of his vehicle to take the turn assuming the roadway is clear. This notice will alert the driver that traffic approaching him has been identified and taking this turn may not be secure and result in a crash. This notification will fade away as the traffic approaching that vehicle clears (Qian and Moayeri, 2008). Fig. 7 elaborates the working of this application.

Fig. 6: Intersection motion assist

Fig. 7: Left/right turn assist

Real-time traffic

The on-going movement information can be stored at the Road Side Unit (RSU) and can be accessible to the vehicles at whatever point and wherever required. This can play a vital role in taking care of the issues, for example, roads turned parking lots, maintain a strategic distance from blockages and in crisis alarms such as accidents etc. Application of Real-time traffic information is explained in Fig. 8.

Collaborative message transfer

Dilatory/Stopped Vehicle will trade messages and collaborate to help other vehicles. Despite the fact that dependability and potentiality would be of real concern, it might automate things like emergency braking to ignore unexpected accidents. Likewise, emergency electronic brake-light might be another application (Fig. 9).

Fig. 8: Real-time traffic

Fig. 9: Collaborative message transfer

Post-crash notification

A vehicle associated with an accident that would communicate cautioning messages about its position to tracking vehicles with the goal that it can do justice with a time close by and also to the highway watch for tow away help (Fig. 10).

Fig. 10: Post crash notification

Road risk control notification

Cars alerting different cars about landslide or info about road attribute notice because of the road curve, unexpected downhill and so on. Application of Road Risk Control Notification is explained in Fig. 11.

Fig. 11: Road risk control notification

Traffic vigilance

The cameras can be placed at the Road Side Unit (RSU) that can do work as input and act as the current tool in low or zero tolerance campaign against driving offenses (Guo and Balon, 2006). Fig. 12 provides an overview of this application.

Fig. 12: Traffic vigilance

Weather condition

In this safety application of VANET vehicle sensor get the date from surrounding like wipes advancement, outcast measuring instrument and handle control and furthermore, RSU communicates the climate condition for the customer. In roadway and urban district, maps help the customer for avoiding different other conditions (Kamini and Kumar, 2010). Fig. 13 depicts the working of this application.

Traffic signal notifications

Notice about the condition of traffic signals is headway of VANET. That message is used for the driver to Slow/Stop vehicle and Stopped vehicle will correspond with other nearby vehicles to notify them too (Kamini and Kumar, 2010). The stopped vehicle will utilize the information acquired through vehicle-to-vehicle communication (V2V) to interact with other vehicles (Fig. 14).

Fig. 13: Weather condition update

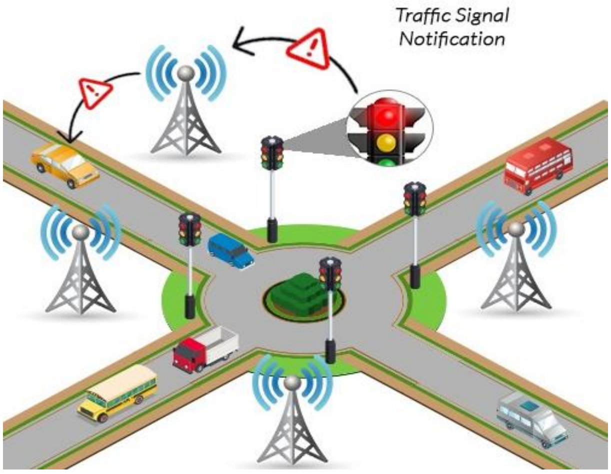

Fig. 14: Traffic signal notification

Automatic parking

In VANET this safety application gives assistance to the driver in parking condition. Programmed parking is another Application in which vehicles are automatically parked without driver intervention. Vehicles are automatically stopped and parked at the accurate position without crash and collision (Kamini and Kumar, 2010). In Fig. 15, this VANET security application is shown which provides assistance to drivers in parking cars.

