To Enhance ECODE Protocol for improving Congestion Control and Network Life using Single Hop communication in VANET

A Dissertation submitted

By

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To

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In partial fulfillment of the Requirement for the
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LOVELY PROFESSIONAL UNIVERSITY

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School of: Computer Science & Engineering

DISSERTATION TOPIC APPROVAL PERFORMA

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ABSTRACT

Vehicular adhoc networks (VANET) are a new emerging technology in the world. VANET communication is an inevitable topic of research in the field of wireless networking. A VANET is responsible for creating a network by turning each and every participating vehicle into a wireless router or node allowing a vehicle to connect with each other. The foremost goal of vehicular adhoc network is to increase road safety and provide comfort to the passengers. As number of vehicles increases day by day, traffic also increases. So to overcome these problems different methodologies should be used to avoid the traffic congestion. In the proposed method is the improvement in the Efficient Traffic Congestion Detection Protocol (ECODE) by reducing the bandwidth usage in the network.

Each vehicle must communicate with RSU which lies in the transmission range. The vehicle must send a message to the RSU, the message should contain information like vehicle id, its speed and location, direction and destination and time of message generation. The RSU must be placed in the last quarter of the road segment. The reason for this particular placement of the road side unit is accounted for the fact that the congestion is bound to occur at the intersection of the road segments. And if the road side unit is placed in the last quarter of the road segment, then after receiving all the information from the vehicles, the RSU can provide the vehicle with the proper directions and the driver of the vehicle will have all the directions before reaching the intersection itself. However, if the RSU is placed just at the intersection of the road, then the driver of the vehicle might not get enough of the time to assess the conditions. So after all the vehicles send their information to the RSU of one particular segment, it can communicate with the RSU of the other segment and inform it about the traffic conditions in its own segment. After assessing the traffic at the intersection, RSU will provide information to the vehicle to maintain the traffic by taking effective decision to follow a less congested route to the destination. In this way, we aim to reduce the congestion in the network. This technique will provide better outcomes in terms of congestion control and end to end delay.

ACKNOWLEDGEMENT

I owe a debt of deepest gratitude to my thesis supervisor, **Mr. Rohit Sethi**, Department of Computer Science And Engineering, for his guidance, support, motivation and encouragement throughout the period this work was carried out. His readiness for consultation at all times, his educative comments, his concern and assistance even with practical things have been invaluable.

I would like to thank the people who took their time to help us to complete this work. Last but not the least; I would like to thank parents who are acting as a source of support throughout the period of this work.

DECLARATION

I hereby declare that the dissertation proposal entitled, **To enhance ECODE Protocol for improving congestion control and network life using single hop communication in VANET** submitted for the M.Tech Degree is entirely my original work and all ideas and references have been duly acknowledged. It does not contain any work for the award of any other degree or diploma.

Date: Investigator: Nahita Pathania

Registration No: 11301033

CERTIFICATE

This is to certify that **NAHITA PATHANIA** has completed M.Tech dissertation proposal titled, **To enhance ECODE Protocol for improving congestion control and network life using single hop communication in VANET** under my guidance and supervision. To the best of my knowledge, the present work is the result of her original investigation and study. No part of the dissertation proposal has ever been submitted for any other degree or diploma.

The dissertation proposal is fit for the submission and the partial fulfilment of the conditions for the award of M.Tech Computer Science & Engg.

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CHAPTER 1

INTRODUCTION

In today's world, wireless networks are emerging as an outstanding technology. These are those networks that do not have any wired link between them. Radio waves are used for the broadcasting of data in wireless networks. This generally takes place at the physical layer of Open System Interconnection model. Wireless devices such as laptops and mobile phones uses wireless networks for communication. Two types of wireless networks are there:

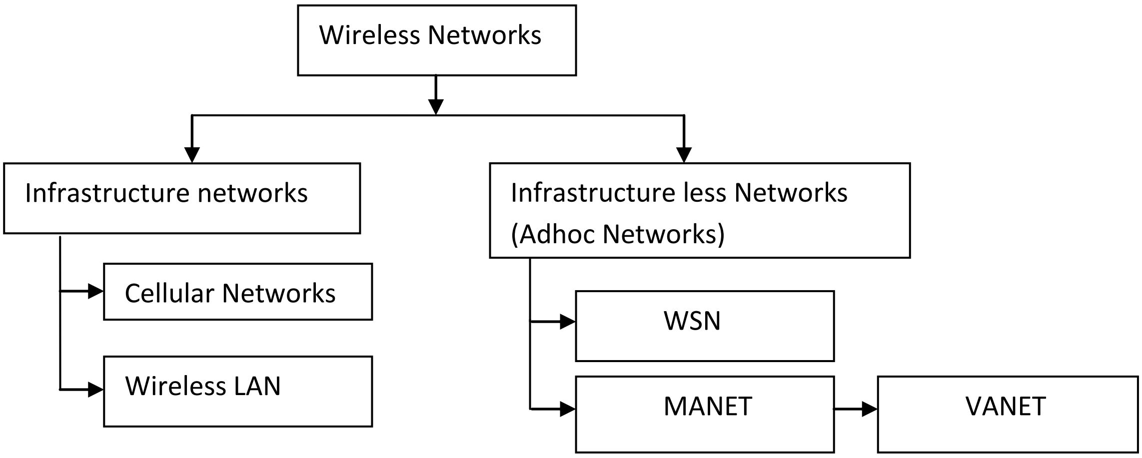


Fig 1.1 Types of Wireless Networks

Infrastructure networks: These networks can be termed as arranged or managed networks. These networks make use of access points for the communication that takes place between devices or base stations. For example- cellular networks and wireless LAN.

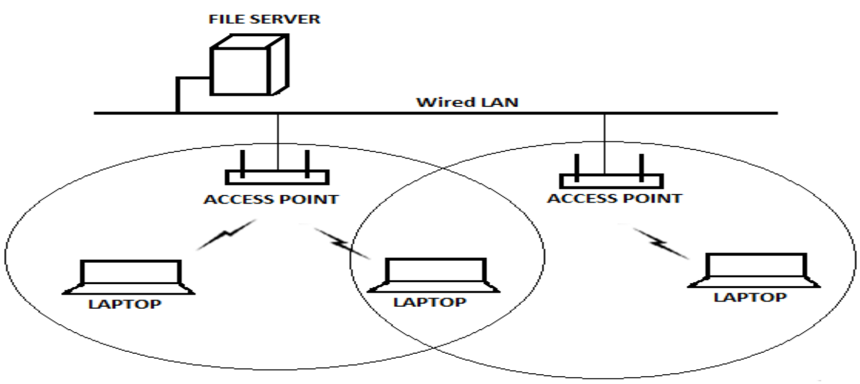


Figure 1.2 Infrastructure Network

Infrastructure less networks: These networks can be termed as adhoc networks in which there is no predefined infrastructure. The nodes in these networks are mobile in nature and are linked dynamically in a random behaviour. In these networks, nodes behave as routers and participate in route discovery and maintenance in the direction of other nodes.

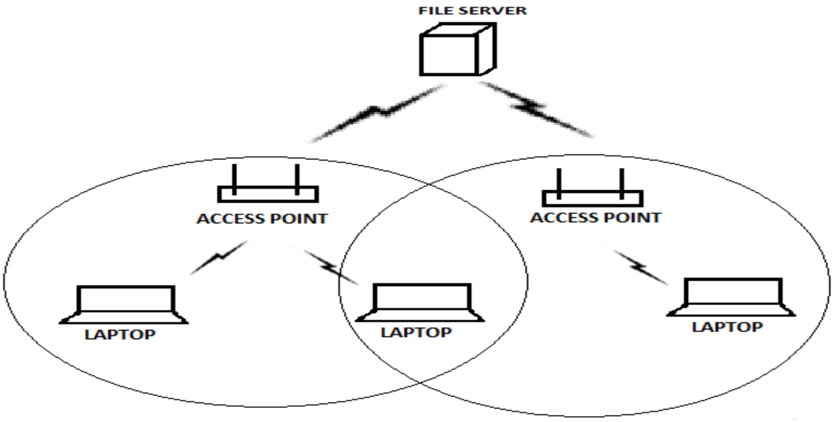


Figure 1.3 Infrastructure less network.

1.1 ADHOC NETWORKS

Wireless networks that are self-organising, decentralized and infrastructure less in nature are termed as adhoc networks. Mobile nodes in adhoc networks use wireless communication for transmission of data. Adhoc networks can form a short-term network anywhere without the use of any present infrastructure and can be laid down anywhere. This indicates the adaptive nature of adhoc networks. These networks can operate in stand-alone fashion. These networks do not rely on fixed infrastructure i.e. no access point is there. Adhoc network use flooding for forwarding of the data.

1.1.1 Types of Adhoc Networks:

a) **Wireless Sensor Networks**: It is an infrastructure comprising of sensing, computing and communication elements to supervise physical or environmental conditions like temperature, sound, etc. Nowadays mobile phones are also equipped with sensors like proximity sensors, light sensors. Other types of sensors are biosensors, chemical sensors, etc.

The main components of a sensor network are:

- A collection of distributed sensors
- An interconnecting network
- A central point of information clustering
- A set of computing resources at a central point

b) MANET- In mobile adhoc networks, the mobile nodes itself act as routers to communicate with each other. There is no fixed topology (i.e. random topology is there) because the nodes keep moving due to their mobile nature. In MANET, multihop wireless links are used for communication. Different features of mobile adhoc networks are random topologies, restricted security, bandwidth and energy constraints.

Uses of MANET:

- Sharing of information.
- Used in various military applications.
- Intranet and internet hot spots.

Mobile adhoc network has its further subclass known as VANET (Vehicular Adhoc Networks). VANET is one of the influencing areas for the improvement of the ITS in order to provide comfort to passengers and safety to the road users. In VANET, the mobile nodes are known as vehicles. In VANET, wireless links known as onboard units are mounted on each vehicle (node) through which communication takes place. VANET is a self organising network i.e. no permanent infrastructure is needed. But there are few stationary nodes known as roadside units (RSU) to support the vehicular networks for serving geographical data. In VANET, vehicles move on already defined roads. The vehicles have to follow the traffic signs and obey traffic rules. Vehicular networks usually use dedicated short range communication (DSRC) which is the improved version of Wi-Fi. DSRC is basically used where the topology changes very quickly. In vehicular networks, DSRC provides data transfer between vehicles and roadside units. DSRC provides high data rates and quick responses in vehicular networks so that critical situations like road accidents can be avoided.

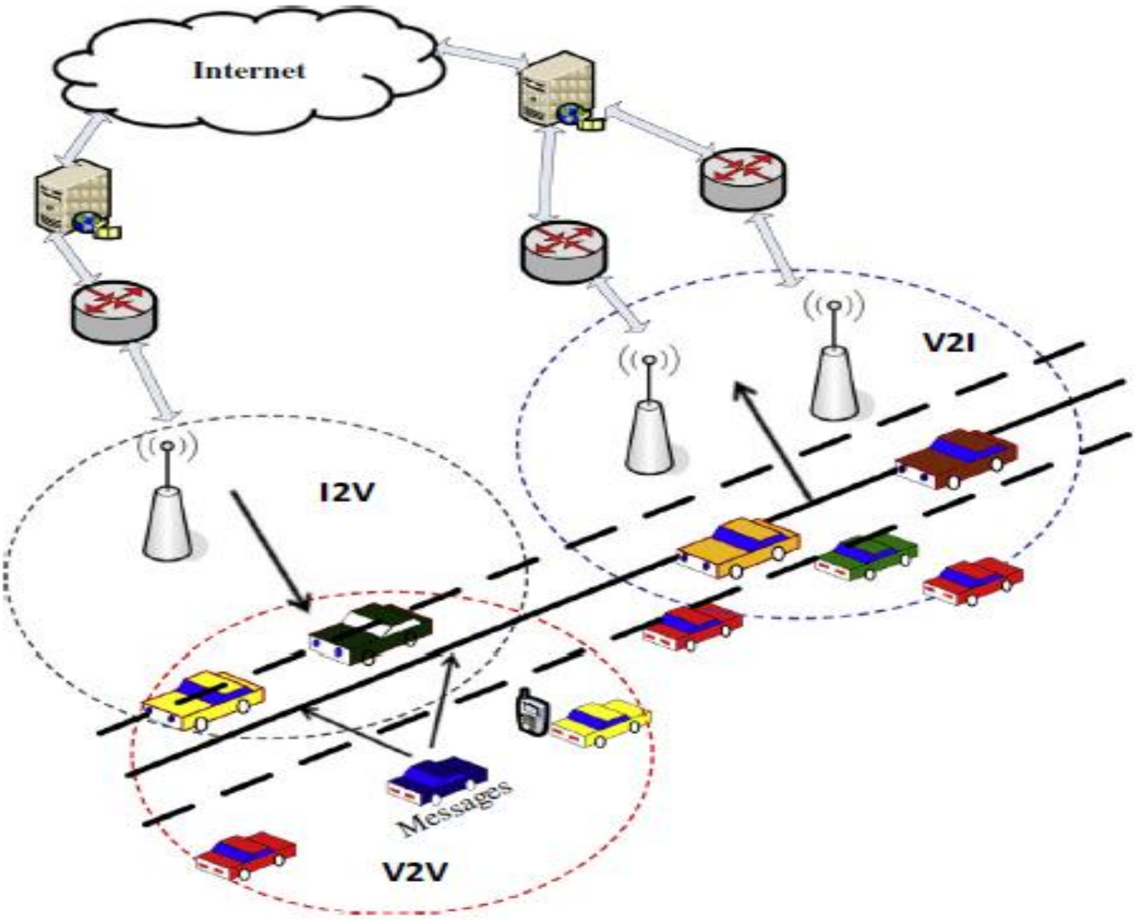


Figure 1.4 VANET ARCHITECTURE (Pierre et al. 2014)

1.2 COMMUNICATION TYPES IN VANET

- **Vehicle to vehicle (V2V) –**V2V communication is suitable for short range vehicular network. It is fast, reliable and also provides real time safety. It does not need any roadside infrastructure. This type of communication is possible only in dense vehicular network. In V2V warnings are broadcast from vehicle to vehicle.

