Article

Prioritizing Exit Requests by the Platoon Leader in the Case of Concurrent Entry-Exit Requests by Platoon Members Improved the Performance of the Vehicular Ad-Hoc Network

Kardan Journal of Engineering and Technology
3 (1) 62–95

Kardan Publications
Kabul, Afghanistan
DOI: 10.31841/KJET.2021.20
https://kardan.edu.af/Research/Kardan_journal_of_engineering_and_technology.aspx#

Amjad Khan

Abstract

Moving vehicles as nodes for creating mobile networks is a technology that shows moving vehicles as nodes. A VANET is a subclass of mobile ad hoc networks (MANETs) that consists of groups of moving or stationary vehicles connected by a wireless network. The concept is simple: the combination of wireless communication and data sharing can turn a vehicle into a network like the networks we use in homes and offices. Vanet is an emergent technology with a promising future as well as great challenges, especially in its security. The technical challenges deal with the technical obstacles that should be resolved before the deployment of VANET. Network management, congestion and collision control, environmental impact, and security and safety are some of the challenges. VANET packets contain life-critical information, hence it is necessary to make sure that these packets are not inserted or modified by the attacker. But the main issue in this paper is the safe entering and exiting of vehicles to and from platoons. Platooning is an important mechanism to increase the capacity of roads and the efficiency of driving, which is a group of vehicles moving close to each other to decrease fuel consumption and increase road capacity. Simulation results show that if the platoon leader entertains the exit request on a priority basis as compared to the entry request, it will enhance the performance of the platooning technique in Vehicular Ad-hoc Networking. This paper is organized in such a fashion that the first introduction of the Vehicular Ad hoc network is stated, followed by a literature review. Parameters for vehicular mode are set in the methodology section along with simulation results. In the end, the conclusion and future work are specified. The VENTOS Simulator is used for vehicular models and simulation results.

Received: 01 Mar 21
Revised: 02 Jul 21
Revised: 14-Aug 21
Accepted: 24-Dec 21

Keywords: IOV(Internet of Vehicles), IoT, RSU(Road Side Units), ITS, VANET, MANET.

Introduction

Vehicular Ad-hoc Networks (VANETs) are created by applying the principles of Mobile Ad-hoc Networks (the spontaneous creation of a wireless network of mobile devices) to the domain of vehicles. VANET is a technology that uses moving vehicles as nodes for creating mobile networks. VANET can create a wide range of networks by changing every vehicle into a wireless node and allowing cars to connect to each other that are 100–300 metres apart. VANETs were first mentioned and introduced in 2001 under "car-to-car ad-hoc mobile communication and networking" applications, where networks can be formed and information can be relayed among cars. It was shown that vehicle-to-vehicle and vehicle-to-roadside communications architectures will co-exist in VANETs to provide road safety, navigation, and other roadside services. VANETs are a key part of the intelligent transportation systems (ITS) framework. Sometimes, VANETs are referred to as "intelligent transportation networks."

VANETs support a wide range of applications – from simple one-hop information dissemination of, e.g., cooperative awareness messages (CAMs) to multi-hop dissemination of messages over vast distances. Most of the concerns relevant to mobile ad hoc networks (MANETs) are also relevant to VANETs, but the details are different. Rather than moving at random, vehicles tend to move in an organized fashion. The interactions with roadside equipment can also be characterized fairly accurately. And finally, most vehicles are restricted in their range of motion, for example, by being constrained to following a paved highway.

VANETs can use any wireless networking technology as their basis. The most important ones are short-range radio technologies like WLAN and dedicated short-range communication (DSRC). In addition, cellular technologies like LTE can be used for VANETs. The latest technology for this wireless networking is visible light communication (VLC).

VANET research began in universities and research labs as early as 2000, evolving from researchers working on wireless ad hoc networks. Many have worked on media access protocols, routing, warning message dissemination, and VANET application scenarios. V2V is currently in active development by General Motors, which demonstrated the system in 2006 using Cadillac vehicles. Other automakers working on V2V include Toyota, BMW, Daimler, Honda, Audi, Volvo, and the Car-to-Car communication consortium.

Communication between vehicles and infrastructure can bring cooperative systems where vehicles can exchange information to improve safety, fuel economy, traffic efficiency and comfort. Here the platooning comes. Platooning is a collection of vehicles travelling together and cooperating in formation. The concept of platooning is different depending on the various projects because there are different goals and motivations for doing platooning. In platoons, the decision-making for performing different manoeuvres is in the hands of the platoon leader. The platoon leader is the vehicle at the very front of the platoon. This project is about the entering and exiting of two vehicles into and from a platoon at the same time. The problem is that the leader would give permission to the vehicle to perform the maneuver. The purpose of this project is to find the technique and solution that allows vehicles to drive in platoons on highways without facing any problems. Nowadays, congestion is a major issue. To overcome this issue, platooning is the viable approach. Platooning would avoid wasting time and energy consumption. To be really effective, such a system should be based on driverless vehicles. The reason is human factors such as reaction time, some being careful and some not, which can cause traffic disturbances.

The technique for the solution is to perform those manoeuvres in a simulator in order to check the reliability of a platoon of driverless or automated vehicles. The simulator which has been chosen for this project is VENTOS. VENTOS is an open-source integrated VANET C++ simulator for studying vehicular traffic flows, collaborative driving, and interactions between vehicles and infrastructure through DSRC-enabled wireless communication capability. Dedicated Short Range

Communication (DSRC) is an 802.11p-based wireless communication technology that enables highly secure, high-speed direct communication between vehicles and the surrounding infrastructure.

VENTOS uses SUMO to perform road traffic simulations and uses OMNET++ to build network simulators. SUMO is an open-source and highly portable traffic simulation package designed to handle large road networks, and OMNET++ is an open-source, extensible, modular, component-based C++ simulation package, primarily for building network simulators. The OMNET++ will be used for defining modules for the entering and exiting maneuvers, and the SUMO will be used for presenting the designed modules.

2. Literature Review

Vehicular ad-hoc networks (VANET) are the spontaneous creation of a wireless network of mobile devices in the domain of vehicles. VANET can form networks and exchange information among the cars. It was shown that vehicle-to-vehicle and vehicle-to-roadside communication architectures will co-exist in VANET to provide road safety, navigation, and other roadside services, which is the best way of communication in platooning.

Platooning is an important mechanism to increase the capacity of roads and the efficiency of driving, which is a group of vehicles moving close to each other to decrease fuel consumption and increase road capacity. Vehicular ad-hoc networks (VANET) can enhance the performance of a platoon.

In their work, "Effect of Configuration of Platooning Maneuvers on the Traffic Flow under Mixed Traffic Scenarios", automated driving and platooning are assumed to increase road capacity and improve traffic flow under mixed traffic, which means automated and non-automated vehicles altogether. Automated driving is assumed to be very effective in traffic safety and management, which will be based on cooperative adaptive cruise control (CACC) and platooning.

Platooning manoeuvres can require a non-negligible time of execution, like merging two platoons takes more than 15 seconds, leaving a platoon takes more than 7 seconds. But the duration of the manoeuvre increases in mixed traffic. For example, a non-automated vehicle can interfere with the leave or split manoeuvres between automated vehicles. Especially relevant are the desired and safe gaps. The safe gap is the distance between vehicles while changing lanes during platooning.

Previous studies also confirm the increase of road capacity by 20% using platooning. With a high or low penetration rate of the technology, platooning can increase road capacity.

By increasing the desired gap, you augment the time needed for the vehicle to complete the maneuver. Nevertheless, in mixed traffic, non-automated vehicles can interfere with platooning manoeuvres and delay the formation of platoons by more than 50%.

Larger gaps require more space and increase the probability of non-automated vehicle interference. Shorter gaps reduce the probability of non-automated vehicle interference. But a shorter gap must be selected carefully to not affect safety.

Platoon length has its own impact on traffic. The length represents the maximum number of vehicles inside a platoon. Affections are in two ways:

1. The automated vehicle is not allowed to join if the platoon has already reached its maximum length.
2. Two platoons are not allowed to merge if the sum of their lengths exceeds the maximum platoon length.

When the percentage of automated vehicles is low, the percentage of aborted manoeuvres increases. However, larger lengths also increase the duration of the manoeuvre and increase the probability of finding obstacles and the rate of aborting maneuvers.

Safe gaps also have a relevant impact on the success of platooning manoeuvres. Shorter gaps reduce the percentage of aborted manoeuvres and require less time and space for maneuvering. It means a lower percentage of finding obstacles during maneuvers.

As previously mentioned, shorter and safer gaps reduce the percentage of aborted manoeuvres and increase the length of platoons, which has a positive impact on traffic flow. It means that automated vehicles inside a platoon maintain a short distance with the front vehicle compared to non-automated vehicles.

This positive impact generally increases with the percentage of automated vehicles in a maneuver. This indicates that traffic flow increases with platooning, even when there is a low percentage of automated vehicles in maneuvers.

This paper demonstrated that the impact of platooning maneuvers, the effect of their configuration, the effect of safe gaps, and the maximum platoon length have a significant impact on the traffic flow in mixed traffic.

Intervehicle communications (IVC) enable vehicles to exchange data among themselves, improving the efficiency of road network use. In urban areas, congestion is a major issue. To overcome this issue, platooning is the viable approach. Platooning would avoid wasting time and energy consumption. To be really effective, such a system should be based on driverless vehicles. The reason is human factors such as reaction time, some being careful and some not, which can cause traffic disturbances.

Most traffic simulators model human driving behavior, such as the Intelligent Driving Model (IDM) and the Human Driving Model (HDM). But simulation of autonomous vehicles with IVC is an important field where new research will be done on it.

Dedicated Short Range Communication (DSRC) has low latency and a reasonable range for V2V (Vehicle to Vehicle). Nevertheless, DSRC is suitable for short-range communications in safety or vehicle coordination-related tasks.

SUMO (Simulation for Urban Mobility) capabilities are to study cooperative behaviour of communication-enabled autonomous vehicles and the study of autonomous vehicle platoons with constant spacing and intervehicle communication.