Fig. 15: Automatic parking

Pre-crash sensing cautioning

In Sensing cautioning available RSU and the Vehicles on an irregular basis send cautioning message to anticipated impacts. The shared information joins point-by-point vehicle measurement and area information. It can help to empower an improved usage of vehicle apparatus to reduce the effect of an accident. Such security appliances can be an air pack and seat belt etc. (Vanhala, 2009). In Fig. 16, sensing cautioning is shown in which available Road Side Unit (RSU) and the Vehicles on an irregular basis send cautioning messages to anticipate impacts.

Fig. 16: Pre-crash sensing cautioning

Head-on collision cautioning

Head on Collision Cautioning is an application in which security application notify the driver that drives the car in opposite direction. In this situation the possibility of crashing of vehicles is high (Vanhala, 2009). Fig. 17 shows the application in which notice to vehicle drivers driving the cars in a reverse way is sent.

Fig. 17: Head-on collision cautioning

Vehicle overtaking cautioning

Design to expect influence between vehicles in an overtake condition, where vehicle-A notifies vehicle-B to overtake it and also notifies vehicle-C which is coming behind the vehicle-A. If required then Vehicle-B can also notify vehicle-A to stop overtaking. Fig. 18 shows, the courses of action to expect influence between vehicles in a surpass condition, where a single vehicle notify all vehicles (Guo et al., 2005).

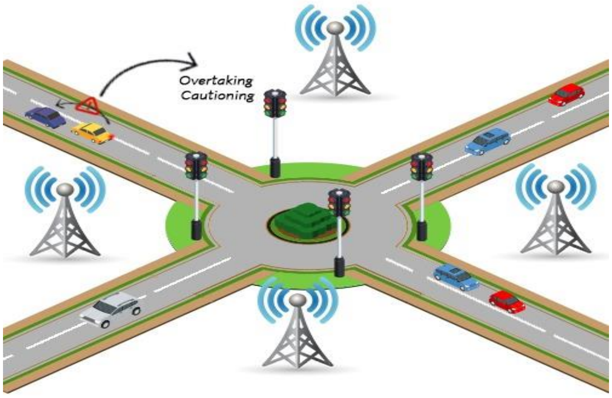

Fig. 18: Vehicle overtaking cautioning

Control loss cautioning

In the situations where the driver of a particular car loses control over his vehicle, a control loses cautioning technique is used. In this technique when a single vehicle loses its control then Road Side Unit (RSU) notifies the vehicles on its way to slow down the speed or stop (Karagiannis et al., 2011). This is very helpful in vehicle crash avoidance. Fig. 19 shows this concept clearly.

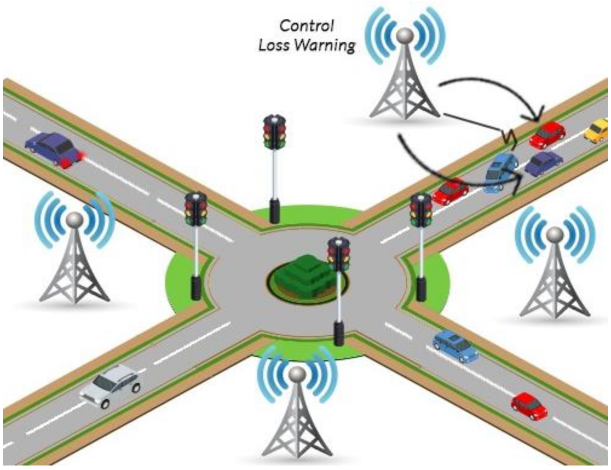

Fig. 19: Control loss cautioning

Road condition cautioning

In this safety application, if a vehicle notices some kind of quick movement development in its way, it notifies the Road Side Unit (RSU) and nearby vehicles about it. That vehicle communicates with nearby vehicles using vehicle-to-vehicle communication (V2V) (Zhang et al., 2013). The Road Side Unit (RSU) notifies all other vehicles in that particular area about this situation to change their route. Fig. 20 shows the working of this safety application.