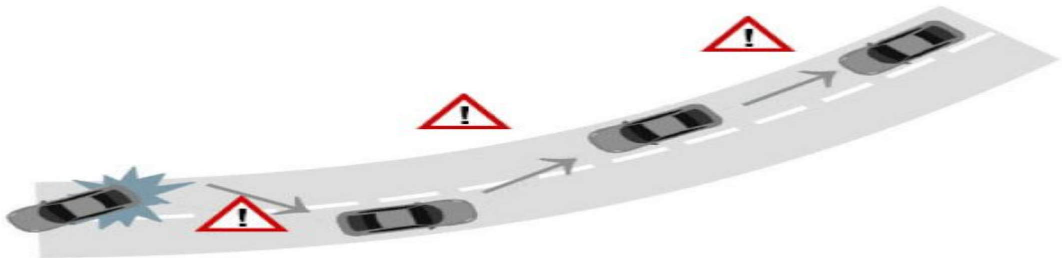


Figure 1.5 Vehicle to Vehicle Communication

- **Vehicle to Infrastructure (V2I)**–V2I provides communication between vehicle and the roadside units. It uses pre existing network infrastructure such as wireless access points. In V2R warning messages are first send to roadside units and then from that roadside unit these warning messages send to the vehicles.

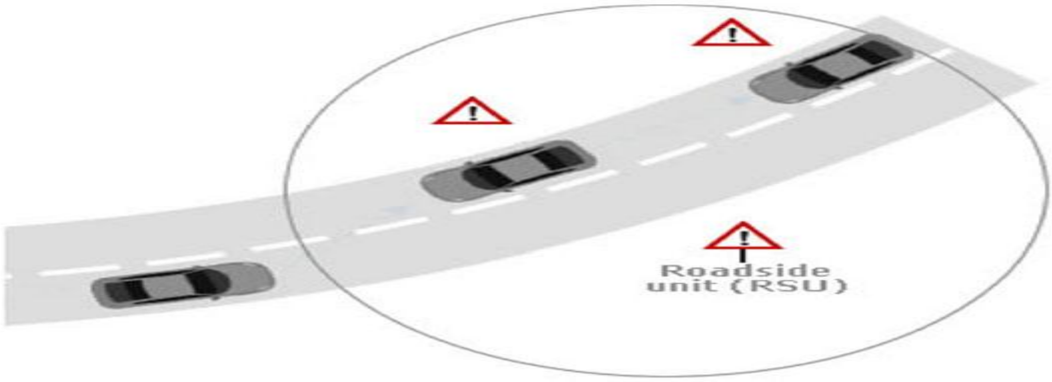


Figure 1.6 Vehicle to Infrastructure Communication

- **Infrastructure to Vehicle (I2V)**–It is just the reverse of vehicle to infrastructure communication.

1.3TECHNOLOGIES USED IN VANET

Various types of technologies have been introduced in VANET to provide radio communication between the vehicles and roadside units. The most widely used technologies are cellular networks (2G/3G/4G), Wireless LAN/Wi-Fi, WiMAX and DSRC/WAVE. Vehicular networks usually use dedicated short range communication (DSRC) which is the enhanced version of Wi-Fi. DSRC is basically used where the topology changes extremely quickly. DSRC uses 5.9 GHz band and provides data transfer between vehicles and roadside units. DSRC provides high data rates and quick responses in vehicular networks so that critical situations like road accidents can be avoided. As shown in Fig. 2, DSRC is protocol stack which includes MAC and PHY layers provided by IEEE 802.11p. DSRC is made up of seven channels; it starts at 172 and ends at the 184 channel number. Each channel has specified a frequency i.e. 10MHz. Channel number 178 is used to control the channel, for safety and secure communication. Likewise channel number 172 and channel 184 is used for safety application, some other services provides safety and non safety uses.

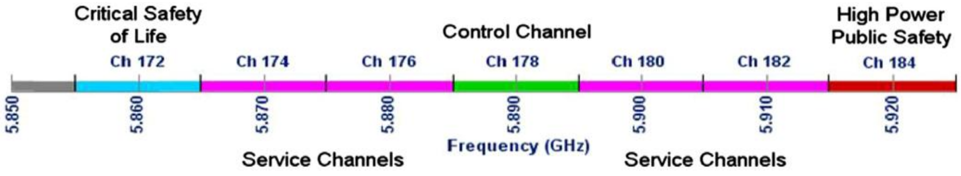


Figure 1.7 75 MHz DSRC Spectrums (Sultan et al. 2013)

1.4 WAVE Architecture for VANET

WAVE stands for Wireless Access in Vehicular Environments. This protocol stack is introduced by IEEE and named it as 1609 standard. Further this standard is divided into six sub- categories. Each one of the following standard has different functionality. The WAVE architecture is represented below.

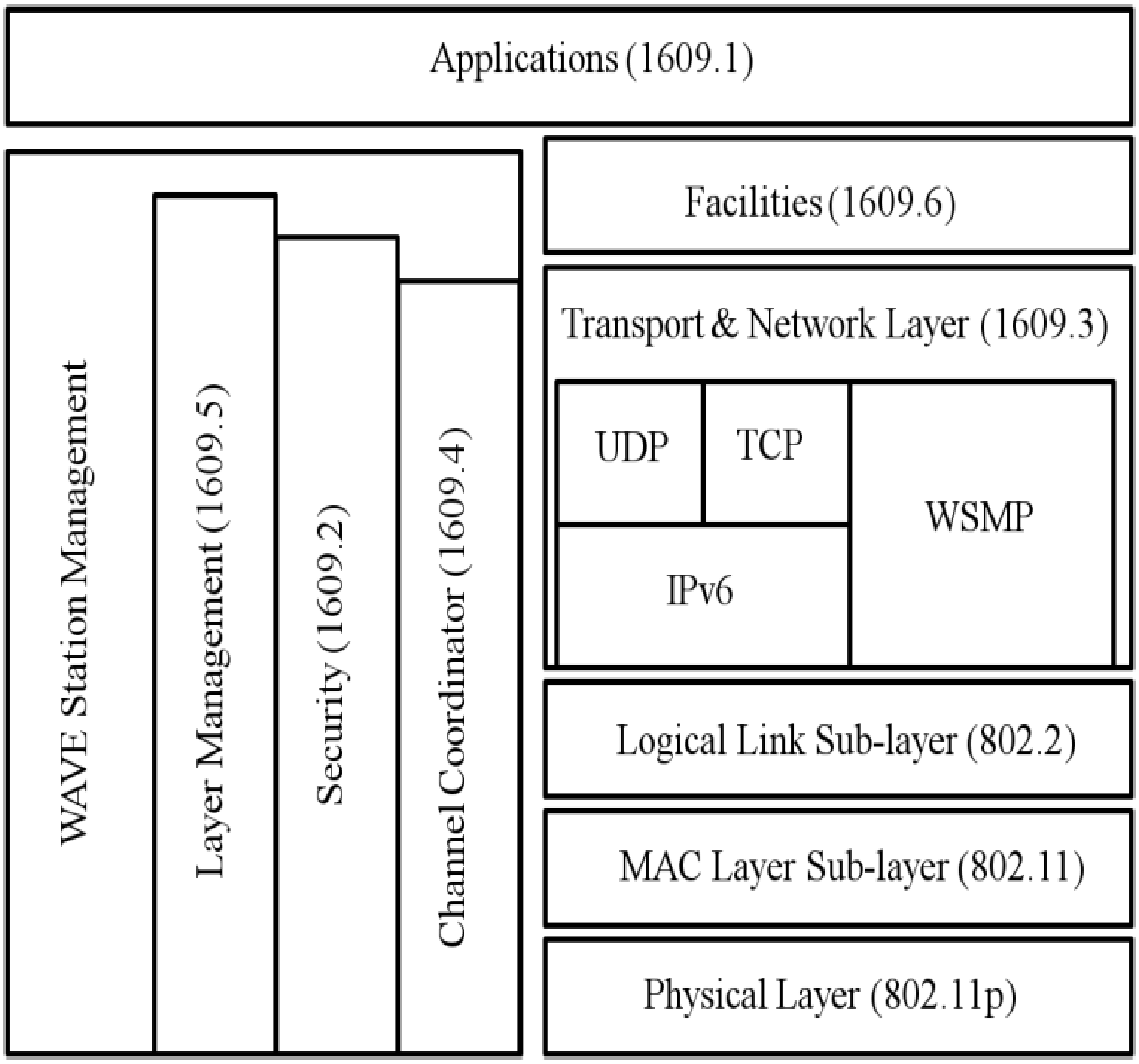


Figure 1.8 WAVE Architecture for VANET (Mohammad et al. 2011)

Applications (IEEE 1609.1) describes about all the running activities that are needed for the appropriate functioning of the applications. Security (IEEE 1609.2) depicts the contemplations to be considered for communication protection. 1609.3 standard is Transport and Network layer standard which gives a committed single protocol, known as Wave Short Messages Protocol (WSMP). This protocol is used for safety related applications. 1609.4 characterize the coordination between the various channels of the range. 1609.5 concerns with Layer Management and 1609.6 suggest a supplementary layer in the centre of transport and application layer, for managing of extra services at the Applications Layer. IEEE 802.11p i.e. physical layer particulars the MAC Layer function of the WAVE architecture.

1.5 CHARACTERISTICS OF VANET

- **High node Mobility**- It depends upon the speed of vehicles, traffic environment driver behaviour and road structure.
- **Frequent topology change**- Due to high movement of vehicles the network topology changes rapidly that is there is rapid pattern movement.
- **Battery power and storage**- The storage capacity and battery power is unlimited in vehicles so it is helpful for making routing decisions and effective communication.
- **Localization**- Onboard sensors like GPS is used to sense the current location and movement of nodes (vehicles).
- **Hard Delay Constraints**- Delay in safety messages can lead to serious consequences like accidents. So, these messages should be delivered on time.
- **Variability in Network Density**- The network density in vehicular adhoc networks depends upon the density of the traffic. The traffic density can be high or low depending upon the traffic jams, etc.

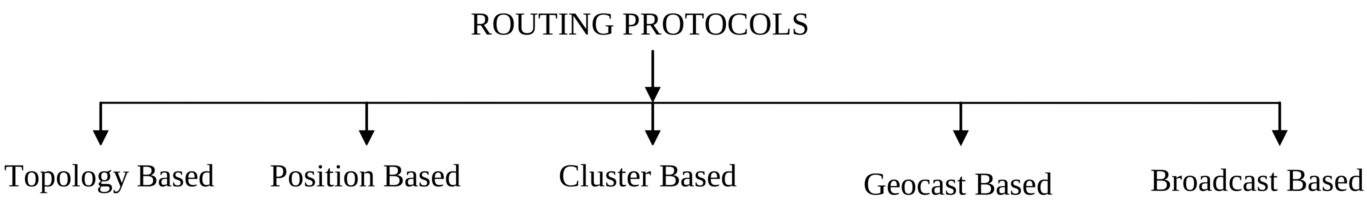
1.6 CHALLENGES AND REQUIREMENTS IN VANET

- **Bandwidth restrictions-** In VANET, vehicles are moving in random fashion. There is no central coordinating authority which can be in charge of communication among the vehicles and handles the bandwidth usage in the network. The bandwidth utilization must be resourceful so that delay is less and ultimately congestion will be less in the network.

- **Signal weakening:** The efficiency of VANET can be influenced by the hurdles that are present between the communicating entities. These hurdles can be vehicles or buildings that thwart the signal from reaching to the required destination.
- **Connectivity:** The transmission power should be improved so that vehicles can communicate for longer period of time. But increasing the transmission range lead to the deprivation of the throughput.
- **Privacy and Security:** The information that is circulating among the vehicles must be accurate and should not contain any malicious content. This is one of the main challenges in VANET.

1.7 ROUTING PROTOCOLS IN VANET

The routing protocols in VANET can be classified into various categories.



- **Topology based routing**- It performs packet forwarding by using the links that exist in the network. The various types of topology based routing are Proactive, Reactive and Hybrid. Proactive protocols are table driven. Reactive protocols are called on-demand routing protocols. Hybrid protocols will reduce the control overhead of proactive routing protocol.
- **Position based routing protocols**- In this each node knows its neighbour by using GPS information. It does not maintain any routing table.
- **Cluster based routing protocols** – In this, vehicles near to each other form a cluster. There are two types of communications inter-cluster and intra-cluster. In intra-cluster vehicles communicate with each other by using the direct links and in inter-cluster vehicles communicate with each other by using the cluster heads.
- **Broadcast routing protocols** – These protocols also known as flooding routing protocols which transmit the information to the maximum nodes when an accident takes place.

- **Geocast routing protocols** – These protocols are also known as the location based routing protocols which is used to send the messages in the selected area called as Zone of Relevance.