The assumptions of the present stage of this research are: Firstly, only longitudinal control of the vehicle is assumed. Secondly, they assume flawless communications due to DSRC's lower range, which is above the Platoon Dimension, which would be about 30m long (8 vehicles at 3m apart). Finally, as the communication algorithm uses time slots coordinated by the platoon leader, no packet collision is expected.

SUMO was selected because it can be connected with other applications and allows research and development of new methods for vehicle cooperation and coordination. SUMO is a traffic simulator that uses IDM, which mimics human behavior. As such, the control of the vehicle was implemented in two steps. 1-The platoon leader, who controls the platoons according to the leader. 2-The remaining vehicles are controlled by the SUMO itself. The initial setup consisted of the launching of eight vehicles at a distance of 3m a few seconds apart. The first one becomes the leader, and the followers obey until they are almost one minute apart. Then, the speed profile is applied to the leader's motion.

Assuming there are three platoons forming, the first one is almost in place. In the second one, the platoon's tail is still approaching maneuver. The third one is in its initial phase of formation.

A 2 m/s acceleration is applied to the leader until it reaches a speed of 5 m/s, then zero until the following departed vehicle with some delay adapts the maximum allowed acceleration to reach the leader.

To approach the manoeuvre from the initial phase of simulation until the 60s, the followers' speed becomes greater than the leader's. are getting closer to each other despite the 1 m objective. At 60s, the leader acceleration becomes 2 m/s again until reaching 25 m/s at 70 s to decrease the spacing error between vehicles.

The SUMO simulator was modified to operate with a new car following model. The results of the simulation confirm the correctness and robustness of the model.

Ehsaan Khanapuri et al. [3] described in their work "Learning-based Adversarial Agent Detection and Identification in Cyber Physical Systems Applied to Autonomous Vehicular Platoons" that the security of cyber physical systems has a significant role in ensuring passenger safety in autonomous vehicle platoons. The concept of automated-driving cars is now a field of research and knowledge. But the primary reason against this technology's becoming accessible worldwide is security. It is well known that these autonomous vehicles are controlled by a computer, and as history has shown, every system, no matter how well designed, has a flaw.

The examination of similar cases in this paper shows that instead of one automated vehicle, it is rather a set of automated vehicles communicating for a common speed and separation between them. Vehicular Platooning is a concept where a set of vehicles follow a common vehicle leader and act as a single unit, which is popular in the fields of truck transportation and automated highway systems.

The string stability is critical in the vehicle platoon. A platoon with stable strings ensures that spacing errors will decrease over time. The purpose of this paper is that a platoon follows a bidirectional control law, and it is expected that every vehicle has access to the position and speed data of its neighboring vehicles. It can be obtained by using sensors like radar and lidar on the vehicles.

In the field of vehicular platooning, very little has been researched on the security aspects of the platoon. An attacker can easily destabilize the whole platoon by just changing the direction of the platoon leader. To avoid such attacks, first the vehicle should detect the attack. The strategy to detect such attacks is the combination of system ID method and clustering algorithms that can recognize an attacker vehicle. In field of networking the importance of detection system is to find the unauthorized access that attempt compromise confidentiality and integrity of the network.

The concept of applying an intrusion detection system for enemy agent detection in a platoon using only sensor readings has only been studied. The detection of attacks can be done either with a Hidden Markov Model (HMM) or by using physics-based approaches. However, for the detection in this work, sensor readings are used, the attacker and victim are decided beforehand in all cases, and destabilization concepts of platoon are used.

For training samples, there were 1000 attack detections, 500 with no attack data and 500 with attack data. Besides that, 4000 training samples were collected for attack identification. The data is then normalized before being used in training. The data was both global and local in nature. Although the global information cases were more helpful in achieving higher network accuracy than the local information cases, they cannot rely on single vehicle data, which can be highly vulnerable. This paper shows that an attack by an opponent agent can be detected and identified with high efficiency by using sensor information. With noisy sensor data and good comparison, the result showed that these networks perform very well and provide good clarity regarding single network performance. To conclude, the range measurement, compared to detection, which uses speed measurement, has better accuracy in detection.

Miguel Teixeira et al. [4] mentioned in their work "Autonomous Vehicles Coordination Through Voting-Based Decision-Making" that autonomous driving has improved over the years with the help of academic and industrial research. The scope is to design such an autonomous vehicle to navigate in urban traffic without the help of humans. The automation point of view is to focus on the decision-making of vehicles.

Multi-Agent Systems (MAS) have developed multiple collective decision-making mechanisms to settle an agreement at tactical and strategic decision-making levels. Nevertheless, previous research has not studied these approaches widely and properly, which means the evaluation was mostly done under unpractical conditions.

In this paper, they studied under practical and realistic conditions the importance of voting schemes for connected automated vehicles (CAVs). They discussed that the evaluation of collective decision-making should be restricted communication. because an unreliable communication channel can affect the performance of a communication system. So, in this case, platooning seems to be a good approach to reduce urban traffic and improve safety.

The use of voting mechanism can improve fair cooperative interaction between a set of vehicles. In this procedure, the preference of all candidates will be collected and a winner or set of winner will be selected based upon their collective preferences. To understand the importance of voting mechanism for cooperative traffic, they assumed that if a platoon which has already been formed and has a voting mechanism, can let each agent (i.e. vehicles) to determine its vote based on perceived utility of each candidate's speed and the given voting rule. At the end the winner will be determined and the exchange of information between the chair and the voters were done through V2V communications. The chair is responsible for the election process.

From a communication point of view, the importance of the iterative voting mechanism has shown its viable and reliable use in vehicular networks at small platoon sizes. For larger platoons, a small number of voting iterations and mechanisms are needed to have a short negotiation time. Longer negotiation times will lead to worse results, such as the end of the platoon.

For simulating the real world of vehicular networks, the decision-making vehicles should be in an environment that has both constraints on wireless communication and mobility. A hybrid simulation framework was developed to achieve this goal, which has the following components:

- agent-oriented platform which is responsible for
- SUMO for vehicular traffic simulation
- OMNET++ for simulation of communication stacks

The results demonstrate that the voting mechanisms have good results in maintaining high satisfaction and that voting might be the best negotiation mechanism for automated vehicles. Voting mechanisms prove that it has a good response time for small platoon sizes, but larger platoons may need more methods for that.

Yaser E. Havwas and colleagues [5] describe in their work "Testbed Evaluation of Real-Time Route Guidance in Inter-Vehicular Communication Urban Networks" how the congestion of urban areas can cause a huge loss of fuel and time. Implementing old methods such as building roadways and

Bridges may not be helpful sometimes due to limitations in space and budgets. Smart real-time route guidance (RG) will be the top research in traffic congestion. Intelligent transportation system (ITS)-based RG algorithms implement advanced computation and communication technologies to check the congestion level in a network and find the best and shortest travel path for every vehicle to reach its destination.

In RG which also known as Centralized architecture, a single traffic management center (TMC) check the traffic congestion and provides permanent path guidance to vehicles. But the issue in TMC is that it easily gets overloaded with information transferred from many different participants which needs more computation, storage capacity and communication capability. If TMC is deployed over a city, the information delivery will have latency and delay which may affect the real time rout guidance of TMC.

To implement RG in real time, a system must be designed that is less dependent on TMC for hardware support and vehicle-to-infrastructure (V2I) communication. It can be achieved only with Intervehicle communication (IVC) or VANET technology which in VANET distributed coordination will be performed by vehicles using vehicle to vehicle (V2V) communication for safety. Comparing to other centralized systems, V2V based RG algorithm has lower cost of deployment.

Recently, the two different forward and backward IVC-based RG algorithms were developed in a simulator and compared against the centralized and decentralized RG algorithms. The result was good enough to encourage them to implement the third IVC-based RG algorithm that has a more efficient communication protocol and fewer communication requirements. The third generation of IVC-based algorithms has proved to be easily implemented in a real-time environment for reducing complexity, processing time, and bandwidth.

To test the efficiency of RG algorithm, a vehicle in real world should be equipped with on-board-unit (OBU) to perform RG algorithm operations. The configuration requirement of OBU is based on the input processing and output algorithm functionalities. The input should give OBU two different data which is sensed and derived information. For the processing functionalities, the information acquired from input have to be processed based on algorithm procedure to achieve the RG output. Finally, a stable firmware, to manage all the units and perform efficiently the RG algorithm operations without any issue, should be developed for the OBU.

On the development of the OBU, their functionalities and working conditions will be tested before installing them on vehicles. All the RG algorithm operations from the basic to advanced levels will be checked during the testing section. Upon the success of the testing section, the functionalities will be tested further in different control environments of different test-beds. The scope of the test-bed is to confirm the effectiveness of the RG algorithm in different situations by removing the real-world problems created by communication during deployment.

From the analysis of requirements, the system design and OBUs were built with reliable hardware, firmware, processing modules, GPS modules, and communication modules to perform real-time RG. Multiple different tests were performed to check the efficiency of OBUs working conditions, in which the functionalities were tested separately. All the tests proved the successful performance of the functionalities of OBUs as per the RG algorithm standards.

The advantages of the solution to V2V-based RG are the lower computation complexity, processing time, and required bandwidth compared to centralized systems. The proposed system was tested in two different geographical areas (one in India and one in the UAE) based on the results achieved from the test-bed section.

Ankur Sarkar et al [6] mentioned in their work of "A Review of Intelligent Controller, Sensing and Communication, and Human Factors Aspects for Information-Aware Connected Autonomous Vehicles" that when the PATH (Partners for Advanced Transit and Highways) developed the platooning application of six AVs (Autonomous Vehicles) for highway sections, the AVs field testing began. After the promotion from the Defense Advanced Research Projects

Agency (DARPA), most of the companies including Google developed AVs that are not dependent on special highway infrastructure to operate in mixed traffics.

The Society of Automotive Engineers (SAE) has classified the AVs from no-automation (level 0) to full (level 5). The full AVs have maximum traffic safety, efficiency, and environmental impact. AVs need more different, complex, independent factors such as safety, management, understanding human driving behavior, and sensor management. Due to multiple crashes of AVs in different countries, more than 75% of American drivers are not comfortable using AVs. The research of technological advancement and advanced inter-disciplinary research, which requires the overall study of human driving behaviors, would help to overcome the trust issue with AVs.