Driver assistance

This safety application of VANET shares the information about the driver with the military which is used by the military in emergency cases. This safety application also notifies the driver of the location which helps the driver to stay safe from accidents and hazardous locations (Kamini and Kumar, 2010; Zeadally et al., 2012). Fig. 21 shows the proper working of this safety application.

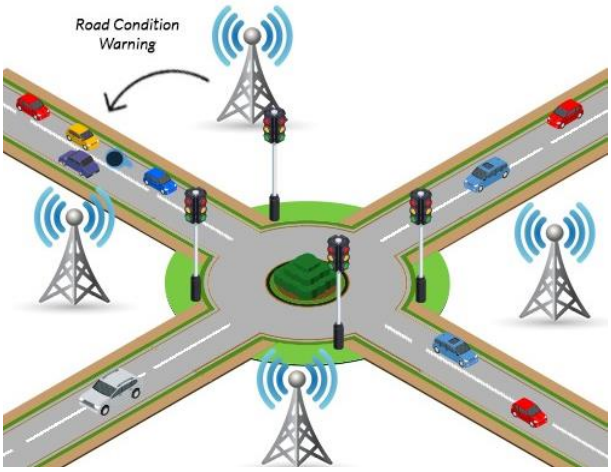

Fig. 20: Road condition cautioning

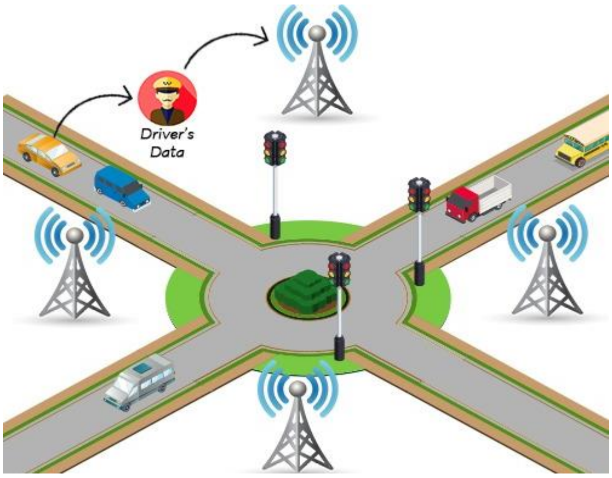

Fig. 21: Driver assistance

Overcrowded road alert

In this type of safety application that recognizes and notifies the driver about the blockage of the road, which can be useful for the drivers about experience masterminding (Kamini and Kumar, 2010). Fig. 22 shows overcrowded road alert that distinguishes and advises about street blockage to the drivers.

Unsafe location notification

Any vehicle or any RSU signs to various vehicles about risky areas such as a hindrance all over the place, a development work or unidentifiable road conditions (Vanhala, 2009). Fig. 23 shows the complete concept of this safety application.

Highway/rail collision avoidance

An RSU perceives the danger of crash with the Train and high way speed traffic. Then it produces a message for the driver to make a fast move in this situation (Kamini and Kumar, 2010). Fig. 24 shows an RSU which perceives the danger of crash with the Train and high way speed activity and then this unit creates a message for the driver to make a quick move.