Protocols	Proactive Protocols	Reactive Protocols	Position Based Protocols	Cluster Based Protocols	Broadcast based Protocols	Geocast Based Protocols
Prior Forwarding Method	Wireless multihop Forwarding	Wireless multihop Forwarding	Heuristic Method	Wireless multihop Forwarding	Wireless multihop Forwarding	Wireless Multihop Forwarding
Virtual Infrastructure Requirement	No	No	No	Yes	No	No
Recovery strategy	Multihop Forwarding	Carry and Forward	Carry and Forward	Carry and Forward	Carry and Forward	Flooding
Digital map requirement	No	No	No	Yes	No	No
Realistic traffic flow	Yes	Yes	Yes	No	Yes	Yes
Scenario	Urban	Urban	Urban	Urban	Highway	Highway

Figure 1.9 Comparison of Various Routing Protocols In VANET

1.8 CONGESTION CONTROL IN VANET

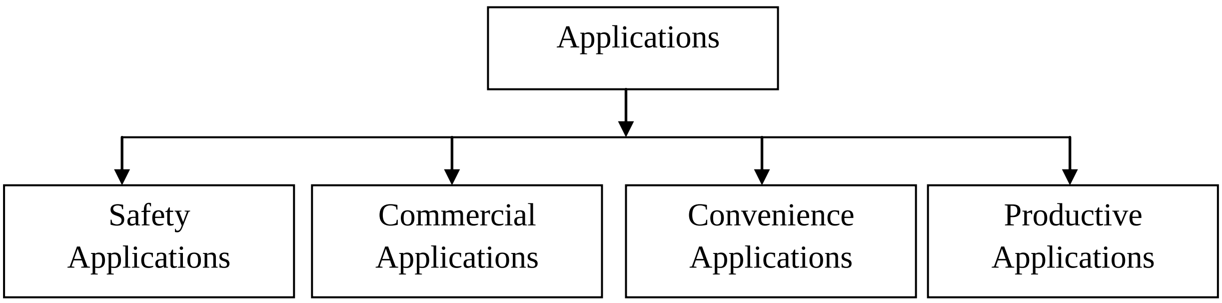
Vehicular Ad hoc Networks (VANET) play an imperative part in future on street Vehicle-to-Vehicle correspondence frameworks and related applications like masterminding toward oneself, gaining movement data utilizing sensors and dispersing it to the adjacent vehicles, which are taking into account broadcast transmission plans. It is a difficult errand to supervise networks in active domain because of the trait for high mobility rate, high relative velocity, distinctive driver conduct and uncertain failures. One of the principle criteria in VANETs that has pulled in the analysts' thought is congestion control. Congestion is a real issue all over world, bringing about wastage of profitable time and money.

Congestion is one of the biggest problems in vehicular adhoc networks. Most of the researchers aim at decreasing the congestion level in the network but results is not obtained up to the mark. This is due to the increasing number of vehicles in the transportation system. We know that with increasing number of vehicles traffic also increases which may lead to congestion in the network.

There can be various reasons for the congestion in the network like under-construction road, accidents, weather and rush hour. One of the main factors can be driver’s behaviour. Communication channel congestion can lead to packet drops in the network which results in the channel degradation. The main aim of VANET is to provide safety on road. So, it uses two types of messages. One is beacon messages and other is emergency messages. Beacons are used to exchange basic information like speed of vehicle or location of the vehicle and emergency messages are send in critical situations like accident warning. Beacon messages usually consume much bandwidth as compared to emergency messages. So, sometimes emergency messages are dropped which may result in accidents. There can be various ways by which congestion can be controlled. One is to reserve the bandwidth for emergency messages. Also there are various congestion control protocols which can be used to detect or avoid the congestion in the network, thus providing a smooth and safe travel.

1.9 APPLICATIONS OF VANET

VANET applications can be classified as safety and non- safety applications.



1.8.1 Safety Applications

Safety applications are those applications that are critical to life. Security applications incorporate checking of the encompassing street, approaching vehicles, surface of the street, street bends and so on. Safety applications can be classified into

1) Traffic based on real time situations: This type of traffic information can be put away at the RSU and can be accessible to the vehicles at whatever point and wherever required. This can play an important part in taking care of the issues, for example congestion avoidance and in crisis cautions.

2) Transfer of Messages: Vehicle will trade messages and assist to help other vehicles. In spite of the fact that reliability and latency would be of real concern, it may computerize things like crisis braking to evade potential mishaps. Likewise, emergency electronic brake-light can be an additional application.

3) Post Crash Notification: A vehicle included in a mishap would telecast cautioning messages about its position of the rear vehicles so that the situation can be controlled within time.

4) Road Risk Control Warning: Vehicles notify neighbouring vehicles about roads having landslide or avalanche or any other calamity.

5) Collision Notification: this warning warns the drivers that they are under accident prone zone and should change their path.

1.8.2 Business Applications

Business applications will furnish the driver with the amusement and administrations such as web access, audio and video streaming. These applications can be categorised as:

1) Vehicle Personalization: It helps in downloading of customized vehicle settings or transferring of vehicle diagnostics framework.

2) Accessing the Internet: Vehicles can get to web through RSU if RSU is equipped with these capabilities.

3) Value-added hoardings: These basically include the advertisements put by service providers to attract the customers. This can be done by giving offers or discounts to the customers.

4) Video and Audio Streaming: People can watch movies online in their vehicles and they do not have to wait to go home and download it and then watch it.

5) Downloading of Digital Maps: Maps of various regions can be downloaded by the car drivers to know the location of the new geographical area.

1.8.3 Convenience Applications

These applications specifically deal with the traffic supervision to increase traffic effectiveness. These applications include:

1) Route Diversions: Routes can be changed in case of congestion on roads.
2) Availability of Parking: Availability of parking slots can be find with help of VANET in geographical areas.
3) Toll Collection by electronic means: toll tax can be collected electronically through toll tax barriers. These barriers should be able to read the vehicle's onboard unit.

1.8.4 Productive Applications

These are the additional applications in context with the previous applications. These applications include:

1) Time utilization: The driver as the driver previously knows about the congested roads and also aware of the path which the driver has to follow to the destination. Thus, a lot of time is saved by driver by having this information.
2) Fuel Saving: A lot of fuel is saved as vehicles need not to stop for toll tax collection. It will be automatically collected when the vehicle passes the toll barrier, thus minimizing the wastage of fuel.

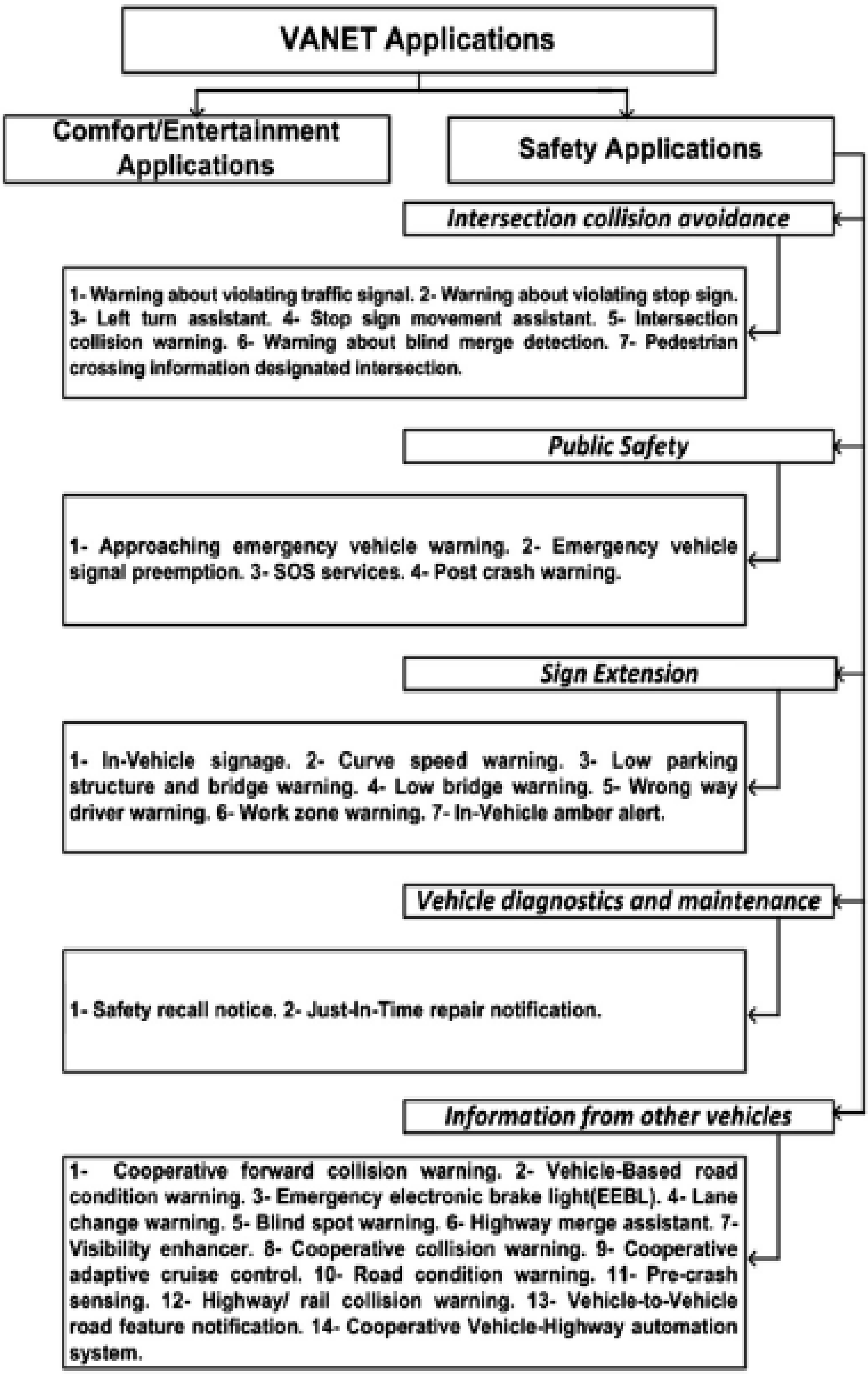


Figure 1.10 Applications of VANET (Sultan et al. 2015)

1.10 INSTALLATION STEPS OF NS2

To install NS2 in windows cygwin is required. Cygwin is used to install softwares that run on Linux. In Linux, NS2 can be installed directly. The following steps describe how to install NS2 on Linux.

Step 1: Open the website and download NS2.35. Copy it to the home directory in Linux. Suppose the home directory is assigned the name nahita.

Step 2: Now extract NS2.35. This can be done in two ways.

a) Open terminal in LINUX and write

    tar -xzvf ns-allinone-2.35.tar.gz

b) Right click on ns-allinone-2.35.tar.gz and extract.

Step 3: To successfully install NS2, following packages should be downloaded from the internet.

a) sudo apt-get install build-essential autoconf automake
b) sudo apt-get install tcl8.5-dev tk8.5-dev
c) sudo apt-get install perl xgraph libxt-dev libx11-dev libxmu-dev

Step 4: Now after extracting NS2. Open file "ns-allinone-2.35/ns-2.35/linkstate/ls.h" in text editor. Change in line number 137 by replacing 'erase' with 'this->erase' and save it.

Step 5: Then go to folder ns-allinone-2.35 and install ns2 by writing the following command in terminal:

cd ns-allinone-2.35

./install

Step 6: After successful installation of NS2, now set the path by typing following command in the terminal- gedit ~/.bashrc.

Now insert these lines into opened document.

#LD_LIBRARY_PATH

OTCL_LIB=/home/nahita/ns-allinone-2.35/otcl-1.14

NS2_LIB=/home/nahita/ns-allinone-2.35/lib

X11_LIB=/usr/X11R6/lib

USR_LOCAL_LIB=/usr/local/lib

export
LD_LIBRARY_PATH=$LD_LIBRARY_PATH:$OTCL_LIB:$NS2_LIB:$X11_LIB:$USR_LOCAL_LIB

#TCL_LIBRARY

TCL_LIB=/home/nahita/ns-allinone-2.35/tcl8.5.10/library

USR_LIB=/usr/lib

export TCL_LIBRARY=$TCL_LIB:$USR_LIB

#PATH

XGRAPH=/home/nahita/ns-allinone-2.35/bin:/home/nahita/ns-allinone-2.35/tcl8.5.10/unix:/home/nahita/ns-allinone-2.35/tk8.5.10/unix

NS=/home/nahita/ns-allinone-2.35/ns-2.35/

NAM=/home/nahita/ns-allinone-2.35/nam-1.15/

PATH=$PATH:$XGRAPH:$NS:$NAM

Now save the file.

Step 7: Validate the Ns2 installation, move to terminal and type

cd ns-allinone-2.35/ns-2.35

./validate

Step 8: To check whether NS2 is installed correctly or not, go to terminal and type ns. If % sign is displayed it means NS2 is successfully installed.

Organization of Work:

Chapter 2: This chapter contains the review of literature i.e. it includes all the related work that has been analysed to solve a problem. Various congestion control protocols have been discussed in this chapter.

Chapter 3: In this chapter present work has been discussed i.e. problem definition and then how to solve the problem. For this research methodology has been defined and also algorithm steps have been defined in this chapter to solve the problem.

Chapter 4: This chapter covers the result and discussions. A scenario has been taken to represent the VANET scenario and results based on throughput, delay and packet delivery ratio has been compared to the previous work that has been done. The results are shown in the form of Xgraphs.

Chapter 5: This chapter contains the conclusion of the thesis work. The results show that the proposed algorithm is better in terms of performance. Also the future scope has been discussed.

Chapter 6: This chapter includes the references i.e. the name of the research papers, websites that has been referred while performing the research work.

Chapter 7: It includes the abbreviations i.e. the full form of the short forms which are used in this report.

CHAPTER 2

REVIEW OF LITERATURE

A Design Approach of Congestion Control for Safety Critical Message Transmission in VANET(Madankar et al. 2014) - In their paper they proposed a congestion control technique which will guarantee that an adequate amount of bandwidth is assigned to beacons and emergency messages so that in dense environment the congestion can be avoided. In the proposed scheme, proper time slots are assigned to beacons and emergency messages.