AV with vehicle-to-vehicle (V2V) and vehicle-to-infrastructure (V2I) communication is also called "Connected Autonomous Vehicle" (CAV). A communication-aware controller designs the safety, efficiency, and traffic throughput of CAV. CAVs use V2V and V2I communication to enable this controller to get information using on-board sensors from surrounding vehicles and infrastructure to make the CAVs safer and more efficient.

To design the communication-aware controller, the SAE classified the functional structure of a level 5 AV into perceiving the environment based on sensors' information, locating the destination, finding the general route to the destination, selecting which driving mode to use under different roadway traffic conditions, and finally, executing the chosen driving mode. These classifications rely on the information gathered from V2V and V2I communication technologies. Nevertheless, the communication can benefit the controller design. But the distance and velocity information of the current vehicle and neighboring vehicle will be used in designing a control algorithm for those vehicles without communication capabilities.

CAV has a high standardization of providing safer transportation under different road transportation systems by cooperatively sensing and networking between different components. The analysis has shown that with sensors and communication technologies, 79% of all different traffic accidents will be avoided. On-board sensor technologies (RADAR, camera, and LIDAR) are installed inside the vehicle and do not communicate with other vehicles. In fact, they are avoidance technologies that use the surrounding information to warn the driver about possible hazards and how to avoid them.

The improvement of CAV is dependent on human problems of manual driving, which can be reduced with the help of communication-aware controllers, sensing and communication technologies, and human factors. Since the sensing and communication technologies gather more information to improve the controller efficiency, the user preferences must be met in order to improve the safety and comfort of CAV systems.

Bugra Turan and Seyhan Ucar [7] described in their work of "Vehicular Visible Light Communications" that the purpose of intelligent transportation systems with vehicular communication is to reduce congestion, accident, energy and time wastage. But vehicular communications are assumed to provide efficiency regarding of those problems. For Vehicle to Vehicle (V2V) and Vehicle to everything communications (V2X), the Dedicated Short Range Communication (DSRC) and Long Term Evolution (LTE) are the best candidates due to their complementary technology to increase road safety and safer automated driving applications.

Modern vehicles are equipped with light-emitting diodes (LEDs) for low energy consumption and longer durability. The second equipped part is the sensors such as PDs and cameras, which PDs are used to detect the light levels, and the camera is used to assist the driver in recognizing traffic signs and forward collision warnings. Usage of LED lights and image sensors would allow low vehicular visible light communication (V2LC) system implementation costs.

Visible light communication (VLC) uses intense signals over the signal phase information to make the VLC work well for vehicle communications. To this day, VLC has achieved more data rate support with 27 Mbps up to 1000 m distances compared to Dedicated Short Range Communication (DSRC).

The one application which can help to secure vehicular communications through V2LC is the vehicular platoon. With the VLC range of 100 m for headlights and 30 m for taillights, the transmission area can restrict the availability of data for the attackers while allowing communication in platoon. Platoon may decrease communication because of inter-vehicle distance during a curvy road. To overcome this problem, the hybrid architectures are proposed.

Security of vehicular network in vehicular visible light communication is divided into three parts: 1 - System level: attack on hardware, software and security certificate.

- network level, such as RF radio.
- Application level: injecting wrong information into the

To avoid these attacks, the identity of the vehicle, permission for the authorized vehicle to access the communication medium, and integrity must be satisfied. It will ensure that only the participating vehicles can decode the content of messages. To enable these protections, the additional layers for V2LC, such as physical layer protection, stenographic protection, and cryptographic key generation and management security methodologies, are required. In this case the stenographic will keep the secret data within the transmitted message in existing communication. In cryptographic, there is a secret key which will be used by one sender and receiver or multiple for securing and maintaining the VLC"s private information.

The following advantages make the V2LC a promising candidate and as solution for vehicle communications: Low complexity and cost, scalability, security, and compatibility. Due to scarcity of RF, the interest in using DSRC as Wi-Fi make the VLC larger to support multiple V2LC channels Simultaneously.

Bahidja Boukenadil and Mohammed Feham [8] described in their work "Internet for VANET Network Communication-Fleetnet" that the purpose of the VANET is to bring safety and comfort to passengers by placing a particular electronic VANET device in vehicles to provide Ad-hoc Network Connectivity. The purpose of ad-hoc network connectivity is to receive and transmit messages through wireless communication. FleetNet is one of the upcoming technologies of VANET that uses the DSRC standards.

The FleetNet was launched for communicating vehicle to vehicle within a group by German car manufacturers. The scope was to provide an intelligent system for vehicle networks, to be an improvement for the passengers‟ safety and comfort. The routing architecture is based on location and navigation for providing internet access service. The architecture enables the access to internet from vehicle or access to vehicle from the internet. The FleetNet aim is to improve road safety by using the IVC communication, Implement V2V and V2I for ITS and presenting standards dedicated to the vehicular communication. The characteristics are the IVC for IVC, low data transmission delay, low cost of data transmission delay, and awareness in the road.

FleetNet routing needs geographical position of the vehicle to improve scaling behaviour and adaptability of VANET networks, comparing to non-position mechanisms. Therefore, routing mechanism implements the system of location and navigation, handle positional errors and uses forwarding mechanisms. The wireless LAN components are used to verify and test the created standard solution for V2V communication in the FleetNet. For the „real world‟ test bed of Fleetnet, a group of ten smart vehicles with touch screens, cameras and internal computer for vehicle‟s navigation system equipment and roadside stations are used to test an intelligent transportation platform.

APEC [9] described in their work of "Internet of vehicle" that the IOV (Internet of Vehicle) consist of inter-vehicle network, intra-vehicle network and vehicular mobile network. On the basis of these three, they defined the internet of vehicles for wireless communication and exchange of information between V2X according to communication protocols and standards like IEEE 802.11p. The importance of integration of IOV is same as building of the IOV technologies which results in becoming a part of IOT (Internet of Things) by its completion.

With experience having evolved, future vehicles can address and solve issues related to automotive society with the goal of minimizing accidents and energy consumption through the development of automobiles and the transportation system. However, there is a huge gap between IOV and the IT industry due to IOV technologies which are under development and the IT industry which updates quickly and is too open to ensure the use of relative products in vehicles for reliability and safety.

The industrial application of IOV technologies, research and development will ensure the integration of automotive and IT, which contributes toward an intelligent urban transportation system. According to a 2013 report, all manufacturers will use IOT technologies to the tune of 80 to 100 percent by 2025.People will enjoy the comfortable services provided by the application of IOV technology. But the biggest challenge to implementing the IOV is the lack of coordination and communication, which can only be solved by adopting open standards and combining closed and one-way systems into an effective system for the smooth sharing of information.

R.Jerlin Emiliya et al [10] mentioned in their work "Control of a Platoon of Vehicles in VANETS Using Communication Scheduling Protocol" that VANET is a wireless communication network which has two types of communication, namely: 1-Vehicle-to-Vehicle 2-Vehicle-to-Infrastructure. Vehicles are in platoons with inter-vehicle spacing to increase traffic efficiency and accuracy due to the availability of automotive sensors and communication techniques such as DSRC for comfort and safe driving. Because of the unpredictable timing of vehicles, the V2V communication will have a fixed distance spacing. With some special techniques, the challenges like short connection time, high mobility, and frequent handoffs can be reduced to some levels, but the major issues are the access scheduling and random packet dropouts, and the inefficient method will lead to more accidents on highway roads, especially at the area of lane changing intersection points.

The solution works based on the assigned priority rules. To transmit information, the central scheduler assigns a buffer to each vehicle. The binary sequence for each vehicle will be generated to be free from conflicts. The successful transmission of a packet is governed by Bernoulli's process based on the probability function. The number of modes switched between the open and closed modes is called the chatter frequency, which ensures the string stability.

To solve the communication conflicts, the scheduling should start with first come, first served rules, giving priority to vehicles with earlier arrival, duty factors, or high index numbers if two vehicles come at the same time. Typically, the merging occurs at the main road and the ramp road, which increases the risk.

The possibility of accidents Sorting strategies are used for these kinds of problems, but they lack priority, which is solved in communication scheduling.

In this paper, communication scheduling is investigated to solve the communication conflicts in VANETS. Also, the platoon merging concept relies on using the same information to overcome the problem without any prior knowledge of vehicle nature. Using the dynamic configuration of the network can help to make an immediate decision about the platoon merging at an intersection point. The two issues to investigate are the scheduling methods and employing encryption and decryption techniques for secured communication.

Julian Heinovski and Falko Dressler [11] described in their work "Platoon Formation: Optimized Car to Platoon Assignment Strategies and Protocols" that from 2005 to 2015, individual cars were the major transportation system, with a share of 71% in comparison to public transport. These many vehicles cause environmental pollution and congestion on the roads. Platooning has been developed to overcome the problem of continuously growing traffic needs. Multiple vehicles have a small gap between them, which is maintained by cooperative adaptive cruise control from the platoon to increase the road utilization. Platooning reduces air drag, reduces fuel consumption and, with smoother speed changes, can lead to improved traffic flows and increase driving comfort.

The research focuses on existing platoons to improve the reliability of the IVC protocols to achieve perfect string stability, which ensures the safety of passengers. The situation on the freeway is different. Every car entering the freeway, drive on their own until they find an appropriate platoon to join with. Hence, the solution for the platoon formation is the next step toward platooning.

By the time the candidate cars are selected, they should be able to perform manoeuvres to join existing or form a new platoon.

For platoon formation, a car has to start searching for available candidates. If there is a platoon, the car may join it and end the search; otherwise, a new platoon should be formed. This process consists of finding available candidates and performing join maneuvers.

Platoon formation is an optimization problem from the viewpoint of searching for people to join platoons. Therefore, two solutions are suggested; first, the centralized approach, which has more knowledge about vehicles and more candidates. This has the advantage of fewer aborted join maneuvers. Second, the distributed approach has longer platoons as several cars join the platoon eventually. Overall, time was needed to find the platoon in both approaches. Fuel saving can be acknowledged for platooning in general. Certainly, more time in a platoon leads to a higher savings.