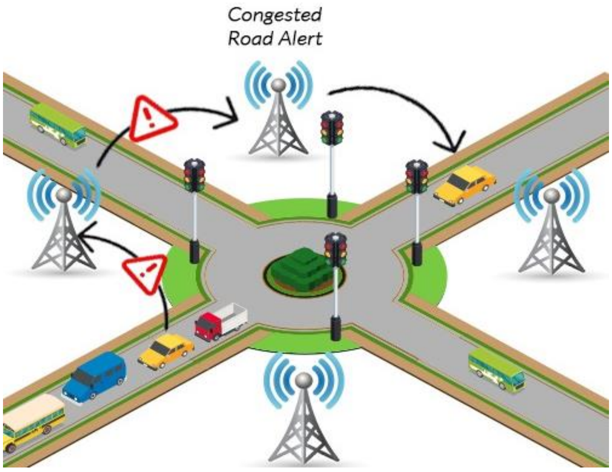

Fig. 22: Overcrowded road alerts

Fig. 23: Unsafe location notification

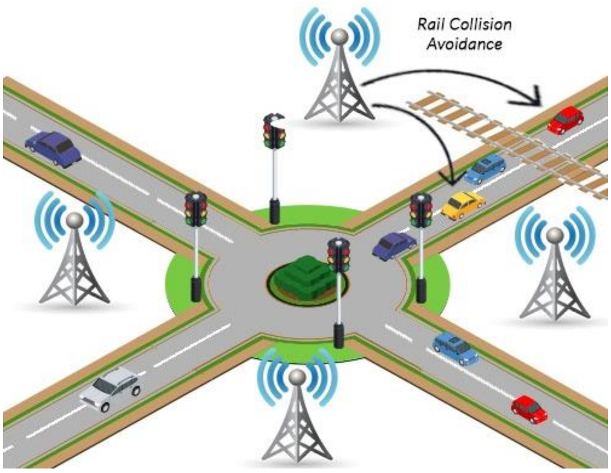

Fig. 24: Rail collision avoidance

Emergency messages broadcasting

A Road Side Unit (RSU) communicates the emergency messages for vehicle drivers to make a move according to unexpected situations like streets are blocked because of road accidents or emergency circumstances (Kamini and Kumar, 2010). Fig. 25 shows the concept of this safety application.

Fig. 25: Emergency messages broadcasting

Accidents/crash avoidance

In this safety application of VANET, by providing an alert about half a second before the crash occurs, 60% of the accidents could be avoided. Once the driver receives the alert message, the driver may possibly avoid the sudden accident (Fig. 26).

Fig. 26: Crash avoidance

Collaborative driving

In this safety application, Road Side Unit (RSU) notifies the drivers about traffic associated warnings such as Lane change cautioning, curve speed cautioning etc. This will make the driver capable of uninterrupted safe driving. The Fig. 27 shows the concept of collaborative driving.

Traffic optimization

In this safety application of VANET, by the use of sending of signals like accidents, jam and many more to the vehicles, traffic can be optimized. So that the drivers can decide the alternative paths to their destination and it will be helpful in saving time. Fig. 28 implements this concept.

Pedestrian crossing data

In this safety application of VANET, Road Side Unit (RSU) will alert the drivers in case a pedestrian unexpectedly comes in the way. For example, if the pedestrian makes a wrong assumption of traffic signals, this can give rise to him coming in the way of traffic. Road Side Unit (RSU) will generate a notification to alert drivers and save any mishap. Fig. 29 briefly describes the concept of pedestrian crossing data.