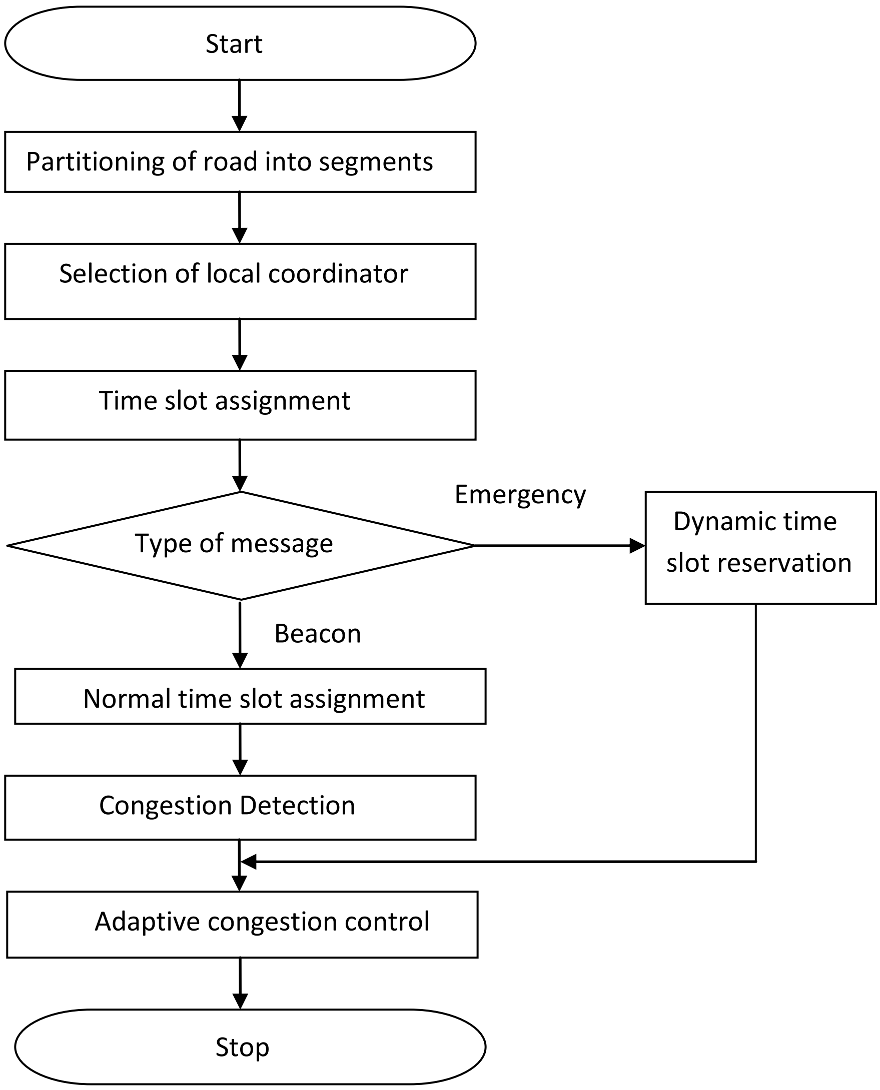


Figure 2.1 Flowchart of proposed design

In the proposed design, first we will partition the road into small segments or sectors. Each sector will have equal or unequal vehicle density. If the vehicle density is unequal then the local coordinator is selected that is near to the centre of the vehicles and sector. After that, local coordinator will select the time slot for other vehicles. As we know that according to the DSRC, each vehicle will create beacons after 300ms, so if vehicle density is high the sector will get congested easily. So the congestion must be detected without delay and a dynamic time reservation slot must be assign to emergency messages. If the vehicles do not discover any time slot in the sector then intersegment slot transfer can be there. Thus, congestion can be controlled by the proposed method.

VANET Security Surveys (Engoulou et al. 2014) – In this paper, the author explains about the security issues and challenges that arises during exchange of information in vehicular adhoc networks. Firstly, they explained about the architecture and characteristics of VANET. After that they explained about challenges like time constraints, scalability, highly mobile nodes etc which should be addressed. Then they explained about the security requirements. The main requirements are authentication, integrity, confidentiality, non-repudiation, integrity, availability, access control, etc. Then the security threats have been discussed which include denial of service, eavesdropping, impersonation, message alteration, etc. Then various methods have been listed to address the security problems. It includes the use of digital signatures.

Then the authors discussed about the global security architecture which is a five level system which includes material level, cryptographic level, data level, trust level, authentication level. The cryptographic level comes under privacy, both data and trust level comes under detection and correction. Authentication and material level comes under prevention.

VANET Routing Protocols: Issues and Challenges (Aggarwal et al. 2014) –In this paper, the author discussed about the various protocols to be used in VANET while routing takes place. The protocols are explained below:

Position Based Routing Protocols: In this protocol, the nodes are positioned with the help of global positioning system in which hello messages are send to the vehicles to update the information. They are further of two types: first is Distance routing effect algorithm for mobility (DREAM). Second is: Greedy Perimeter stateless routing (GPSR).

This protocol works well in terms of performance in areas where we are having less dense traffic. Processing overhead is lowest. Stability increases with high mobility of vehicles. No need of global route to be maintained from source to destination. But the disadvantages are that GPS is needed and sometimes, location servers go into standstill condition.

Topology Based Routing Protocols: It uses the existing information regarding the link that exists in the network to forward the packet. In this, the bandwidth consumption is less but overhead is more because in this route discovery mechanism is used. It is further of three types: proactive, reactive and hybrid. Proactive protocols are also known as table driven routing protocols. In this the routing table is maintained in which information about every node is present. Reactive protocols are on demand routing protocols. Both proactive and reactive routing protocols are combined to form hybrid protocols.

Broadcast Based Routing Protocols: This protocol broadcast the packet in the whole vehicular environment. This method is used when the destination node lies outside the transmission range. This is mainly used of safety related applications.

Cluster Based Routing Protocols: In this cluster is formed which consists of vehicles having same characteristics. A cluster head is chosen to communicate with all the neighbouring nodes or vehicles. This protocol has high scalability but overhead is more.

Geocast Based Routing Protocols: In this the communication takes place between a particular region called zone of relevance. If the destination node does not belong to ZOR then the communication takes place via Zone of Forwarding. In this protocol congestion is less and packet delivery is reliable.

A Performance evaluation of an efficient traffic congestion detection protocol (ECODE) for intelligent transportation systems (Younes et al. 2014) – In this paper, authors proposed a protocol that do the traffic estimation in terms of traffic speed, traffic density and approximate time needed to travel throughout the road segment. This protocol assumes that RSU"s are installed at the end of each road segment. This protocol considers the direction of the traffic evaluation. In this protocol they worked to improve the end to end delay and bandwidth consumption. From the simulation results, authors found that if the road segment is longer, then the number of vehicles would be more. Hence, more consumption of bandwidth will be there and delay times of traffic evaluation will be more. In this paper, they also discussed that overhead is less when we use hybrid protocol as compared to reactive and proactive protocols. Then the performance comparison of ECODE is done with the previous control protocols and found that that ECODE is much better as compared to previous protocols.

Multi Agent Based Congestion Control in VANETs (Mahabaleshwar et al. 2014) –
In this paper, authors proposed a multi operator based congestion control plan, which skillfully procures the status of the neighboring vehicle data and chooses the congestion free way for the safe conveyance of packet. Multi agent plan comprises of set of static furthermore, movable agents. Proposed methodology ensures the reliability and also ensures the delivery of messages on time. This technique focus on congestion control mechanisms that controls the congestion caused due to bandwidth, Cache and Buffer memory. The Agents are utilized to gather and control information of these parameters. The proposed method will choose the vehicle or node having more memory and lesser bandwidth usage. The VANET architecture as explained by the authors is represented below.

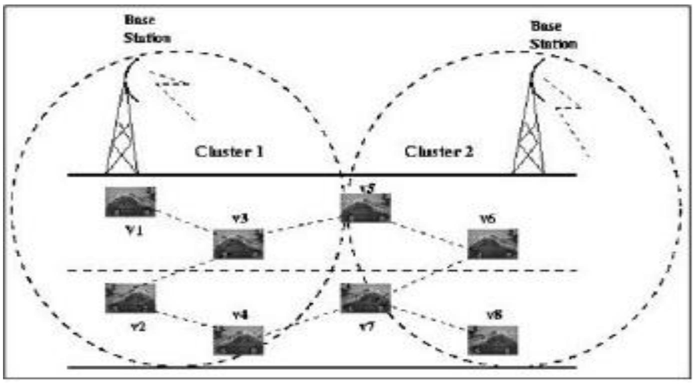


Figure 2.2 NETWORK ENVIRONMENT

The congestion factor is determined which is calculated as follows:

$$; = M / BCBw$$

where M = mobility of the node
Bw = bandwidth utilized
B = buffer memory
C = cache memory

Figure 2.3 Congestion Factor

Thus, Multi agent based plan shows better transfer speed utilization and packet delivery ratio and minimizes the latency.

A Novel Method Based on VANET for Alleviating Traffic Congestion in Urban Transportations (Kimura et al. 2013) – This paper is about traffic congestion. A system known as vehicle information and communication system (VICS) has been developed to reduce the traffic congestion. This system globally sends the information to all the vehicles to move from congested area to non congested area. But this is big problem because all the vehicles will receive the same information so the area which was less congested will become more congested. So to avoid this to and fro motion of the vehicles a novel method has been proposed based on vehicular adhoc networks. VICS depends on road infrastructure.

In this paper instead of obtaining global information by VICS, the researchers utilize local information obtained by VANET. In this proposed system, each vehicle tries to obtain the information about the traffic so that the vehicle could move to the non -congested area from the congested area. Therefore, a uniform traffic distribution is there in the whole transportation system. They calculated total trip time and velocity of vehicles to calculate the congested area. They also calculated TTL (Time to live) value which tells the number of times the message send by sending vehicle will be relayed. The message contains the information about the sending vehicle i.e. its ID, serial number and TTL.

The results of simulation experiments shows that the suggested system works better in terms of trip time and velocity of vehicles but time to live value can be improved if each vehicle collects minimum local information regarding congestion.

Efficient Traffic Congestion Detection Protocol for Next Generation VANETs (Boukerche et al. 2013) – In this paper, authors discussed regarding the ECODE protocol which detects the road segments that are suffering from traffic congestion by means of cooperative vehicular communication. This protocol makes use of multihop communication and geocast ideology to collect and analyze general data of vehicles per road segment. This protocol handles the broadcast storm problem, limited bandwidth and reliability challenges. To solve the broadcast problem the author make use to relay vehicles to forward data. To put into practice this protocol correctly, usual traffic allocation and minimum traffic density is needed. In this each vehicle generate a traffic monitoring report which consist of traffic speed, traffic density and estimated travel time. This protocol is direction based that is it consider the direction in which vehicle is travelling. Then this protocol is compared with the previous two protocols namely StreetSmart and COC and found that ECODE is much better that both these protocols in terms of bandwidth consumption and end to end delay.

On Alleviating Beacon Overhead in Routing Protocols for Urban VANETs (Lee et al. 2013) – In this paper, authors' proposed two distinct routing protocols, entitled Routing Protocol with Beacon Control (RPBC) and Routing Protocol with Beaconless to remove the loss of packets. Beacons are the signal messages. In RPBC, every vehicle figures out if to transmit a signal message in view of a new signal control plan which by minimizing repetitive signal messages diminishes transmission overhead significantly. On the contrary, RPBL is a beaconless protocol where a vehicle advertise packet to its neighboring vehicles and transmits packets by means of numerous ways to accomplish low packet loss. The authors thought of virtual signals and utilization it to further enhance our proposed protocols. The simulation results demonstrate that the proposition can attain low packet loss, less end to end delay, and little overhead.

Performance Comparison of VANET Routing Protocols (Sharma et al. 2011) – In their paper, authors compare the three basic protocols which includes Adhoc On – Demand Distance Vector Routing (AODV), Destination Sequenced Distance Vector (DSDV) and Distance Vector Routing (DSR). The parameters taken for the comparison are throughput, Routing overhead, packet delivery ratio, average jitter rate and average number of hop count. When they compare these three protocols they found that none of the protocols performed well for all the parameters. But the performance of DSDV is worst as compared to other two protocols. So, finally they conclude that it's better to use hybrid protocols so that performance can be enhanced.

An Improved AODV Routing Protocol for VANETs (Ding et al. 2011) - In this paper, AODV protocol is modified and an improved version of AODV has been introduced. The improved version of AODV includes two step optimization process in route discovery and route selection process to improve link stability and packet delivery ratio. The direction and speed of the vehicles are taken as parameters to improve the performance of the protocol. For simulation, two types of variables are used i.e. speed of nodes and number of nodes. A simulation result shows that the new protocol is better in terms of performance. The limitation is that only particular area is taken for simulation not the whole network.

Performance Evaluation of Reactive Routing Protocols in VANET (Choi et al. 2011)- In this paper authors tend to analyze the performances of the reactive protocols entitled On Demand Distance Vector (AODV), Dynamic Source Routing(DSR) and Adhoc On Demand Multipath Distance Vector(AOMDV) in vehicular adhoc networks. The assessment of protocols is done on the basis of uncertain mobility or portability, speed of the vehicle and number of sources. The parameters used for evaluating the performance of the protocols are end to end delay and packet delivery ratio and routing load. It has been proved that AOMDV performs better than DSR and AODV because AOMDV uses multipath routing. The packet delivery ratio is also better in case of dynamic source routing. The simulation is done using VanetMobiSim.

Efficient Congestion Control in VANET for Safety Messaging (Mughal et al. 2010) **-** In this paper authors described about the two types of safety messages that are been used in VANET to provide safety on road. These are beacons (periodic safety messages) and event driven messages. The beacons are used to exchange status information like speed, position. Event driven messages broadcast messages in case of emergency situations for e.g. accidents. Both beacons and event driven messages uses the same control channel, so it becomes difficult for the event driven messages to access the channel because beacons consume the most of the channel bandwidth. Thus this is a major concern regarding the safety on road. So researchers have planned various approaches to overcome this problem. One basic strategy is to limit the bandwidth for beacons and preserve some bandwidth for the event driven messages. In the paper, the authors make use of transmission rate or power control techniques to overcome this bandwidth problem. For making an efficient congestion control scheme we have to use both these techniques simultaneously so that we can get optimal results. But combining both these techniques give rise to various technical challenges like:

i) Proper utilization of bandwidth when there is no event driven safety messages to send.

ii) To make the efficient use of both techniques simultaneously

iii) Proper use of resources among vehicles within a particular region

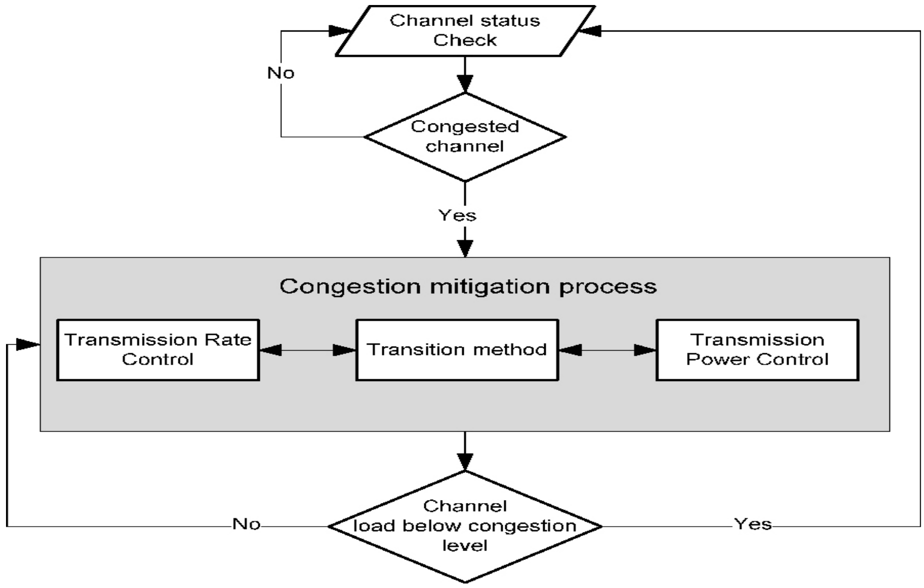


Figure 2.4 Flow chart of Conceptual view of congestion control scheme.