Carl Bergenhem et al [12] mentioned in their work of "Overview of Platooning Systems" that new ITS (Intelligent Transportation System) are used to advance the communication technology between Vehicles and with infrastructure. Communication of vehicles and infrastructures can bring cooperative systems where vehicles can exchange information to improve the safety, fuel economy, traffic efficiency and comfort. One of the example of ITS is platooning. Platooning is a collection of vehicles travelling together and cooperates in formation. The concept of platooning is different depend on the various projects because there are different goals and motivations for doing platooning and technical solution. There they had shown three examples of these variations which are:

SARTRE: is a European project which supports changes in transport utilization. The purpose of this project is to find the solution which allows vehicles to drive in platoons on highways without defining any infrastructure. SARTRE defines the platoon leading by a manually driven heavy vehicle. The other vehicles will automatically follow. Vehicles can leave or join the platoon dynamically. The SARTRE goal is to check the technology for the platooning on the road without

Bringing changes to the infrastructure until it is safe enough to mix with the other users of public roadways

To increase the capacity of highway lanes, the PATH research on automated platoon got started, so the increase in travel demand could be accommodated with a little new infrastructure construction. The PATH studies of highway capacity showed that it could be possible to increase passenger car lane capacity by a factor of two to three if the vehicles were driven in platoons of up to ten cars.

Energy ITS: a national ITS project by the Japanese Ministry of Economy, Trade, and Industry, started in 2008. It has two motivations, one of which is an automated truck platoon and an evaluation method for energy saving, and the other one is to mitigate the lack of skilled drivers.

Elmano Ramalho Cavalcanti et al [13] described in their work of "VANET‟s Research Over the Past Decade: Overview, Credibility, and Trends" that the industries and academies have more attention on Vehicular Ad hoc Networks (VANETs) since its beginning. Currently, the focus is on the term of vehicle to everything (V2X). For VANET"s, there is a noticeable increase in number of published papers, while a reduction is observed for Mobile Ad hoc Networks (MANET"s) publications. To support the growth of wireless ad hoc networks, researchers have designed a variety of protocols, spanning the main layers of the protocol stack. When it comes to evaluating such protocols, analytic modeling, experimentation and simulation are the three main approaches available to researchers. However, one of the major issues concerning simulation results from its frequently low credibility level.

In this paper, they analyzed the current state of VANET's research by taking into account hundreds of papers published from 2007 to 2016. The goal of the survey was to check whether the research community has evolved due to the principle of credibility in simulation-based studies. To conduct the survey, they considered the papers containing the words "VANET" or "Vehicular Ad hoc Networks" in title, abstract, or index terms published during the period from 2007 to 2017. They manually checked 283 papers, extracting all the valuable information required to characterize the research and highlight how the authors performed their research.

The results show that simulation is still the leading approach for validating and evaluating solutions in MANETs. The percentage of articles that employ simulation remains basically the same as in 2000–2005. Even though there are several network simulators for a great variety of networks, the focus is on simulators suitable for vehicular networks. Some general remarks can be highlighted from survey results to indicate the trends of research during the last few years, such as the increase in the number of published papers related to physical layer, link layer, and routing solutions, and also new services and data management studies. Such an increase is directly related to the new demands for solutions from users and manufacturers.

As vehicular networks are expected to be integrated with 5G mobile technology by 2020, we noted that less research has been done regarding protocol performance evaluation. The focus has moved toward new solutions for services such location tracking and estimate correction, QoS, cross layer protocols, and maximization of network resources based on network coding. The results of their survey showed that VANETs simulation based studies still lack credibility due to issues similar to those reported in previous studies.

Sabih ur Rehman et al [14] mentioned in their work of "Vehicular Ad-Hoc Networks (VANETs) – An Overview and challenges" that however, Vehicular Ad-hoc Networks cannot be a new topic but it continues to provide new research challenges and problems. The main objective of VANET is to help a group of vehicles to set up and maintain a communication network among them without using

any central base station or any controller. One of the major applications of VANET is in critical medical emergency situations where there is no infrastructure and it is critical to pass on the information to save human lives. Vehicular Ad-hoc Networks are responsible for the communication between moving vehicles in a certain environment. A vehicle can communicate with another vehicle directly which is called vehicle to vehicle (V2V) communications, or a vehicle can communicate to an infrastructure such as Road site unit (RSU), known as Vehicle-to-Infrastructure (V2I).

In principle, there is no fixed architecture or topology that a VANET must follow. However, a general VANET consists of moving vehicles communicating with each other as well as with some nearby RSU. A VANET is different than a MANET in the sense that vehicles do not move randomly as nodes do in MANETs, but rather move along fixed paths such as urban roads and highways. But it is easy to consider VANETs as a part of MANET.

In fact, we can define three possible communication scenarios vehicles. One possibility is that all vehicles communicate with each other through some RSU. Second possibility is where vehicles directly communicate with each other and there is no need of any RSU. In third possibility, some of the vehicles can communicate with each other directly while others may need some RSU to communicate.

One of the major challenges in the design of vehicular ad-hoc networks is the development of a dynamic routing protocol that can help disseminate information from one vehicle to another. Because of the highly dynamic and ever-changing topologies in the former, VANET routing differs from traditional MANET routing.Few protocols that were earlier designed for MANET environment have been tested on VANET.

Iago Medeiros et al. [15] described in their work "A Comparative Analysis of Platoon-based Driving Protocols for Video Dissemination over VANETs" that VANET is an evolving technology which allows vehicles to form self-organized networks without the need for any permanent infrastructure. It facilitates a smooth exchange of data among vehicles and introduces new use cases for enhanced safety driving at high vehicle speeds and cooperative driving. Platoon-based driving is one of the main forms of autonomous driving, since autonomous or semi-autonomous vehicles organise themselves into a set of vehicles called a platoon. The platoon leader defines the speed and direction for platoon members and exchanges commands about when to accelerate, slow down, or break. Platoon-based driving can help its users in many ways, such as content dissemination and sharing, especially due to its stable speed and distance to each other.

Although platoon-based driving brings many benefits to its drivers, the joining decision still relies on the driver's decision. For the driver, joining the platoon can be encouraged through the use of monetary incentives by offering discounts at local markets, free parking lots, free movies, priority for video consumption and network resources, among others. Therefore, the decision to join the platoon can be treated as a conflict of interest situation.

Video dissemination is being considered as an interesting use case for autonomous driving, since it can feed world sensors through a set of cameras like dash, side-view, rear, and birds-eye view cameras. Hence, video distribution over VANET provides a wide scope of new multimedia services, ranging from on-road safety to entertainment video flows. Platoon-based driving provides a cooperative driving pattern for a group of vehicles with a common path, where vehicles maintain a constant distance. In classic platooning applications, the Adaptive

Cruise Control system considers the board sensors to detect the distance between vehicles and autonomously adjust the speed.

In this paper, they introduce a comparative simulation study for video dissemination with different platoon-based driving protocols. Based on the simulation results, they conclude that there is a clear need for cooperation among vehicles for transmitting multimedia content in order to maximize the QoE for video delivery in VANETs. However, it is necessary to make a quick and precise choice of platoon members to forward video packets with low packet loss, which is achieved by P2V.

P.Agith [16] mentioned in his work of "Enhancement of Vehicular Ad-Hoc Networks Using Vehicle Platoon Aware Data Access" that Innovation in low-cost wireless connectivity together with peer – to – peer co-operative systems is transforming next generation vehicular ad hoc networks. Inside the moving vehicles both drivers and passengers are able to get and share their interested data such as news, video clips, music. To improve the data access performance and to reduce the effect of intermittent connectivity, data replication been widely used nowadays. With data replication they can increase the data availability and reduce the query delay if there is enough memory space available in the vehicles. To connect vehicle with road side infrastructure easily and quickly and to get the data, the data must strategically place. Their solution is based on vehicle platoon in VANETs, where vehicles form a group while in motion. Vehicles can contribute part of their buffer to replicate and share data for other vehicles, if they move as a relatively stable platoon.

They use Vehicle Platoon Aware Data Access Solution in Vehicular Ad-Hoc Networks. Vehicles use a part of their buffer to replicate data for other vehicles in the same platoon to share data with them. If a vehicle leaves a platoon, it pre fetches the interested data in advance and transfers it to other vehicles so that they can still access the data.

In this paper they proposed V-PADA (Vehicle Platoon Aware Data Access) which is a novel vehicle-platoon-aware data access solution for VANETs. V-PADA makes use of the "vehicle platoon" mobility pattern to collaboratively replicate data and optimize data access among vehicles. The proposed solution in this paper is not limited to VANETs and can be extended to other mobile ad hoc networks.

Rakesh Kumar and Mayank Dave [17] described in their work "A Comparative Study of Various Routing Protocols in VANET" that vehicular networks are the main new part of wireless ad hoc networks that enable communication between vehicles. Before that, drivers used gestures, horns, and observation to communicate. With an increase of vehicles, it made it hard to manage. Therefore, the traffic police took charge of controlling it. Then, automated traffic signals came with variable message signs on the roadside. But these communications were restricted to certain limits. Now, with wireless communication, drivers can exchange complete and customized information.

VANET does not rely on fixed infrastructure but follows the same principle and applies it to the highly dynamic environment of surface transportation. A combination of infrastructure networks and ad hoc networks could be a possible solution for VANET. Such a hybrid architecture, which uses WLAN and cellular capabilities as gateways and mobile network routers, can make it possible for vehicles with only WLAN capability to communicate through multi-hop links and remain connected to the world.

The VANET routing protocols are categorized based on Topology based routing protocols, Position based routing protocols, cluster based routing protocols, Geo cast routing protocols and broadcast routing protocols which are on basis of area /application where they are most suitable. These routing protocols use links information that exists in the network to perform packet forwarding.

Position-based routing has a class of routing algorithms. Using geographic positioning information, they share the property to select the next forwarding hop. The packet will be sent and the neighbor hop

which is close to destination doesn't know about it. The benefit of position based routing is that there is no need of creating and maintaining global route from source to destination.

In this paper, they review the existing routing protocols. The first prior forwarding method is used for the first routing decision. In the event of a delay, a bound protocol will be used. The digital map will provide street level maps and traffic statistics such as traffic density and vehicle speed on the road at different times. Therefore, digital maps are mandatory. Clustering can create a virtual infrastructure to provide scalability. A recovery strategy is used to recover from an unfavorable situation.