Fig. 27: Collaborative driving

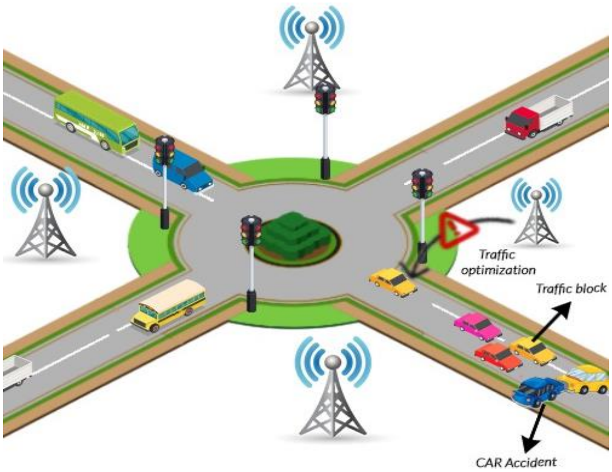

Fig. 28: Traffic optimization

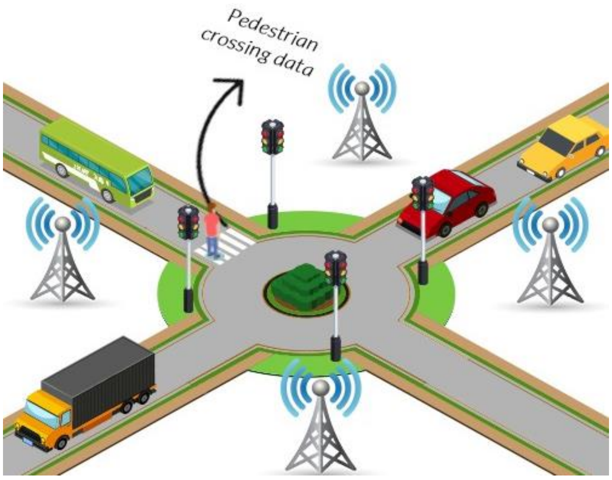

Fig. 29: Pedestrian crossing data

Stop sign violation cautioning

Stop sign violation cautioning is the safety application in which Road Side Unit (RSU) will alert the driver in case he misses the stop signboard. Road Side Unit (RSU) will also notify the other vehicles that are coming behind so that they may not miss the stop signboard. This will save any kind of masses mishap. Fig. 30 briefly describes the stop sign violation cautioning.

Fig. 30: Stop sign violation cautioning

Emergency vehicle approaching vehicle

In this safety application of VANET, situations like a vehicle approaching another vehicle in a fast speed suddenly are taken care of by providing notifications or alerts to the drivers through a Road Side Unit (RSU). This early notification by the Road Side Unit (RSU) will serve as a medium to lessen the chance of any severe accident. Fig. 31 describing this situation is provided below.

Fig. 31: Emergency vehicle approaching vehicle

Emergency vehicle at scene warning

This safety application of VANET conveys alerts to warn the drivers of vehicles from all directions about the presence of emergency vehicles. These are those vehicles that are officially approved to take care of and react to life-threatening circumstances (Zeadally et al., 2012). The rate for transmitting data is 3mbps to 12mbps. The size of warning notification will considerably be 39 bytes. Fig. 32 describes this concept.

Vehicle safety inspection

In vehicle safety inspection the Road Side Unit (RSU) communicates with the On Board Unit (OBU) of the vehicles and notifies them if there is a problem with the vehicles. In this way, VANETS are also useful in the inspection of vehicles and are helpful in avoiding accidents or harms that can be caused by the fault in vehicles. This situation is described in the Fig. 33.

Fig. 32: Emergency vehicle at scene warning

Fig. 33: Vehicle safety inspection

Electronic license plate

This safety application of VANET deals with the tracking of the illegal license plate (number plate). This can be done as the license plate will be registered with the information of car and driver on the On Board Unit (OBU) of the car and can be taken in use by the police or army when necessary. The Road Side Unit (RSU) communicates with the On Board Unit (OBU) of the vehicle and if the electronic license plate does not matches the one registered with the vehicle then it generates warning to the person in charge of the Road Side Unit (RSU) hence the fake or illegal electronic license plate will be tracked down using VANET technology. Fig. 34 describes this application.

Electronic driver's license

This safety application of VANET deals with the tracking of an illegal driver license or under aged drivers. This can be done as the driver's license information will be registered with the information of car and driver's details such as name, address on the On Board Unit (OBU) of the car and can be taken in use by the police or army when necessary.

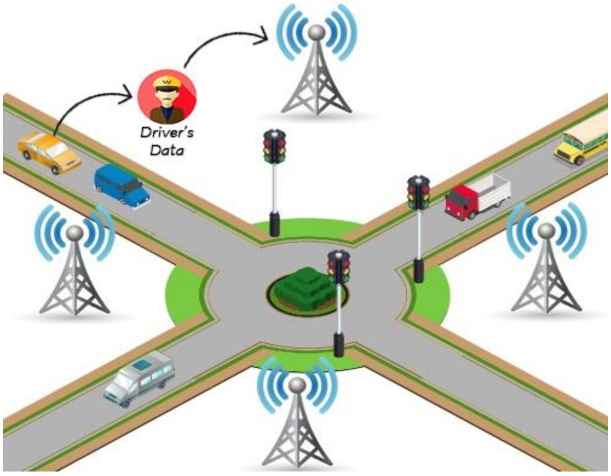

Fig. 34: Electronic license plate

The Road Side Unit (RSU) communicates with the On Board Unit (OBU) of the vehicle and if the driver's license does not match the one registered with the vehicle then it generates warning to the person in charge of the Road Side Unit (RSU) hence proper action could be taken by using VANET technology. Fig. 35 depicts the situation.