In this above mentioned scheme, all the vehicles are informed regarding their channel level continuously. When the channel gets saturated, a vehicle can sense the congestion at that particular time. If this happens, the vehicle immediately starts congestion mitigation process. This step is performed until the channel load gets below congestion level. In their paper, the authors do not propose any algorithm to achieve this and this technique is not implemented by the authors in the given paper.

A Transportation Control System for Urban Environments (Fratila et al. 2012)- As we all know that with increase in vehicles the traffic problems increase, so in this paper, they present the traffic control and congestion avoidance system to overcome these problems. This system is created over the cars in the traffic and their corresponding road infrastructure. Traffic congestion is a great problem in urban environments. There can many reasons for traffic congestions like weather conditions, traffic incidents, work zones etc. In this paper, the system proposed for traffic control is basically for large cities. To monitor traffic, sensors within road infrastructure are used and also in this system cars are acting as data collectors which will provide great help in congestion avoidance. The main advantage of this proposed system is that data is collected automatically by the cars (mobile devices) and wireless traffic lights and aggregated so that best path can be chosen to reach destinations.

Analytical Study of Position based Routing Protocols in VANET (Batish et al. 2012) – In this paper, the author discussed about various position based routing protocols **B-MFR-**Border-node based most forward within radius routing protocol, it uses the border nodes as the next hop count for forwarding packets from source to destination and it minimize end to end delay and optimize the path length between the vehicles. BMFR does not use the interior nodes as the hop count it uses the border nodes and it select the border node which is nearer to the destination. But there is a problem in the BMFR protocol, if the two border nodes are equidistant from each other then it is difficult to select the border node.

AMAR- Adaptive movement aware routing .In this protocol, the next forwarding node is the neighbour node of the current node which is closest to the destination. To select the next hop it uses the greedy forwarding technique. In AMAR it calculates the direction, speed and position of the vehicles and these three factors are used to calculate the weighted score Wi. But there is also problem in that if the weighted factor is same.

BMAR- Border Node Based Movement Aware Routing protocol is resolving the problem of the border node by using the features of AMAR.

Simulators for Wireless Networks: A Comparative Study (Sharma et al. 2012) – In this paper they discussed about various simulators in terms of performance. Various simulators discussed in this paper are GlomoSim, NS2, OPNET, OM-Net++, J-Sim. GlomoSim is open source software. NS2 is the most used software for simulation purposes. J- Sim is a java based simulator. The various factors considered while performing the comparison are installation issues, visualization capabilities and scalability of the simulator. NS2 and OMNet++ are found to be best among all the simulators but NS2 has complex structure as compared to other structures.

Position Based Routing Protocol (RAM SHRINGAR RAW, 2011) – In this, authors compared various position based routing protocols namely GPSR, GSR, A-STAR, GYTAR, BMFR, AMAR, BMAR. Position based routing protocols uses the GPS information to select the next forwarding hops so no global route between source and destination. These protocols require knowledge about the neighbour nodes and the destination nodes to send the packet successfully. Hello messages or beacon messages are used to update the information. A source node uses the hello messages to find the location of the neighbours. The position information of all nodes and vehicles are identified by location services. In this paper, they simulated protocols GyTAR, EBGR, B-MFR on two parameter end-to-end delay and packet delivery ratio.

Data Collection for the Detection of Urban Traffic Congestion by VANETs (Liu et al. 2010) - described about the vehicle traffic congestion detection models and discussed two broadcast approaches to control the traffic congestion. These two are restricted 2-hop broadcast (R2HB) and probabilistic restricted 2-hop broadcast (PR2HB). These both techniques are used for collecting the data in perspective of vehicle to roadside communication. RH2B select fewer vehicles to rebroadcast beacons. Safety messages are known as beacons. In case of R2HB, the beacons broadcasted by different vehicles have the opportunities to be rebroadcast, but these opportunities are disseminated to the most coherent vehicles in singular rebroadcasting Zones (RZs). The simulation outcomes prove that PR2HB and R2HB give better results than 2-hop broadcast and broaden the discovery range of roadside units.

Design and Simulation of an Artificially Intelligent VANET for Solving Traffic Congestion (Ghazy et al. 2009)–The main aim of the paper is to put together the VANET and artificial intelligence to lessen traffic waves. In their paper they explain that traffic congestion can be due to exterior factors like road repairs or due to natural devastation like landslides. The main reason for traffic congestion described by them is the driver behaviour and the traffic waves. Traffic waves are the travelling interferences in the dissemination of cars on a roadway. According to the researchers the main reason for this is human error. For e.g. vehicles are thought to be moved at regular speed but due to human inaccuracy, the drivers are not able to maintain a regular speed and these small fluctuations in speed can cause great congestion. There are two ways to avoid this congestion problem. One is to change the road infrastructure which is very costly and the other one is the development of traffic management system.

A VANET technology known as Zigbee Standard was developed when the research was ongoing. Zigbee standard is a low- power (allows longer life for batteries), low-cost (allows the technology to be widely spread), wireless mesh networking (provides larger range and high reliability) standard. But Zigbee standard lacks in transmission of data at high speeds. Zigbee supports three types of network topologies. They are star, mesh and cluster tree network topology. There are three types of Zigbee devices:

- **Zigbee Coordinator**: It maintains thorough knowledge of the network and consumes most of the power.
- **Zigbee Router:** Carries all the functionality and features of 802.15.4 standard.
- **Zigbee End Device**: Carries limited functionality to control cost and complexity. To preserve the battery life is usually less active.

Zigbee coordinator nodes are disseminated all over the map and record the number of vehicles in the cluster. This information will be send to all the nearby vehicles so that an efficient path must be followed by the driver. For the simulation, the authors use TraNS simulator. TraNS is a combination of NS2 with SUMO. The TraNS framework uses TraCI interface to exchange information between SUMO and NS2 simulator.

CHAPTER 3
PRESENT WORK

3.1 Problem Formulation

With the advent in technology, a great deal of research efforts are being focused towards making the use of vehicular ad hoc networks oriented towards traffic oriented applications to avoid accidents and fatalities caused. Vehicular ad hoc networks consist of vehicles communicating with each other, they exchange important information related to their speeds, traffics conditions, accidents etc. Since the vehicles move at greater speeds, the source vehicle has to find the fresh route to the destination so it has to broadcast the route request packets.

In VANETs, emergency messages (e.g. emergency stop of a vehicle, collision) should be sent with minimal delay, with a high priority and with a loss rate near to zero. If a large number of vehicles sends beacons at a high frequency, or event-driven messages are broadcasted multiple times then the communication channel will easily get exhausted which results in poor bandwidth usage. It is very important to keep the common control channel (CCH) free from bandwidth usage in order to ensure timely and reliable delivery of safety messages.

In the work put forward by authors, they have attempted to reduce the bandwidth congestion with the help of efficient road congestion detection protocol (ECODE). In their work, they have assumed RSU at each road intersection for monitoring the traffic of the surrounding segments. They have tried to reduce the bandwidth usage with a mechanism with the help of which every vehicle will broadcast an advertisement message to all the vehicles in its neighbourhood community or in its range. RSU chooses the relay vehicles according to the information provided in the broadcasted message. The information includes ID, Speed, Location, Direction, Destination etc. However, in the dense city scenarios the numbers of vehicles are more and broadcasting the advertisement messages may result in congestion in the network. So there arises a need to design a mechanism to reduce this bandwidth consumption which is quite minimal in these types of protocols which further results in better communication to make better congestion detection on various road segments. Single hop communication will take place only from vehicles to RSUs so in this case the no. of RSUs will be increased due to short range communication take place between the nodes to make better TMR.

3.2 Objectives

1. Reducing congestion in the network by introducing new RSUs.
2. Eliminating relay nodes for generation of neighbours report in the network.
3. Establishing RSU to RSU communication for generating traffic report instead of relay nodes.
4. Improve time latency factor by generating faster neighbour report through RSU to RSU.
5. Improve traffic congestion by signalling vehicles by RSU at intersection road links.

3.3 Research Methodology

The research will be carried out in the following steps:

1) Installation of NS2 and study the concepts.
2) Develop the congestion control method.
3) Implement that mechanism and compare it with the ECODE.

3.3.1 Simulation Tool Used

NS2 is a network simulator which is used for simulating networking research which can simulate wireless LAN, adhoc networks and wired-cum-wireless networks. NS2 can run on different platforms. These platforms are:

1) UNIX
2) LINUX
3) Free BSD
4) SunOS/Solaris
5) Windows 7/8 with Cygwin

Network Simulator uses ‘tcl’ as a scripting language. Network Simulator version 2 is an event based simulator. The network simulator is discrete event packet level simulator. It covers a very large number of various kinds of protocols and packets. In it scripting language is used. It contains “NAM” files through which animation is run.

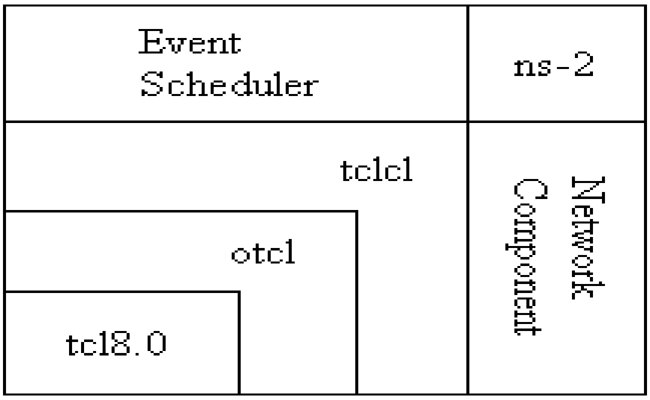


Figure 3.1 NS2 Architecture

Front End- OTCL scripting language is used. It is used for the following reasons:

1) To describe different network topologies.
2) To show applications of protocols.
3) Easy to use and freely available.

Back End- Programming language i.e. C++ is used. The main motive of using programming language is:

1) It is used to implement the protocols and their functionalities.
2) It optimizes the efficiency of the simulation.

3.4 Algorithm Steps

Step 1: Collect information: In this step, we are focusing on collecting the information about the vehicle speed, destination of the vehicle, and in which direction the vehicle needs to go can be considered as information that needs to be collected.

Step 2: Create traffic report: Traffic is main factor; we need to focus on when vehicle is moving from one location to another location. Vehicle moves in a particular direction and it follows the specified path, but while movement of the vehicle it communicate with each other and it may happens, it creates congestion, solution for this problem is be aware of the traffic in the network, create a traffic monitoring report and maintain it. This traffic report also helps to decide the vehicle how to reach destination as soon as possible.

Step 3: Maintain the traffic monitoring report: The traffic monitoring report gets the entries from the table and stores it in the table. While vehicles are moving from one location to other vehicles creates the congestion, to prevent the congestion traffic monitoring is very necessary to maintain traffic monitoring report. The traffic monitoring report contains the following entries.

S.No	Vehicle_id	Speed	Direction	Destination

Step 4: Identify the no. of nodes to reach the destination: Roadside Unit provides all information about the route to reach to the destination that includes the information about the number of node vehicle need to cross to reach to the destination. The RSU increment the number of nodes for the destination with respect to vehicle.

S.No	Destination	Threshold Limit	Current No.

Step 5: Transfer the updated report: Once vehicle get to know about the route it need to follow, it starts moving, while it in running state RSU sends and receives the information about the vehicle, information contain vehicle_id, speed of the vehicle, direction of the vehicle and where it has to go i.e. destination. Then RSU transfer the report updates to the next adjacent RSU unit.

Step 6: Transfer of traffic report to the corner RSU: When it start transferring of updated report to the next RSU. This report need to reach by corner RSU, because it decides the direction of the vehicle when it reaches on the corner of the road. So, updates of transfer of traffic report will be executed till the corner RSU receives the updated report.

Step 7: Send the updated report to the vehicle: When RSU send the traffic report to the next RSU and it reaches to the RSU at the intersection point; it has every crucial information about the vehicle and the network which is necessary to direct the vehicle to control the congestion. So, when the vehicle reaches at the corner most segment, RSU updates the vehicle with current info and direction to follow for the destination.