Arjun Arora et al [18] mentioned in their work of "Strengthening Connectivity in VANET by Making use of Driverless Cars" that majority of researches take the VANET as beneficial and solution in resolving the expensive price of accidents. Connections established have been created to enable interaction in Vehicular ad-hoc networks especially, Dedicated Short Range Communication and Wireless Access in Vehicular Environments. Connections in VANET are achieved either by vehicle to vehicle or vehicle to infrastructure communications. In case of V2V Communications, vehicles connect alongside one another in ad hoc manner, and in V2I, Vehicles connect to established infrastructure alongside the roads. The V2V interaction is normally a problem because majority of vehicles do not permit for steady connections. However, the V2I communication results in an expensive charge of operation and care.

A majority of automobile manufacturers are actually focusing on producing driverless cars. BMW began investigating in 2005, while Tesla and Uber had done so earlier.Driverless cars are monitored using aim for preparation of the course for the automobile to cut back the travel duration. There are some principles problems regarding structure which is the foremost being expense of installing and maintenance. Although RSUs are set up for VANETs connections, they normally use established structure as backbone.

Driverless Vehicles in Control (DVC) is a game in which driverless vehicles work cooperatively, handling their rate and route, choosing the shortest path that is possible from the initial site of their location to improve the system in totality. Cars' paths can be set up as highways or in populous cities. In the case of a highway, cars travel in a straight path, making it simple to choose whether to stay on the highway or not. But in the case of a populous city, that will be a difficult situation both in deciding and controlling.

This paper presents DVC as a distributed game strategy which intends to enhance the system connections by altering the path of driverless cars. This was achieved via a decentralized concept of cooperative approach and delivers stability between cars to improve the VANET connectivity. The simulation results reveal that DVC is unquestionably one step which will be essential in functional recognition of VANETs possibilities.

Shivam Vats et al [19] described in their work "VANET: A Future Technology" that VANET is a technology which shows moving vehicles as nodes for creating a mobile network. VANET can create a wide range of networks by changing every vehicle into a wireless node and allowing cars to connect to each other that are 100–300 metres apart. While cars fail to connect to the present network, other cars can connect other vehicles to one another to create a mobile internet. The first systems that were integrated were for police and fire vehicles to provide safety. Vehicular networks are rapidly evolving for the purpose of deploying and developing new and traditional vehicle applications.

Vehicles that are equipped with sensors, interface cards, on-board units, and externally are known as "smart vehicles." The benefit of smart vehicles is that their management applications are focused on optimizing vehicle flows to reduce the time taken to travel and avoid traffic congestion. For instance, the radar present on-board can detect traffic congestion and slow the vehicle. On the other hand, sensors can detect that a crash may occur if air bags are deployed. The major systems

The sensors used for intra-vehicle communication are: crash sensors, the data recorder, the braking system, the engine control unit, the electronic stability control, etc.

The concept of smart vehicles is the safety issues of vehicles and with a proper combination of functionalities like communications, control and computing technologies; it will help driver‟s decisions and prevent driver‟s wrong behaviors. The control functionalities are added to smart vehicles directly for connecting to vehicles electronic equipment. Road safety applications distribute information about obstacles and hazards to avoid risk of car accidents and make the driving safer. Traffic efficiency and management applications focus on reducing the time taken by vehicle and situation of avoiding traffic jam to optimize the flow of vehicles.

In fact, these applications depend on the passenger’s desires to communicate either with ground- based destination or other vehicles. The main goal is to provide comfort and convenience to drivers and passengers. For instance, fleet net provides a platform for gaming, a real time parking navigation system will inform the driver of an available parking spot.

In this paper, they proposed a technique in the domain of navigation in VANET. They proposed a grid-based on-road localization system with the help of RSUs, where vehicles can self-organize themselves into VANETs, exchange location and distance information, and help each other learn the exact position of each vehicle inside the network.

Ram Shringar Raw et al [20] described in their work of "Security Challenges, Issues and Their Solutions for VANET" that the load of road traffic affects the safety and efficiency of traffic environment. With increase of accidents, the road safety has become a challenge issue in traffic management. One of the possible ways is to provide the traffic information to the vehicles so they can analyses the traffic environment which can be done by exchanging information between vehicles. In fact, vehicles are mobile and a mobile network is needed to self-organize and operate without infrastructure support.

VANET is an application of mobile ad-hoc network. Specifically, a VANET is a self-organized network for connecting vehicles to improve road safety and traffic management by driver‟s internet access. VANET communications are categorized into types. First a pure wireless ad hoc network for V2V communication without infrastructure support. Second is the V2I (vehicle-to-infrastructure) communications. There are two unites in VANET i.e. On Board Unit (OBU) and Application Unit (AU). On Board Unit has communicational capability and AU executes the programme of OBU‟s communicational capabilities.

First, the safety-related applications, which include collision avoidance, cooperative driving, and traffic optimization; second, the business-related applications, which include Second, there is the User-Based Application, which includes Peer-to-Peer applications, Internet connectivity, and other services such as payment services, fuel station and restaurant location, and so on.

Although the VANET has its own characteristics, some of those characteristics impose some challenges to the deployment of the VANET. Technical challenges deals with the technical obstacles like network management which deals with the network topology and channel condition change rapidly, congestion and collision control deals with the network partitions, environment impact, MAC design, and security which deals with application messages between vehicles. Among all challenges the security is more important but it got less attention. The VANET packets have critical information and it must be sure to not inserted and modified by the attackers.

There are many solutions to the challenges that have been mentioned before, but the most important and precise ones are: ARAN (Authenticated Routing for Ad hoc network) is a secure routing protocol for ad hoc network based on authentication; SEAD (Secure and Efficient Ad hoc Distance Vector) is

new secure routing protocol that protects against multiple uncoordinated attackers who create wrong routing in any other node, SMT (Secure Message Transmission) protocol which operates on end to end manner and requires a security association between source and destination.

In this paper, they discussed the security requirements and challenges to implementing the security measures in VANET. Different types of attacks and solutions were discussed. They mentioned the technologies which were used in the solutions. Among all, requirements authentication and privacy are the major issues in VANET.

Hassan HadiSaleh and SaadTalibHasoon [21] described in their work of "A Survey on VANETs: Challenges and Solutions" that with the increase of public and private vehicles, the number of deaths and accidents have also been increased. Data transfer in the VANET is done through wireless communication using V2V or V2I models. Communication models allow sharing different types of information between vehicles i.e. information of safety application for preventing accidents, an investigation after an accident or traffic deviation. Other types of information are the non-safety application such as passenger information. The main design area in the VANET in order to correctly configure a communications network is to route packets effectively.

VANETs are mostly used to avoid or reduce accidents that result in a passenger's death. So the VANET applications offer info and support the drivers by sharing information between vehicles and roadside units to avoid collisions. Although there is full research on the VANET network, there are still many areas to consider for challenges. Some applications require an address link to the physical site of the vehicles. Data trust and verification of data are more valuable in VANET. Hosting data from different vehicles in the network rather than from another network should be trusted in some way by the entity that created the information.

The following are some solutions to the previous challenges which have been mentioned. For addressing, packets transferred via VANET need specific address and rout topologies. Domain Name System protocol is used to locate position. DNS contains the complete directory to access the IP address level using geographic information. Privacy and anonymity must ensure that encrypted messages do not allow sender identification. The higher level of privacy increases communication and redundant computing. Delay constraint, this part classified every delay protocol by taking suitable steps depending on the layers. Delay bounds are necessary at the standards of the requested layer because it is required to handle emergency important warning messages.

The main contributions of this paper are to the present state of the art in VANET technology. This paper presented an overview and tutorial of various issues in VANET. Various types of research challenges are highlighted in the context of vehicular communication. Research challenges and areas of interest in vehicular communication were discussed. It presented all the challenges discussed in the research and conclusions.

Asim Rasheed et al [22] mentioned in their work of "Vehicular Ad Hoc Network (VANET): A Survey, Challenges, and Applications" that VANET is a challenging network that follows the concept of ubiquitous computing for future. Vehicles with wireless communication technology and act like a computer will be on roads very soon. The concept is simple, the combination of wireless communication and data sharing, can turn a vehicle into a network like the networks we use in homes and offices. VANET is considered as a part of Mobile Ad hoc Networks (MANET). Both MANETs and VANETs are rapidly deployable without the need of an infrastructure.

The VANET architecture was considered a prime problem by many standardization organizations, such as IEEE and ISO. The International Standard

Organization (ISO) started its own standard named CALM (Communication, Air-interface, and Long and Medium Range). Despite the fact that

It is quite complex, focused on seamless inter-node and intra-node communication. IEEE started its work under the label of WAVE (Wireless Access in Vehicular Environment). Though WAVE is a complete protocol stack labelled as 1609 protocol family and is based on current Internet model, so far no major large-scale implementation is available other than test laboratories and small-scale projects.

Routing techniques and protocols are one of the most researched topics in VANET. However, the main challenge to design a VANET routing protocols which is suitable to all scenarios and conditions is still open. Before determining routes, varying real traffic stat is generally not considered by many protocols. All real-life traffic conditions cannot be met through current VAENT routing protocols. Under rapidly change VANET topologies, topology-based routing lacks efficiency. Delay tolerant networks, such as disconnected nodes, cannot be covered using vehicle-to- vehicle communication design.

This paper presents VANETs by highlighting current challenges and applications. The applications envisioned are likely to find their place in inter-vehicular communication, hence making widespread VANET deployment possible in the near future. Although significant research has already been done, many key factors for their success are still open.

3. Methodology

In this section the approach to solve the issue is using VETNOS Simulator. VENTOS is an open- source integrated VANET C++ simulator for studying vehicular traffic flows, collaborative driving, and interactions between vehicles and infrastructure through DSRC-enabled wireless communication capability. Dedicated Short Range Communication (DSRC) is an 802.11p-based wireless communication technology that enables highly secure, high-speed direct communication between vehicles and the surrounding infrastructure. IEEE 802.11p is an approved amendment to the IEEE 802.11p standard to add Wireless Access in Vehicular Environment (WAVE) in a vehicular communication system. It defines enhancement to 802.11 (the basis of products marketed as Wi-Fi) required to support Intelligent Transportation System (ITS) applications. This includes data exchange between high-speed vehicles and between the vehicles and the roadside infrastructure, so called V2X communication, in the licensed ITS band of 5.9 GHZ. 802.11p is the basis for Dedicated Short Range Communications (DSRC) because the communication link between the vehicles and the roadside infrastructure might exist for only a short time interval and for short range.