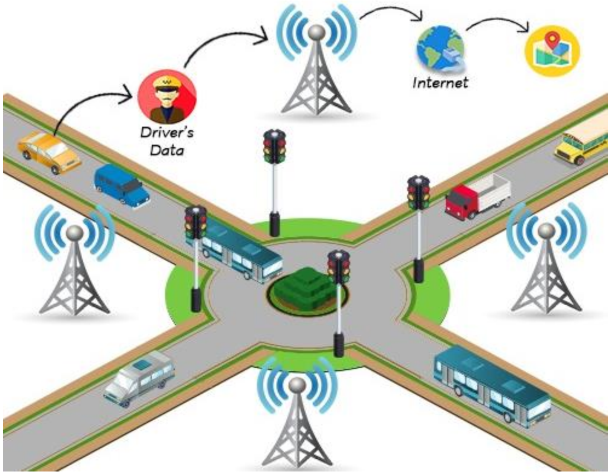

Fig. 35: Electronic driver's license

In-vehicle amber alerts (crime haunt)

If a child is kidnapped in some region then VANET technology can be helpful in tracking the kidnapper if some person gives info/details about the vehicle. The Road Side Unit (RSU) matches the particulars of the vehicle's owner after communicating with the On Board Unit (OBU) of the car and generates info to the person in charge of the RSU then that person gives the info to the police to take further action. Fig. 36 will helps to understand the application.

Stolen vehicle tracking

VANETS can also be used to track a stolen vehicle. The Road Side Units will track the stolen vehicle in their area on the basis of the features of the vehicle. If the vehicle is traced in a particular area the Road Side Unit will notify the person in charge about it hence play its role in tracing of stolen vehicles (Fig. 37).

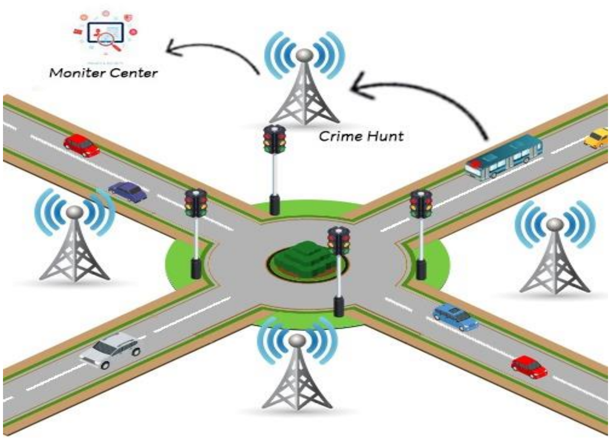

Fig. 36: Crime haunt

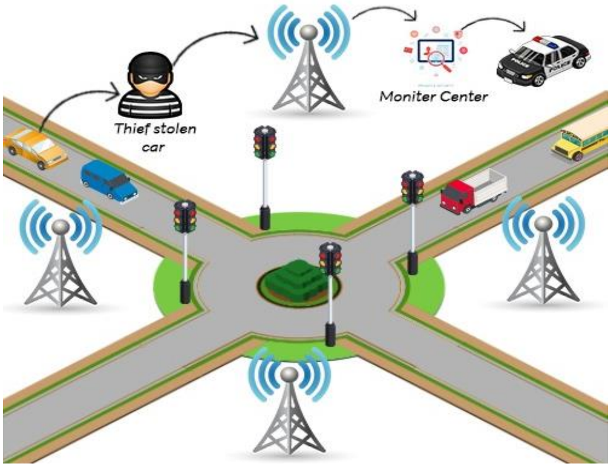

Fig. 37: Stolen vehicle tracking

SOS services

In this safety application, the Road Side Unit communicates with the On Board Unit (OBU) and provides notification if the sensors of any particular part of the vehicle are damaged (Desai et al., 2015). For example, if the sensor of fuel warning is damaged the Road Side Unit (RSU) will sense it after communicating with the On Board Unit (OBU) of the vehicle and generate a warning notification to the driver of that vehicle so that he may not face any kind of emergency situation or mishap. Fig. 38 describes this application.