FLOWCHART OF THE PROPOSED DESIGN:

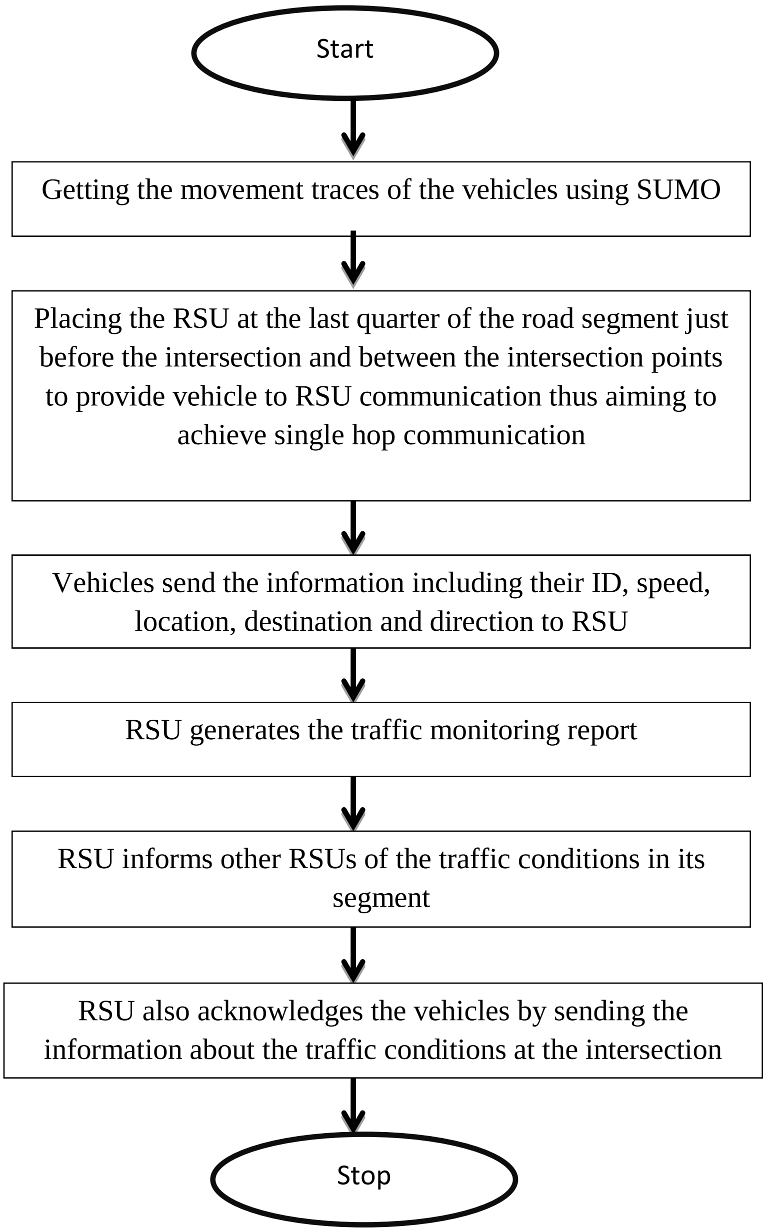


Figure 3.2 Flowchart of Proposed Method

CHAPTER 4

RESULT AND DISCUSSIONS

4.1 Assumptions

- RSU will never fail during the communication.

4.2 Simulation Parameters:

Parameter	Value
Channel Type	Wireless
Mac Type	802.11
Interface Queue Type	Queue/Droptail/Priqueue
Link Layer Type	LL
Max packet in ifq	250
Number of nodes	26
Simulation Time	100s
Traffic Type	CBR

Table 4.1- Simulation Parameters

4.3 Results

The results are shown on the basis of three performance parameters. These are throughput, delay and packet loss. The simulation is done using the network simulator 2.35. The simulation parameters that are taken are listed in a table on the previous page.

The results are discussed as follows:

The given scenario depicts the vehicles and the roadside units. The vehicles are represented as squares and RSU are represented by the hexagon. A grid is made to show the VANET scenario in NS2.

4.3 Implementation

Scenario 1

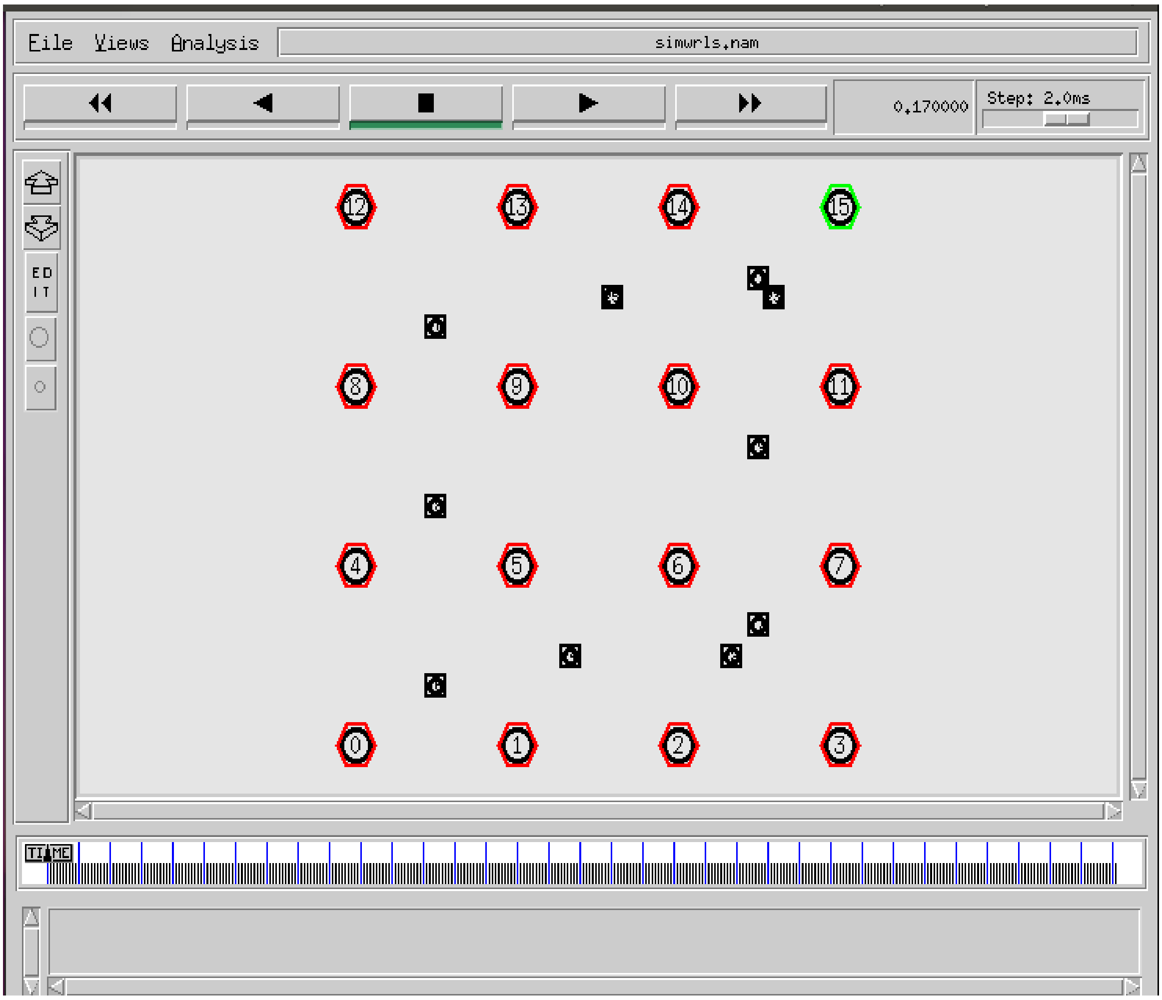


Figure 4.1 Scenario displaying vehicles and RSU

In scenario 1, we can see that nodes with the different colours include red and green, and vehicles with black colour. Green node tells about the location of the destination node.

Scenario 2

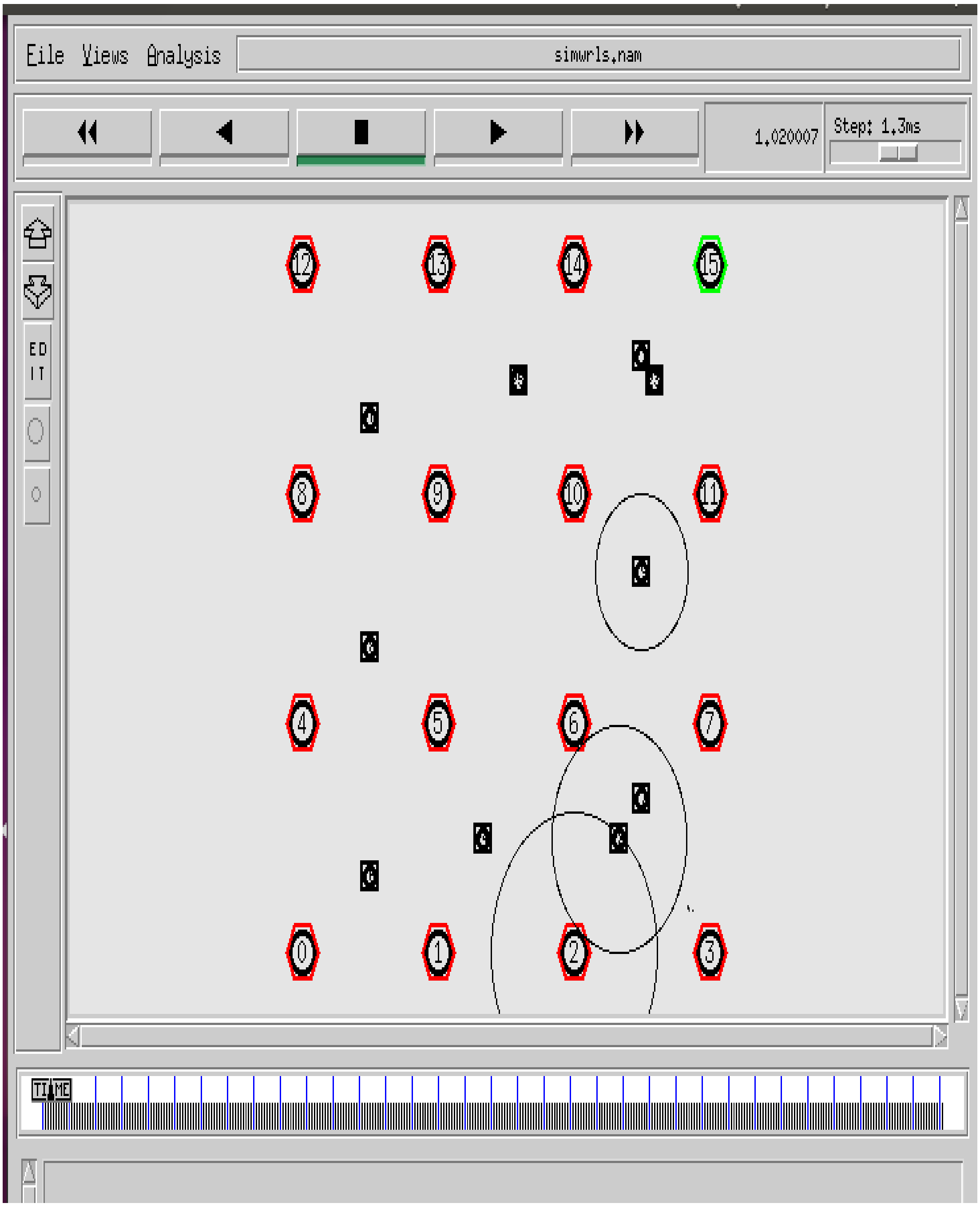


Figure 4.2 Communication taking place between the RSU and vehicles

As shown in scenario, it represents the communication that takes place between the RSU and the vehicles. The circles show the communicating range of the vehicles and the roadside Units. Road side units are placed on the specified distance.

Scenario 3

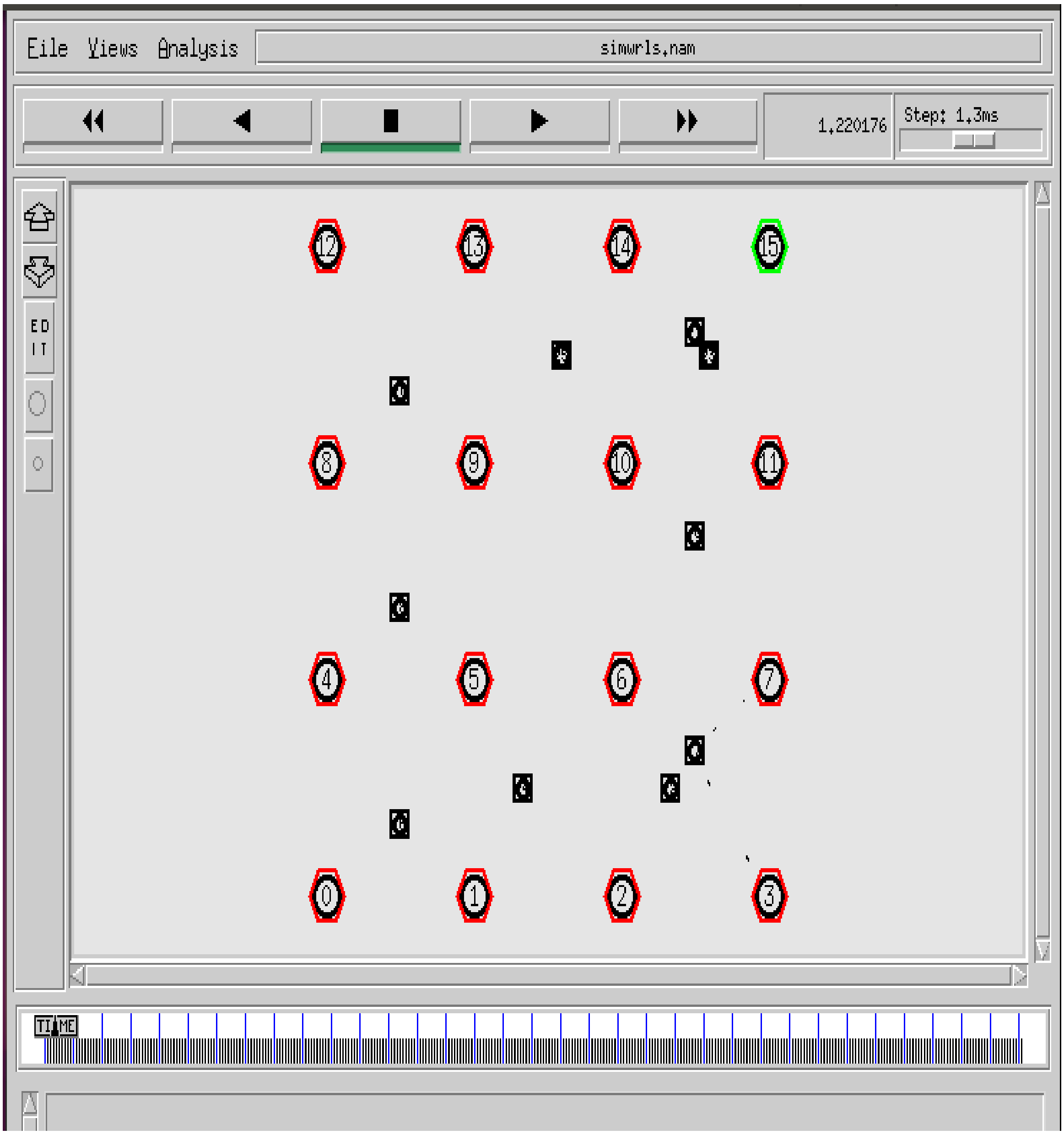


Figure 4.3 Vehicle communicating with the RSU

Scenario 3 shows the nodes with the black colour are mobile in nature and it roams over the network and tries to reach to the destination with help of the directions given by the RSU. Vehicles communicate with the RSU get the information about the direction to reach the destination.