VENTOS uses SUMO to perform road traffic simulations and uses OMNET++ to build network simulators. SUMO is an open-source and highly portable traffic simulation package designed to handle large road networks, and OMNET++ is an open-source, extensible, modular, component-based C++ simulation package, primarily for building network simulators. The OMNET++ will be used for defining modules for the entering and exiting maneuvers, and the SUMO will be used for presenting the designed modules.

The VENTOS has been tested on Ubuntu and MAC OS X operating systems. But the recommended operating system is the latest version of Ubuntu where the most efficient working environment will be provided. Before installing VENTOS the Git application should be installed. Git is an application through which the repositories in Github servers can be accessible. Since the VENTOS files repository is in Github, the git application should be installed first. Running the following command will install Git application.

git sudo apt-get install

Then the VENTOS repository should be cloned into a folder that has write permission, such as the desktop or home folder. Running the following command will clone the VENTOS.

https://github.com/ManiAm/VENTOS_Public git clone

Go to VENTOS_Public folder and run the „runme" script. This bash script checks the system and instals the required packages and libraries. The installation process might take more than an hour but it needs a fast internet. After installation there will be three folders and the OMNET++ launcher icon on desktop.

Figure 1: VENTOS files after installation

By opening the OMNET++ launcher, the Eclipse IDE in an interactive shell which loads all theenvironment variables will be opened.

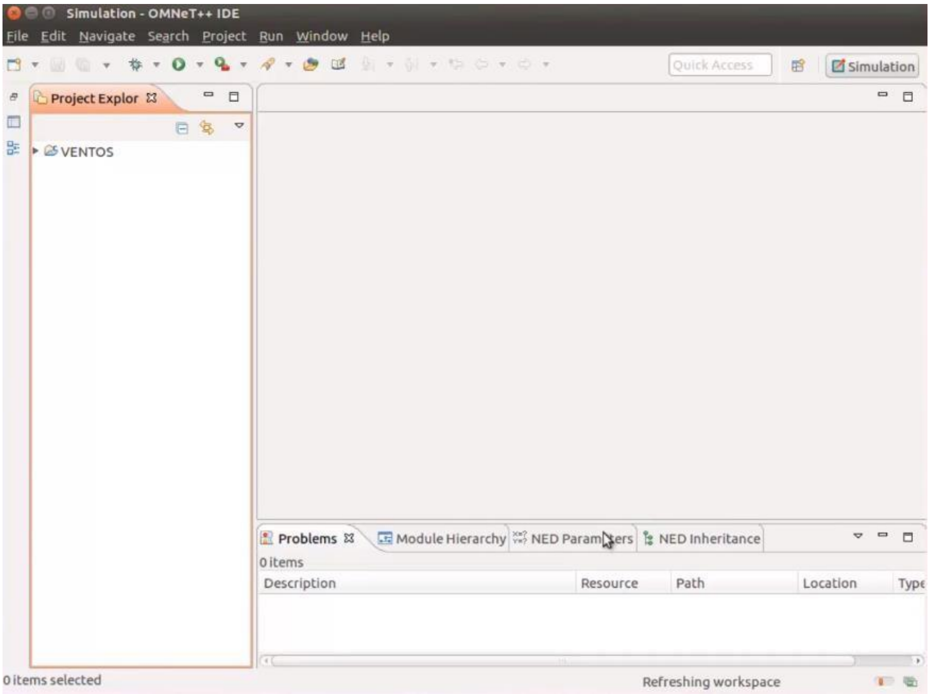

Figure 1 Eclipse IDE Now the VENTOS modules should be imported and built into the project for it, which is a working space. A simulation module in OMNET++ consists of modules that define the topology of the network. Using those modules in the VENTOS folder, we can define our own network simulation. We can define and programme different types of files for streets, vehicles, Road Site Unit (RSU), pedestrians, obstacles, accidents, etc., with the extensions of.xml,.ned,.cpp, and other extensions. But for this project, the node and edge files for the street, the connection file for connecting the nodes and stages to form the street, and the addnode file for adding vehicles and RSU will be needed.

The node file looks like the following:

```
<nodes>
    <node id="C" x="0.00" y="0.00" type="priority" />
    <node id="E" x="100.00" y="0.00" />
    <node id="W" x="-100.00" y="0.00" />
    <node id="N" x="0.00" y="100.00" />
     <node id="S" x="0.00" y="-100.00" />
</nodes>
```

The edge file looks like the following:

```
<edges>
    <!-- incoming edges -->
    <edge id="EC" from="E" to="C" numLanes="3" speed="30"
    priority="3" />
```

```
    <edge id="WC" from="W" to="C" numLanes="3" speed="30" priority="3" />
    <edge id="NC" from="N" to="C" numLanes="3" speed="30" priority="2" />
    <edge id="SC" from="S" to="C" numLanes="3" speed="30" priority="2" />
     <!-- outgoing edges -->
    <edge id="CE" from="C" to="E" numLanes="3" speed="30" priority="1" />
    <edge id="CW" from="C" to="W" numLanes="3" speed="30" priority="1" />
    <edge id="CN" from="C" to="N" numLanes="3" speed="30" priority="1" />
    <edge id="CS" from="C" to="S" numLanes="3" speed="30" priority="1" />
</edges>
```

The connection file looks like the following:

```
<connections>
    <connection from="EC" to="CW" fromLane="0" toLane="0" />
    <connection from="EC" to="CN" fromLane="0" toLane="0" />
    <connection from="EC" to="CW" fromLane="1" toLane="1" />
    <connection from="EC" to="CS" fromLane="2" toLane="2" />
    <connection from="WC" to="CS" fromLane="0" toLane="0" />
    <connection from="WC" to="CE" fromLane="0" toLane="0" />
    <connection from="WC" to="CE" fromLane="1" toLane="1" />
    <connection from="WC" to="CN" fromLane="2" toLane="2" />
    <connection from="NC" to="CW" fromLane="0" toLane="0" />
    <connection from="NC" to="CS" fromLane="0" toLane="0" />
    <connection from="NC" to="CS" fromLane="1" toLane="1" />
    <connection from="NC" to="CE" fromLane="2" toLane="2" />
    <connection from="SC" to="CE" fromLane="0" toLane="0" />
    <connection from="SC" to="CN" fromLane="0" toLane="0" />
    <connection from="SC" to="CN" fromLane="1" toLane="1" />
    <connection from="SC" to="CW" fromLane="2" toLane="2" />
</connections>
```

Now that we have nodes, edges and connections files we can call

NETCONVERT to create a network file.

netconvert --node-files=example.nod.xml --edge-files=example.edg.xml

--output-file=example.net.xml --connection-files=example.con.xml

We can open the generated network file using SUMO-GUI as shown in following Figure:

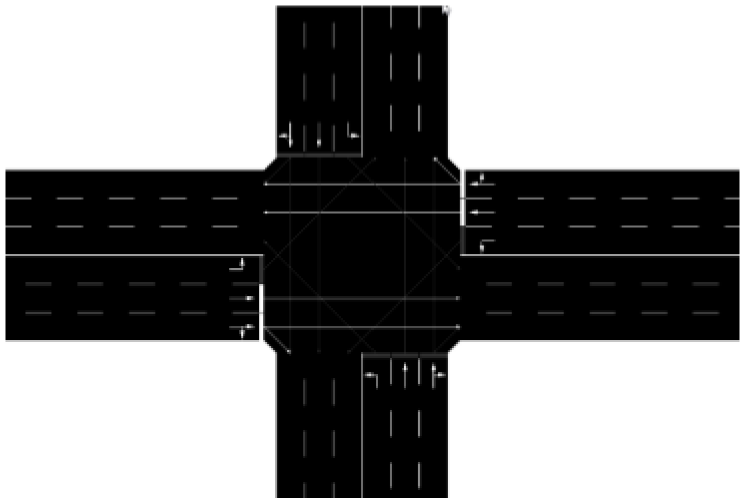

Figure 3: Visualization of the network file in SUMO-GUI

The "addNode" module in VENTOS allows you to easily add different node types to the simulation. We can add fixed nodes such as RSUs, obstacles, etc. as well as mobile nodes such as motor vehicles, bikes, and people. All nodes are defined in the "addNode.xml" file located in the same folder as the omnetpp.ini configuration file. The addNode module reads this file and decides which nodes should be inserted at the beginning of the simulation.

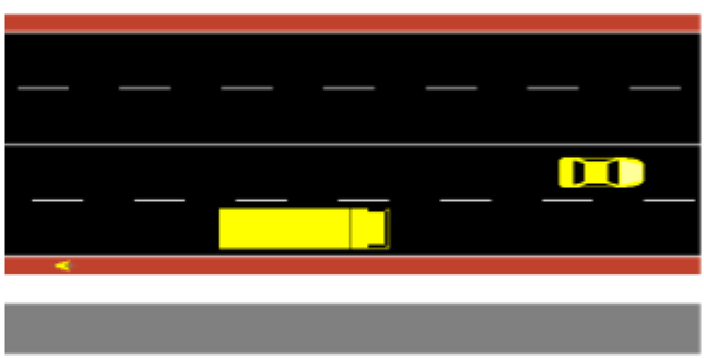

Figure 4: Adding truck and passenger vehicle into the simulation

We use the addnode file to insert vehicles at the beginning of the simulation and form the platoons.The following code shows adding single vehicle into addnode file:

<vehicle id="veh_1" type="passenger" route="movement3" de partLane="4" departPos="30"status="parked" />

The following line inserts a vehicle platoon „plt1“ into the simulation. Platoon „plt1“ is red and has size 5 and departs at time 0 (The platoon size should be greater than or equal to 1). All vehicles in a platoon have the same type „passenger“ and follow the same route. Platoon leader has depth of 0, andit increases as we go farther. Vehicles in the platoon are named: plt1, plt1.1, plt1.2, plt1.3, plt1.4. Note that the platoon leader has the same id as the platoon name.