Work zone cautioning

Work zone cautioning deals with the generation of alert by the Road Side Unit (RSU) if there is some sort of work in progress on the road ahead. The driver receives the alert and changes the path in time to avoid unnecessary time wastage and risk of mishap. This concept is depicted in the Fig. 39.

Wrong way driver cautioning

In VANETS accidents caused by violation of one way can also be avoided. Road Side Unit (RSU) notifies the driver immediately if a car is entering the wrong way mistakenly hence preventing severe accidents that can be caused due to this. Fig. 40 depicts this idea.

Fig. 38: SOS services

Fig. 39: Work zone cautioning

Fig. 40: Wrong way driver cautioning

Curve speed cautioning

The Road Side Unit (RSU) notifies the drivers if they are nearing a curve on the way at a speed that is harmful or endangered. RSU alerts the drivers so that they may slow down near curves and avoid unnecessary risks and accidents. Fig. 41 describes this concept.

Fig. 41: Curve speed cautioning

Low bridge cautioning

If the Road Side Unit (RSU) finds heavy vehicles like buses trying to move on a bridge with less height it will notify its driver to consider changing the route in order to avoid any kind of damage to the vehicle. This concept is illustrated in the Fig. 42.

Fig. 42: Low bridge cautioning

Infrastructure-based road condition warning

If the Road Side Unit (RSU) finds to-be-handled-with-car vehicles on a bumpy grumpy road it will notify its driver to consider changing the route in order to avoid any kind of damage to the vehicle. This concept is illustrated in the Fig. 43.

Fig. 43: Infrastructure based road condition warning

Visibility enhancer

In this type of safety application, If the weather is foggy then Road Side Unit (RSU) notifies the driver about the traffic condition on the road e.g. at how much distance other vehicles are from that vehicle and in which direction they are moving (Doetzer et al., 2005). Fig. 44 describes the visibility enhancer concept.

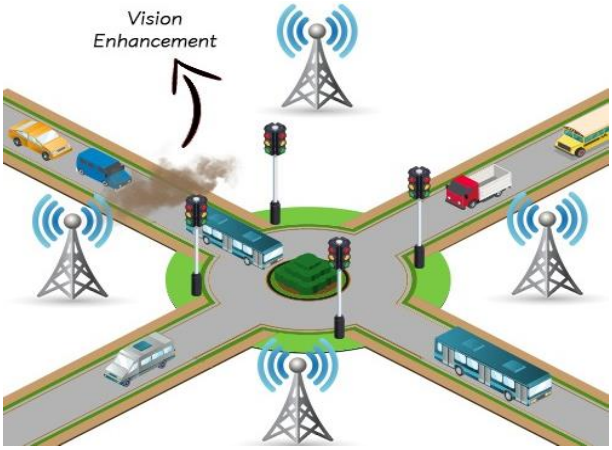

Fig. 44: Visibility enhancement

Lane merging assistance

In this safety application of VANET, the vehicles that tend to change the lane to collaborate with other vehicles on the road and the RSU to get the information that either that move is safe or not. This helps to prevent many accidents as lane will be changed by the drivers of vehicles only when it will be saved to do so. Fig. 45 describes this safety application.