Scenario 4

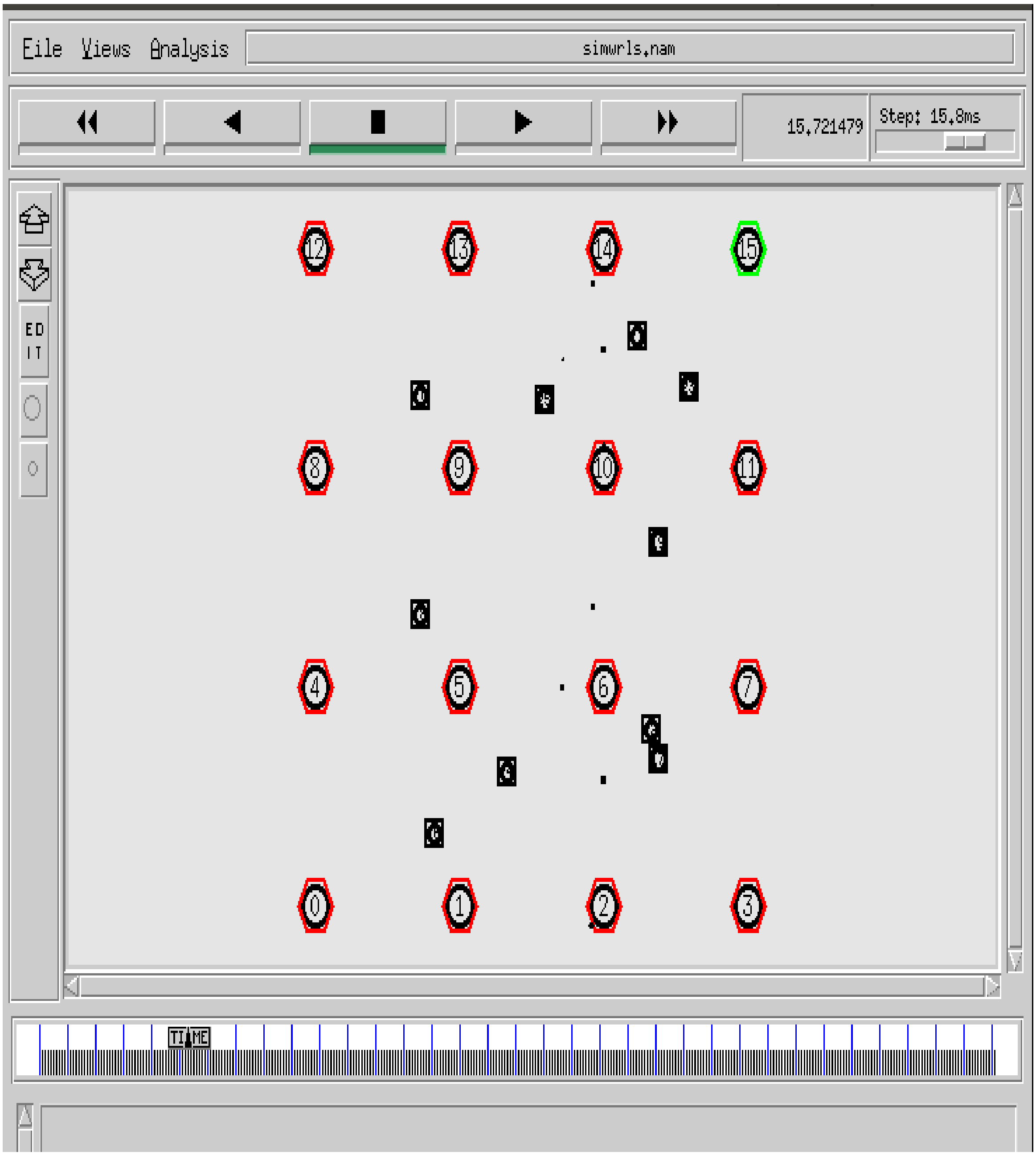


Figure 4.4 Communication between vehicles and RSU showing packet drop

Scenario 4 shows the communication between the vehicle and RSU, while communication between the vehicle and RSU, vehicle packet sends and receives the packet and if congestion occurs while communication, it tends to drop of the packets.

Scenario 5

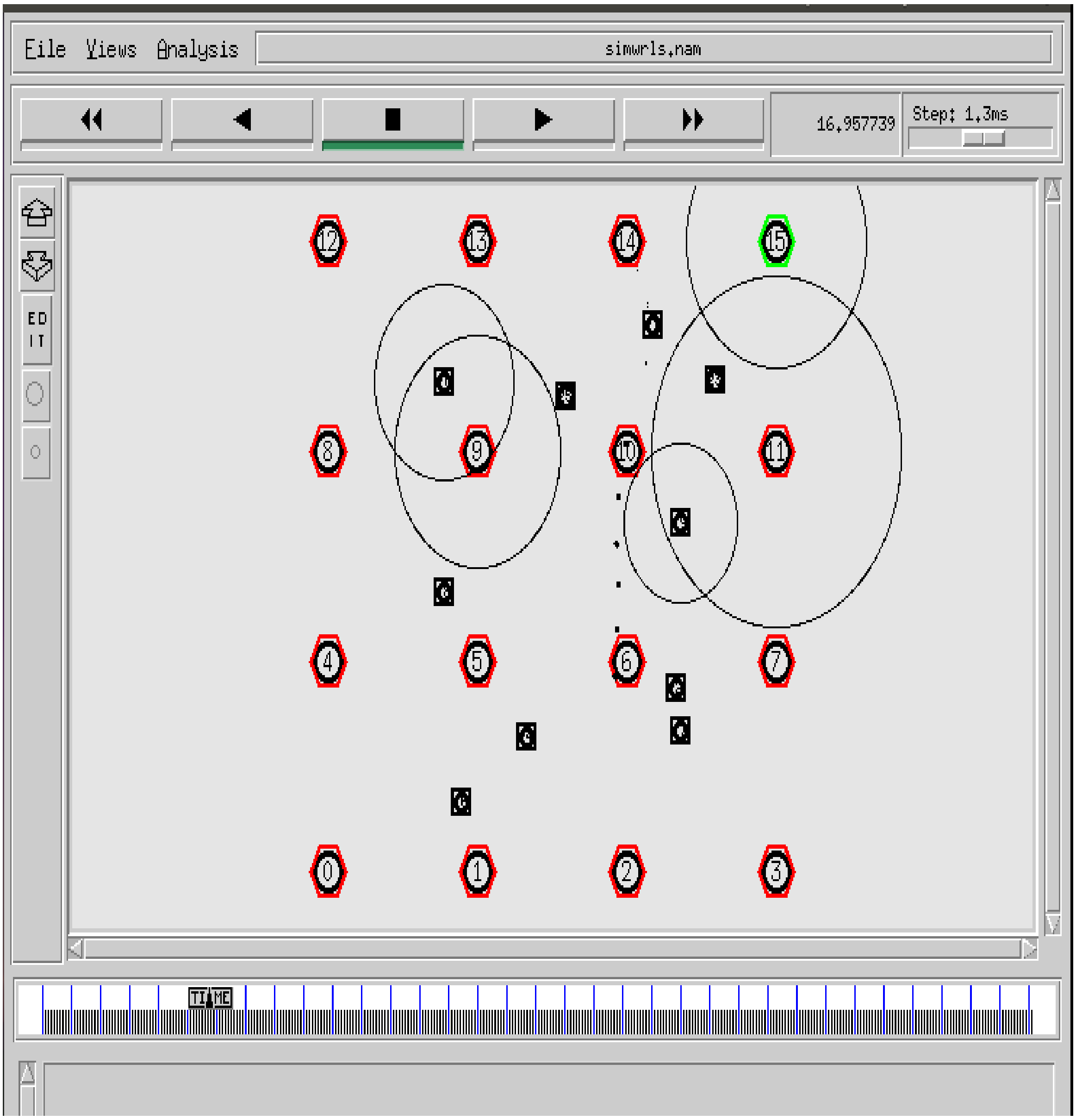


Figure 4.5 vehicles going from source to destination

Scenario shows the movement of the vehicles, following the instruction and information to reach the destination, and if there is any congestion in communication then it dropping the packet, but congestion is controlled by the restricting the communication between the vehicle to vehicle. Vehicle can only communicate with the RSU.

4.4 Comparison of Graphs

4.4.1 Delay Comparison:

Figure 4.6 Delay Comparison of ECODE and EECODE

This figure represents the comparison of enhanced ECODE to ECODE. It gives very less delay in terms of congestion while ECODE gives very poor performance in terms of delay in terms of congestion.

In the above graph the red line shows the ECODE and green line shows the EECODE. It can be clearly seen that that the performance in terms of delay is much better in case of EECODE. This is because the single hop communication is used in EECODE and the concept of relay vehicles is eliminated. Thus, no neighbour report is generated and ultimately there will be less delay in EECODE.

4.4.2 Packet Loss Comparison:

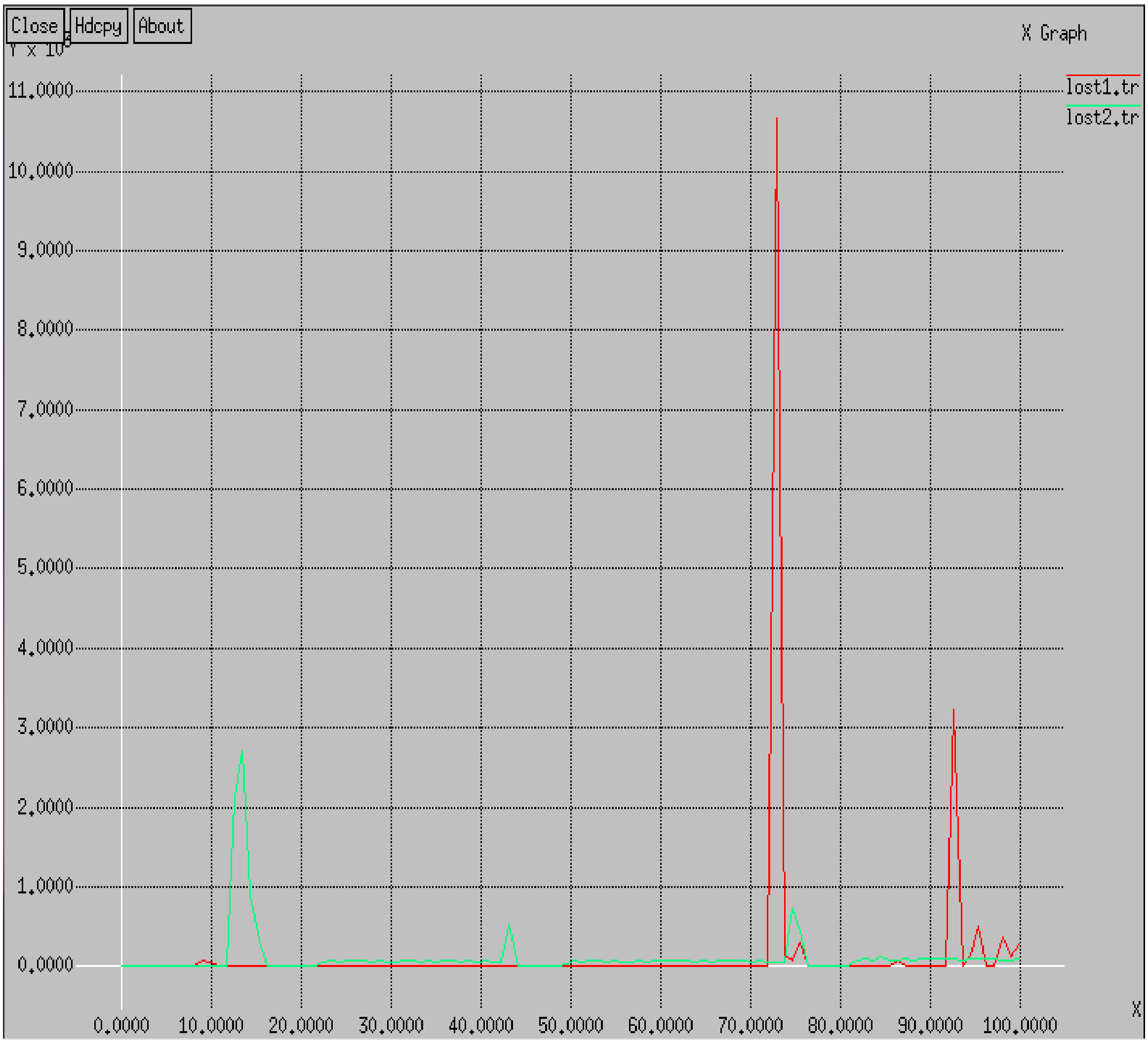


Figure 4.7 Packet loss comparison of EECODE and ECODE

The graph represents the comparison of EECODE and ECODE. The packet loss in case of EECODE is very less as compared to ECODE.