<vehicle_platoon id="plt1" type="passenger" size="5" route="route0" depart="0" departLane="1" departPos="40" platoonMaxSpeed="20" color="red" />

Figure 5: Platoon of 5 vehicles

While forming a platoon, there will be a voting process between vehicles to choose the leader based on the type, size, and speed of existing vehicles. If a platoon leader leaves the platoon, the platoon leader will ask a follower to take over. A VOTE_LEADER message is sent from the platoon leader to its entire follower base to vote on the new platoon leader role. Followers can vote on a new platoon leader by running a distributed leader selection algorithm. The newly elected platoon leader uses the ELECTED_LEADER message to announce this to the current platoon leader. At least one follower should respond, otherwise, the platoon leader will resend the VOTE_LEADER message. After the second or new platoon leader takes over the lead role, the current platoon leader can change the lane and leave the platoon.

For the main issue of this project, we will add a platoon of five vehicles with an inter-platoon spacing of 10 metres and an intra-platoon spacing of 3 meters, as well as a separate vehicle. The third follower vehicle from the platoon will send an exit request to the platoon leader because the vehicle has reached its destination, and at the same time, the separate single-vehicle will send the entry request to the platoon leader.

The following model table contains the attributes, values, and applicability of a platoon.

Attributes	**Values**	**Applicability**
Type	Passenger	Vehicle Type
Size	5	Platoon Size
IntraGap	10 meters	Inter Platoon Space
InterGap	3 meters	Intra Platoon Space
Depart	0	Starting Time
PlatoonMaxSpeed	110	Maximum Platoon Speed
OptSize	5	Optimal Platoon Size
MaxSize	10	Maximum Size of Platoon

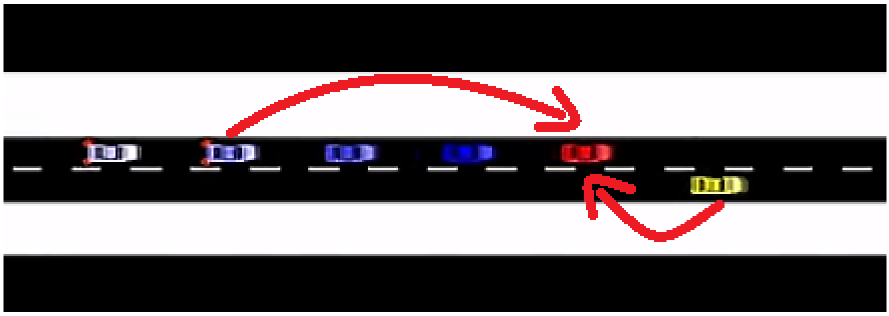

Figure 6: Two vehicles sending Entry and Exit request to platoon leader

Using the „maneuver" element, we can perform platooning maneuvers. This element supports the Merge, Split, Leave, Enter and Exit maneuvers. At the following we define the Exit maneuver and the Entry maneuver.

For the exiting of vehicle from platoon we just define Exit Maneuver code in the addnode file:

<maneuver pltId="plt1.3" begin="20" followerleave="true" leavedirection="right" />

For the entering of vehicle to platoon we define the Entry Maneuver code in the addnode file:

<maneuver id="veh_1" type="Passenger" begin="20" Entry="true" Entrydirection="left" />By the end of simulation the following graph will be generated by OMNET++:

The First graph represents the speed and the Acceleration of the Exiting vehicle.

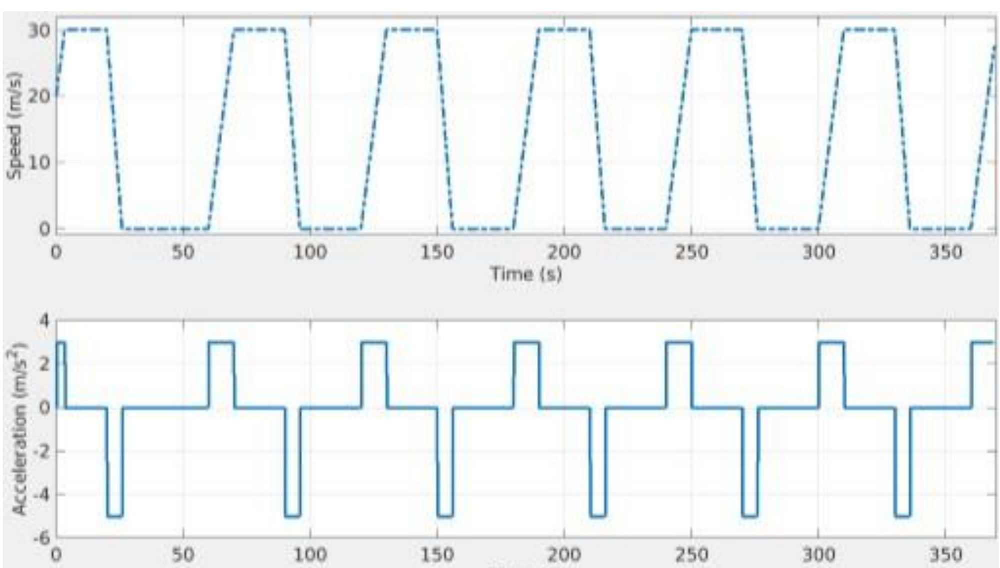

Figure 7: Speed and acceleration of the exiting vehicle

The exiting vehicle sends the exit request to platoon leader that it has reached its destination and needs to separate from platoon.

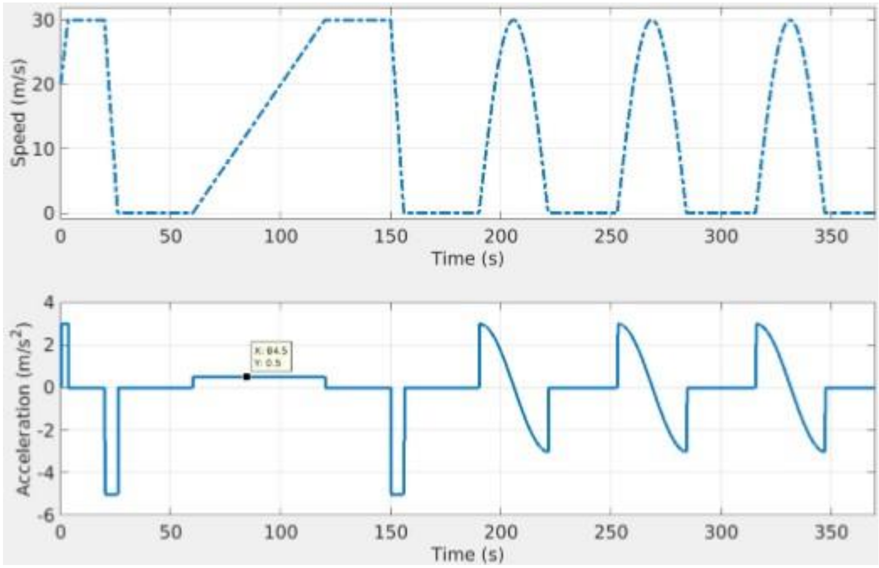

Figure 8: Speed and acceleration of the entering vehicle

The Second graph represents the speed and the Acceleration of the Entry vehicle.

For joining maneuvers providing a safe gap to entry vehicle must be considered at platoon site to ensure a secure entry maneuver.

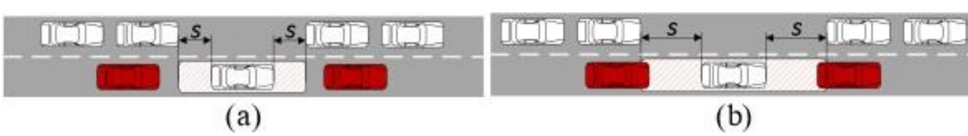

Figure 9: Importance of safe gaps

Figure 4-9 represents a join maneuver. Non-automated vehicles are represented in red. *This* is the safe gap. (a) No vehicle obstructs the manoeuvre since *it* is guaranteed. (b) The manoeuvre is obstructed since two vehicles are at a distance shorter than the vehicle that must change lanes. It shows that when the gaps are short, the probability that a non-automated vehicle will obstruct the manoeuvre decreases compared to when the gaps are larger. A manoeuvre is obstructed if a non-automated vehicle does not respect the safe gaps.

The following graph shows the percentages of success and aborted platooning maneuvers.

Figure 10 also shows that the configuration of the desired and safe gaps has a relevant impact on the success (or not) of platooning maneuvers. In particular, the figure shows that the shorter gap reduces the percentage of aborted maneuvers. Shorter gaps require less time and space for maneuvering. Therefore, it is less probable to find non-automated vehicles during the manoeuvres that would require aborting them.

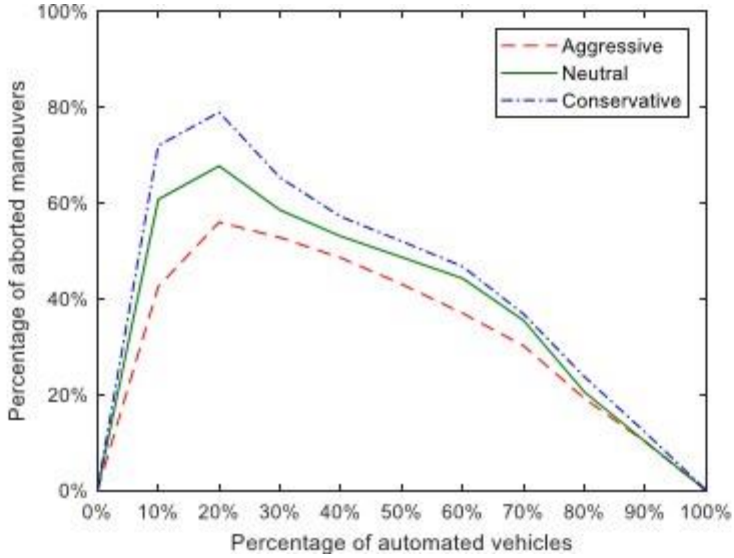

Figure 10: Percentage of aborted platooning maneuvers

The following graph shows the percentage success of maneuver based on traffic flow.