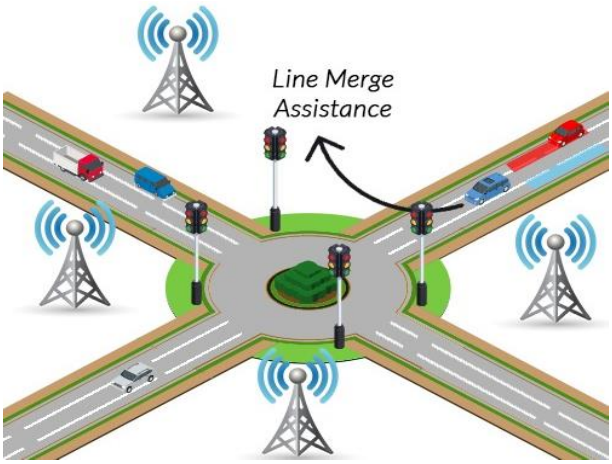

Fig. 45: Lane merge assistance

Rear end collision warning

In this safety application, rear-end collision threats are taken into account. The RSU gets information about the collision and sends the warning notification about it to the driver of the vehicle on the OBU (On Board Unit) of the vehicle to instruct him about the rear collision threat. Fig. 46 describes the working of a rear-end collision warning.

Fig. 46: Rear end collision warning

Stationary vehicle warning

This safety application of VANET provides a warning notification of an emergency situation where a certain vehicle is halted on road due to a breakdown, accident or any other reason; to other approaching vehicles on their On Board Units. The working of this application is described in the Fig. 47.

Fig. 47: Stationary vehicle warning

Collision risk warning

If the Road Side Unit (RSU) finds out the danger of a collision on a certain road between at least two vehicles then it will communicate the warning notifications to all the other vehicles on the road that can be affected by this collision that is they are in the range of the collision. This will save the accident to take a more serious form. Fig. 48 describes the working of this safety application of VANET.

Sleeping driver alert

In this application of VANET, accidents are avoided in situations where the driver of a certain vehicle falls asleep due to a sudden sleep attack, and other vehicles are approaching that vehicle. By communicating with the On Board Unit of the vehicle; the RSU gets to know about asleep driver inside the vehicle using sensors and notifies the other cars/ vehicles about this happening at a safe distance from that vehicle. This concept is illustrated in the Fig. 49.

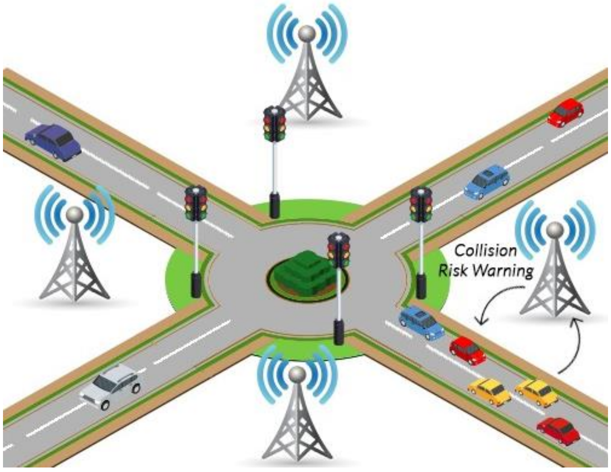

Fig. 48: Collision risk warning

Fig. 49: Sleeping driver alert

Driver not present

In this application of VANET, accidents are avoided in situations where the driver of a certain vehicle is not present inside the vehicle and other vehicles are approaching that vehicle. By communicating with the On Board Unit of the vehicle; the RSU gets to know about the unavailability of the driver inside the vehicle using sensors and notifies the other cars/vehicles on road about this happening at a safe distance from that vehicle. This concept is illustrated in the Fig. 50.

3. Conclusion

With the growing population, the difficulty of traffic control has turned into a challenging problem all over the world. Due to the exponential growth in traffic, the road accidents are increased substantially and roads are becoming unsafe day by day. Consequently, high rates of deaths in road accidents; it is tried to find possible solutions through safety applications of VANETs. Contemporary literature reveals that the VANET safety applications provides promising results in road safety and avoid road accidents and vehicle crashes. It may also be effective in maintaining the drivers and vehicles information for different purposes. Undoubtedly VANET is a future of traffic control and will be effective to avoid vehicle crashes by providing road safety.

Fig. 50: No driver alert

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