The green line shows the EECODE and the red line shows ECODE.

In EECODE the packet loss is less as compared to ECODE because communication is taking place with the help of roadside units, thus less bandwidth will be consumed because RSU are static in nature and vehicles are moving and communication is taking place between vehicles in case of ECODE, so bandwidth consumption will be more in case of ECODE.

4.4.3 Throughput Comparison

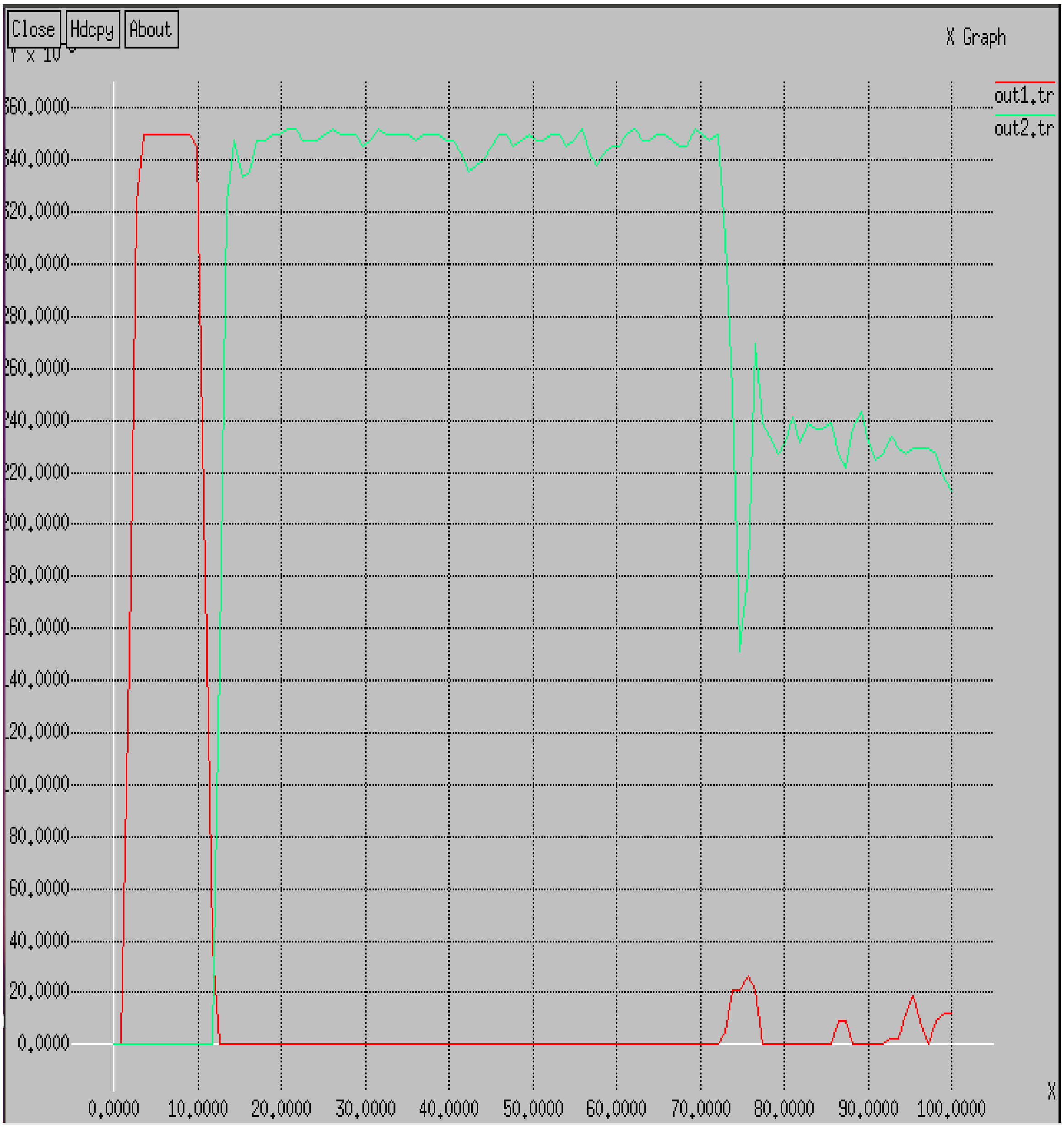


Figure 4.8 Throughput Comparison of ECODE and EECODE

The figure represents the comparison of the EECODE to the ECODE. It gives a very good enhancement in throughput in terms of congestion while ECODE gives a degradation of performance in case of throughput.

In the graph the red line shows ECODE and the green shows EECODE. Throughput is one of the main parameter for congestion control. In EECODE throughput is more because communication will directly take place from RSU to RSU for generating traffic monitoring report. Roadside units will communicate with other and informs about the traffic conditions in its segment. RSU also acknowledges the vehicles by sending the information about the traffic conditions at the intersection. After assessing the traffic at the intersection, RSU will provide information to the vehicle to maintain the traffic by taking effective decision to follow a less congested route to the destination.

4.4.4 AWK Results

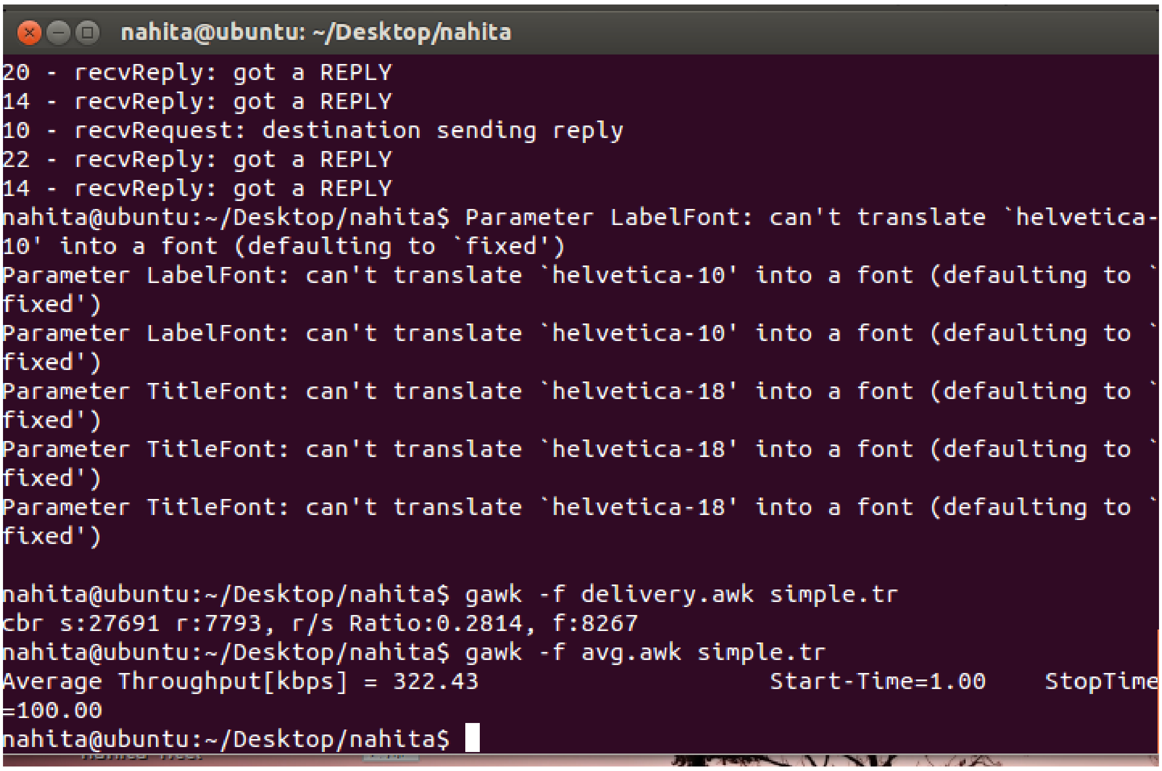


Figure 4.9 Throughput and packet delivery ratio of EECODE

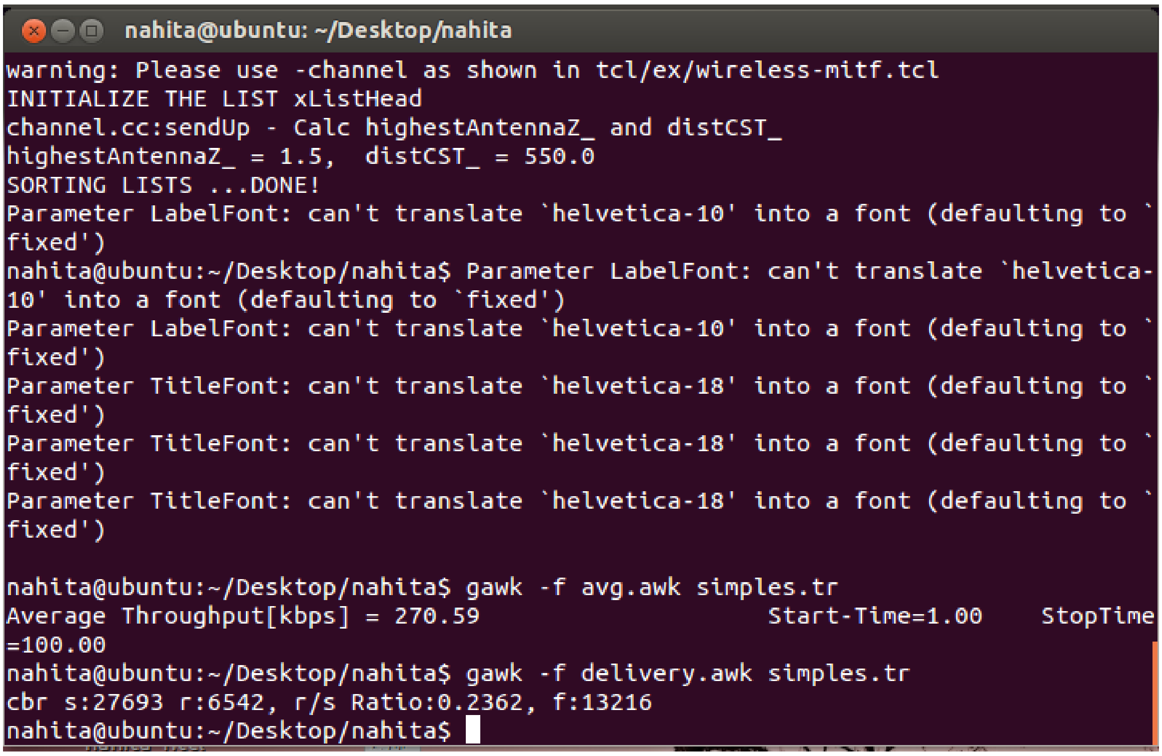


Figure 4.10 Throughput and Packet Delivery Ratio of ECODE

From the above results i.e. throughput and packet delivery ratio, it can be clearly seen that in case of EECODE throughput and packet delivery ratio is more as compared to ECODE.

CHAPTER 5

CONCLUSION AND FUTURE SCOPE

5.1 Conclusion

The main application of the vehicular ad hoc networks is traffic monitoring and congestion control. The vehicle moving on the roads must exchange useful information about the road conditions and vehicle density so as to monitor the traffic conditions and avoid accidents. However this requires periodic update of the information related to the vehicles such as vehicle speed, vehicle destination, vehicle direction etc so that vehicle moving ahead or those moving forward can access the conditions and decide their route accordingly. The periodic exchange of the information results in congestion in the network thus cause delay and further results poor packet delivery in the network.

In the dense areas where the number of vehicles are much more the congestion is bound to occur. However, we aim to reduce the congestion in the network with the help of the road side units. By using single hop communication, there will be direct communication between roadside units and vehicles which will reduce the bandwidth usage in the network. Also there will be decrease in end to end delay because communication will directly take place from RSU to RSU for generating traffic monitoring report. Roadside units will communicate with other and informs about the traffic conditions in its segment.

RSU also acknowledges the vehicles by sending the information about the traffic conditions at the intersection. After assessing the traffic at the intersection, RSU will provide information to the vehicle to maintain the traffic by taking effective decision to follow a less congested route to the destination. Throughput, delay and packet loss has been calculated to check whether congestion is improved or not and the result seen are been positive i.e. better throughput, less delay and less packet loss. Thus, the system is better as compared to the previous system.

5.2 Future Work

In this dissertation, it has been considered that RSU's will not fail during the communication. In future this point has been considered and will try to work on it to get better results in terms of throughput, delay and packet delivery ratio. Also other techniques can be added like clustering approach can be used to enhance the protocol. One most important factor is to minimize the cost for the deployment of the RSU because so many RSU are needed which can put impact on cost factor.

CHAPTER 6
REFERENCES

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CHAPTER 7
APPENDIX

ABBREVIATIONS

MANET	Mobile Adhoc Networks
VANET	Vehicular Adhoc Networks
V2V	Vehicle to Vehicle
V2I	Vehicle to Infrastructure
I2V	Infrastructure to Vehicle
ITS	Intelligent Transportation System
RSU	Roadside Units
DSRC	Dedicated Short Range Communication
ECODE	Efficient Congestion Detection Protocol
EECODE	Enhanced Efficient Congestion Detection Protocol
AODV	Adhoc On-Demand Distance Vector
AOMDV	Adhoc On-Demand Multipath Distance Vector
GPSR	Greedy Perimeter Stateless Routing
BMFR	Border-node based most forward within radius
BMAR	Border Node Based Movement Aware routing
AMAR	Adaptive movement aware routing
OPNET	Optimized Network Engineering Tools Modeler
OMNET++	Objective modular network Testbed in C++
NS2	Network Simulator Version 2
WSN	Wireless Sensor Network
WMN	Wireless Mesh Network
CCH	Common Control Channel
WAVE	Wireless Access for Vehicular Environment

TMR	Traffic Monitoring Report
LAN	Local Area Network
Wi-Fi	Wireless Fidelity
Wi-MAX	Worldwide Interoperability for Microwave Access
GPS	Global Positioning System