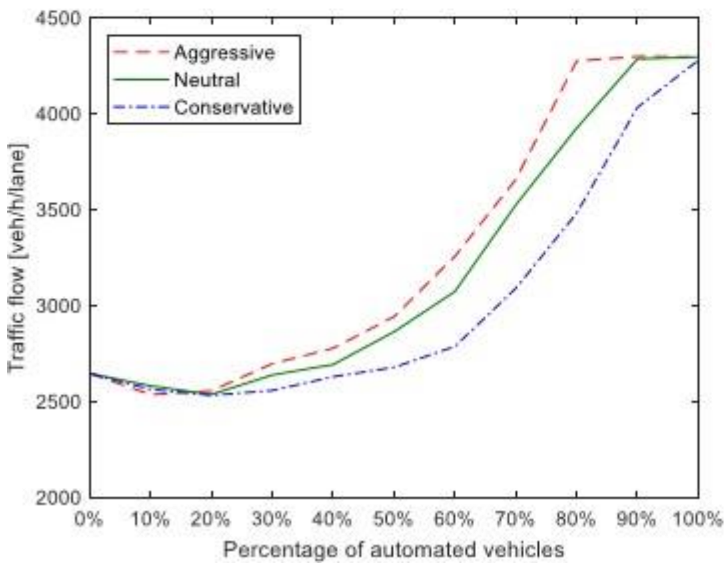

Figure 11: Percentage of success based on traffic flow

Figure 11 shows that increasing the maximum length of the platoon augments the flow, in particular when the percentage of automated vehicles in the scenario is higher than 20%. This is due to the formation of larger platoons that reduce the distance between vehicles inside the platoons and hence augment the road capacity and the traffic flow.

The next three graphs show the acceleration, speed, distance, and spacing error of the leader and the remaining vehicles while maneuvering.

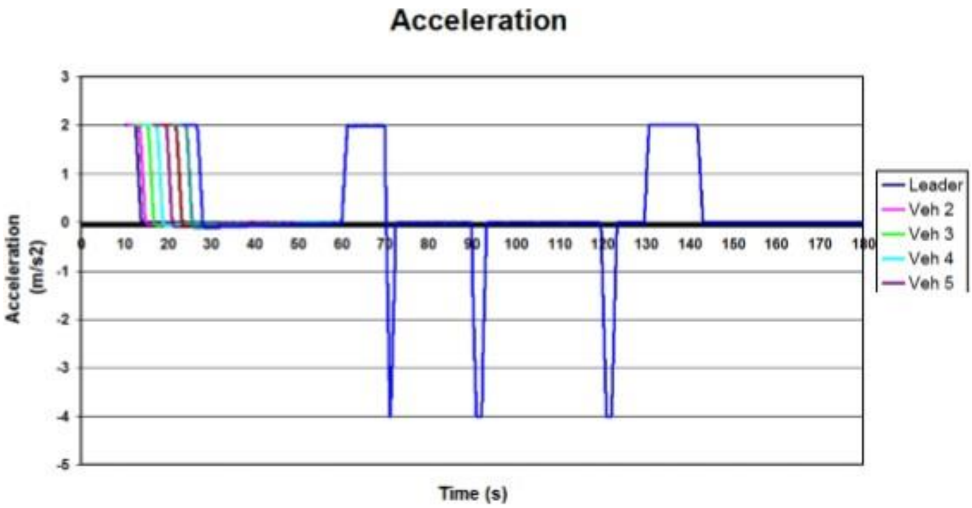

Figure 12: Acceleration of platoon leader and follower vehicles

Figure 12 show the acceleration state of platoon leader and the remaining follower vehicles during the maneuvers. The maximum acceleration is bounded by -4 < a < 2 m/s.

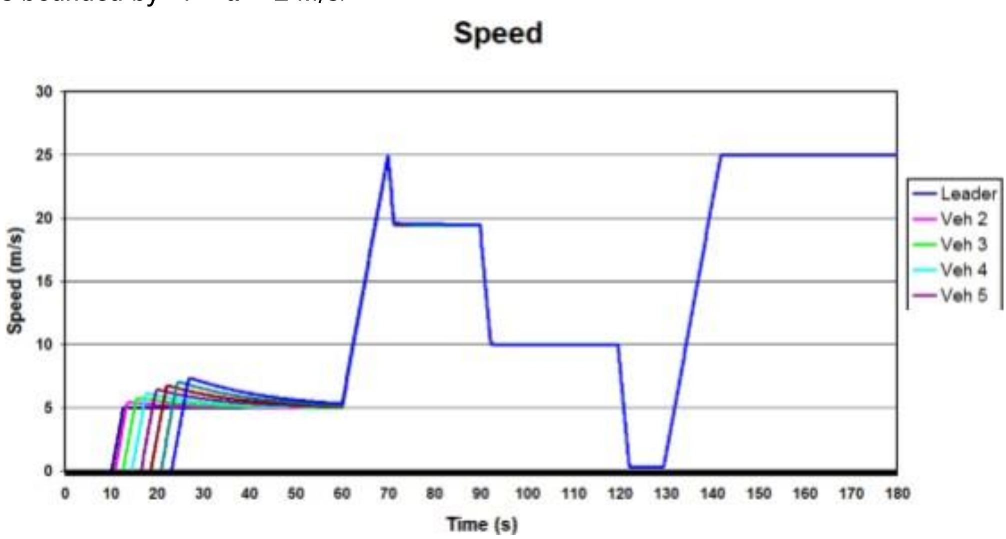

Figure 13: Velocity of platoon leader and follower vehicles

Figure 13 show the velocity of the leader and the remaining follower vehicle during the maneuvers. Note that, while maneuvering the speed of all platoon vehicles change but after the maneuvering, all vehicles follow the leader with the same speed pattern

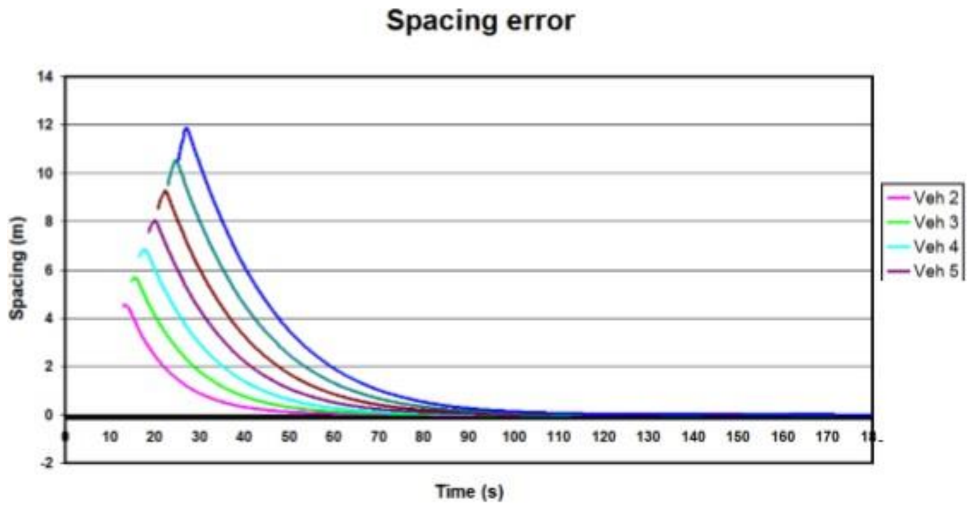

Figure 14: Spacing error

Figure 14 shows the spacing error of follower vehicles during maneuvering. The vehicles can travel a maximum distance of about 5.5m to 12.9m from the created gap. However, as the manoeuvres are done, the vehicles approach their precedent vehicle and the leader, all errors fall below 1 m, and after 70 s, the errors will approach zero.

As the platoon leader is in charge of decision making, he will decide based on the destination of the exiting vehicle that has been reached, the success and aborting percentage of the entry manoeuvre by facing with interfering non-automated vehicles and the percentage of success of the manoeuvre based on traffic flow due to larger or shorter platoons that allow which vehicle to perform its maneuver.

As a result, the simulation outputs were analyzed, and the result was that after performing these maneuvers, it was shown that the platoon leader will authorize the following vehicle to exit first, then authorize the other vehicle to enter the platoon. Because the destination of the exiting vehicle has been reached, the vehicle requests an exit. If the platoon leader didn't authorize the follower vehicle to exit, its destination would be missed and it would be a problem in management and control of the platoon leader.

Conclusion

The main approach of this project is to present the possibility of relying on autonomous vehicles using platooning by showing different safe joining and leaving manoeuvres over platoons. This project presented an overview and tutorial of an issue in platooning. The issue of entering and exiting vehicles into and from platoons at the same time has been discussed. A viable solution which has been researched for this challenge has also been mentioned. The acceleration and speed of vehicles during maneuvers, their success or abort of maneuvers, as well as the speed, acceleration, and distance of the platoon leader and remaining vehicles were shown and described by graphs. Through OMNET++, the network simulator has been built and using SUMO, the road traffic simulation showed that the platoon leader gives priority to exiting vehicles due to the destination that the exiting vehicle has reached.

As a result, platooning has improved road capacity, energy efficiency, and traffic safety impacts on ITS. This project has shown that one of the characteristics of platooning is the high degree of management of the platoon that has been given to the platoon leader. Although it was significant research for this challenge, many key factors for the success of platooning are still open.

This research project has been done to understand platoon management over different maneuvers. The result leads this project to the advantage and safety of platooning in performing different maneuvers. If someone uses this project to check different manoeuvres for platooning, this project will be a great help in understanding the way of forming a platoon, the different manoeuvres in a platoon, and the management and control given to the platoon leader.

Future Projects

Although this work enhances the performance of platooning techniques in Vehicular Ad-hoc Networks (VANETs) by giving priority to exit vehicles as compared to entry requests in the same platoon, in order to combine two different platoons, this work does not give any information. In this case, further investigation and research activity are required. Similarly, splitting a single platoon into two or more segments or platoons can be checked and searched through using the platoon split, which is another research area. Therefore, investigation regarding the performance of both platoon merging and platoon splitting is required. Furthermore, the selection of a platoon leader for new platoons in the case of platoon splitting is another challenging issue that needs to be handled.

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About the Authors

Mr. Amjad Khan, Academic Administrator, Department of Computer Science, Kardan University, Kabul Afghanistan. < *amjad@kardan.edu.af*>